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CONFERENCE PROCEEDINGS

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About the Conference

The Students' Conference on Scientific Research is an annual activity of FPT University. In order to improve research and presentation skills and open opportunities for students to study and exchange. The Student Scientific Conference of 2018 is held at FPT University, Hoa Lac campus, Hanoi. The preliminaries were organized in October 2018 and the final round was on December 9, 2018.

In 2018, the Organizing Committee and the Scientific Council selected 23 reports to reach the Final Round. The topic of reports extended across the fields of Natural Sciences, Social Sciences, Science and Technology

About the Proceedings

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SCIENCE - TECHNOLOGY PAPERS

Computational Hydrodynamics with UPC Architecture

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Abstract

An alternative computer architecture, known as PGAS-UPC, was coupled with high performance computing (HPC) for computational hydrodynamics (CHD) simulations in this study. PGAS-UPC harnesses the respective strength of two traditional parallelism architectures, namely MPI's scalability and OpenMP's direct memory access, to accelerate the computational run time of CHD simulations. A model, termed as UPC-CHD, was developed on the proposed approach together with the 2-step explicit scheme from Lax-Wendroff family of predictors-correctors. UPC-CHD was evaluated on three incompressible, viscous flow cases having moderate flow velocities under laminar conditions, namely (a) Blasius boundary layer, (b) Poiseuille's flow, and (c) Couette's flow. The accuracy of the implemented numerical scheme in UPC-CHD was first validated by comparing the derived numerical results with the respective analytical solutions for the different cases, which showed good overall agreement. The computational performance of UPC-CHD was then compared with that of MPI and OpenMP at their basic designs in a SGI UV-2000 server with 100 cores maximum. UPC-CHD performed most efficiently and achieved a near 1:1 speedup, which suggests the viability of the proposed approach for large-scale CHD simulations in the future.

Keywords:

Computational hydrodynamic simulations, UPC, MPI, OpenMP, high performance computing

1. Introduction

Computational hydrodynamics (CHD) simulations have garnered increasing significance for assisting civil engineers to evaluate and optimize industrial-related applications. Examples included flow simulations within the tight spacers of membrane modules to mitigate both fouling tendency and flow short-circuiting during filtering processes (Bucs. et al., 2014; Jajcevic et al., 2013; Sousa et al., 2014). Combinations of CHD with other computational tools such as discrete element method (DEM) in porous-media related applications had also been introduced (Sobieski and Zhang, 2017; Li. et al., 2011). In these CHD simulations, accuracy is required in the numerical scheme to discretize and resolve the Navier Stokes (NS) hydrodynamic equations. Concurrently, the computation should be accomplished within a reasonable time frame. For large scale CHD simulations, optimization between both factors is desired.

Typically, a large-scale CHD simulation run with high performance computing (HPC) requires significant management of the parallelization architecture in attempts to achieve the

desired optimization. For example, a 100 million two-dimensional (2D) mesh involving 3 equations (continuity and momentum equations only) would result in an approximate 600 million cell information ($100 \text{ million} * 2 * 3$) to be managed during each iterative step. Data sharing among computer cores (CPUs) is unavoidable in CHD mesh-bounded numerical domains. At present, the common parallelization architecture available for data sharing includes the distributed-memory approach with message passing interface (MPI) and the shared-memory approach using OpenMP.

Examples of CHD software using MPI include the very popular Open-source Open Field Operation and Manipulation (OpenFOAM) and ANSYS FLUENT, which involves communication of the shared data between computer cores by transmitting the messages back and forth with either point-to-point or collective communication protocol (Jamshed, 2015). Both types of communication can involve blocking or non-blocking methodologies. The blocking method puts the program execution on hold until the message buffer slots within the computer memory is ready, which might incur significant amount of idle time for significant number of cores. The non-blocking method proceeds on with the program execution and does not wait for the completion of the communication buffer, which minimizes the total idle time. However, data loss might be incurred during the process. To harness the scalability advantage of MPI's, computational parallelism is always required in application-customized algorithms to reduce the communication latency (Frisch, 2014). Thus, designing MPI applications for considerable number of computer cores with escalated levels of memory hierarchy has been difficult so far (Gourdain et al., 2009; Jamshed, 2015).

Comparatively, OpenMP facilitates the programming ease by utilizing a shared memory architecture which can be accessed by all computing nodes publicly. OpenMP architecture is, however, confined to the computational power of a singular system of a fixed number of nodes (Aubry et al., 2011), and additional cores cannot be incorporated into its architecture readily which circumscribes its scalability (Jamshed, 2015). Thus, it is more popular for CHD software to employ MPI as compared to OpenMP. Hybrid parallelism which harnesses both MPI and OpenMP architectures has since been attempted for CHD simulations. Readers are referred to the recent references (Berger. et al., 2005; Djomehri. et al., 2002; Giovannini. et al., 2015; Yilmaz. et al., 2009) for further details. However, hybrid parallelism is more difficult to implement, and the performance gains might not justify the required programming efforts (Rabenseifner et al., 2006; 2009).

Acceleration of CHD simulations can also be accomplished by exploiting graphic processor units (GPUs) from the hardware perspective. For instance, simulations of laminar, turbulent and reactive flows had been attempted (Niemeyer and Sung, 2014), and the achieved speedups were faster than CPU-based approaches. An existing FORTRAN Euler code was altered by Brandvik and Pullan (2008) to work on GPU-based architecture, which achieved an improved speedup for two-dimensional (2D) and three-dimensional (3D) flow cases. However, challenges such as the difficulty of tailoring original codes to the GPU-based architecture and the need for lengthy code development time were mentioned. Readers are referred to recent GPU-based architecture works (Appleyard. et al, 2011; Kuo. et al., 2011; Salvatore. et al., 2012; Schalkwijk. et al., 2012) for further details.

Research efforts are still ongoing in attempts to develop an architecture which achieves an optimal balance between the accuracy of the numerical scheme and the desired speedup with increasing number of cores, while not compromising on the relative ease in its programming

and implementation works. In this study, we developed an alternative parallelism approach for CHD simulations by adopting the Partitioned Global Address Space (PGAS) concept with Unified Parallel C (UPC) as the programming language. PGAS is a relatively new architecture that has been developed on the working principles of message passing and pure shared memory programming paradigms (Tarek et al., 2005). Two key advantages can be achieved with PGAS: (a) locality in the shared memory model which facilitates the ease of use, and (b) data layout control of MPI's which enables performance scalability. The PGAS architecture has been attempted in past literature for other applications, and readers are referred to the following references (Johnson, 2006 and Simmendinger. et al., 2011) for further details. To the best of our knowledge, CHD simulations with the PGAS architecture, as performed in this study, have not yet been reported in the literature so far.

By coupling the PGAS-UPC architecture with the 2-step explicit numerical scheme from the Lax-Wendroff family of predictors and correctors, a UPC-CHD model was developed and evaluated on three incompressible, viscous flow cases having moderate flow velocities under laminar conditions, namely (a) Blasius boundary layer, (b) Poiseuille's flow, and (c) Couette's flow. Validation of the implemented numerical scheme was achieved by comparing the three cases with their respective analytical solutions for the given hydrodynamic conditions, which showed good overall agreement. Lastly, we shall show that UPC-CHD performed more efficiently than MPI and OpenMP at their base designs in a SGI UV-2000 server with a maximum of 100 cores in this study.

This paper is structured as follows. In Section 2, we describe the numerical scheme implemented in the UPC-CHD model, which is followed by the description of UPC-CHD development with the adopted UPC architecture in Section 3. The parallelism performance of UPC-CHD is then examined in Section 4. Section 5 describes the salient pointers derived from this study.

2. Numerical discretization

The governing equations, namely the continuity, momentum and energy equations, to describe the fluid dynamics within an engineering system (Anderson, 2009) can be expressed in the compact and conservative form of Equation 1.

$$\frac{\partial Q}{\partial t} + \frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = \frac{\partial G_{Vx}}{\partial x} + \frac{\partial G_{Vy}}{\partial y} \quad (1)$$

where Q is the conservative temporal term, F and G are the convective flux vectors in the x and y directions respectively, and G_{Vx} and G_{Vy} are the viscous flux vectors in the x and y directions respectively. By assuming fluid incompressibility, adiabatic flow conditions and no external forcing on fluid, the exact representation of the Q , F , G , G_{Vx} and G_{Vy} are shown in Equation 2.

$$Q = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho E_t \end{bmatrix}, F = \begin{bmatrix} \rho u \\ p + \rho u^2 \\ \rho uv \\ \rho(E_t u) + pu \end{bmatrix}, G = \begin{bmatrix} \rho v \\ \rho uv \\ p + \rho v^2 \\ \rho(E_t v) + pv \end{bmatrix}$$

$$G_{Vx} = \mu \begin{bmatrix} 0 \\ u_x \\ v_x \\ 2uu_x + vu_y + vv_x \end{bmatrix}, G_{Vy} = \mu \begin{bmatrix} 0 \\ u_y \\ v_y \\ 2vv_y + uu_y + uv_x \end{bmatrix} \quad (2)$$

where ρ is the density of water (kg/m^3), u is the horizontal velocity (m/s), v is the vertical velocity (m/s), p is the pressure ($\text{kg/m}^2 \cdot \text{s}$), E_t is the energy term ($\text{kg} \cdot \text{m}^2/\text{s}^2$), μ is the dynamic viscosity of water ($\text{kg/m} \cdot \text{s}$), u_x is the x-derivative of the u velocity, u_y is the y-derivative of the u velocity, v_x is the x-derivative of u and v_y is the y-derivative of v .

A comprehensive description of the numerical scheme implemented in UPC-CHD can be found in Appendix A. Equation 1 is first discretized over the representative control volume of a single node in Figure 1. All other nodes within the numerical domain undergo the same discretization format. The temporal term of the discretized form is evaluated using the two-step explicit scheme from the Lax-Wendroff family of predictors-correctors. The predictor step computes the flow condition at the half-time step, whereas the corrector step follows up with the predictor step by employing a central differencing with time at the full-time step.

As discussed previously, the implemented numerical scheme in UPC-CHD was validated by examining three CHD flow cases. The boundary and initial conditions adopted for Cases A, B and C are represented in Figure 2a, 2b and 2c respectively. The temperature of all numerical domains was kept at 293.15K.

3. Development of UPC-CHD

The following parallelisation procedures are adopted within UPC-CHD: (i) the time-consuming functions and different forms of data dependences are first identified, (ii) the appropriate algorithms are then adopted for data divisions and storage as based on the data dependences and model workflow, and (iii) lastly the unique work-sharing function of PGAS-UPC is introduced to parallelize the workflow internally. The details of the implemented computational structure and the respective algorithm for domain decomposition, data storage and work-sharing function involved in developing UPC-CHD will be described in the following.

Computational structure

The adopted computational structure in UPC-CHD is summarized in the pseudo-form of Algorithm 3.1 of Appendix B. The proposed structure minimizes the runtime required to compute the predictor and corrector fluxes within each node in Figure 1, which constitutes the largest portion of the total computational runtime. Referencing to Algorithm 3.1 in Appendix B, the flux predictor at the $n + 1/2$ time level is first computed which is then followed by the flux correction at the $n + 1$ time level. Both the flux predictor and flux corrector are within the nested loop (step 4 and 5 of Algorithm 3.1), and the complexity of the nested loop algorithm is defined as $O(N^2)$, where N is the number of computational cells in a singular direction. The original nested loop is divided into multi sub-loops to prevent data conflicts. After every new nested loop, a synchronization point is inserted using an UPC function, termed as *upc_barrier*, to synchronize all threads before proceeding to the next function. The sub-loops architecture is summarized in Figure 3.

Domain decomposition algorithm

The required fluxes within each of the nodes in Figure 1 are computed via a row-by-row approach utilising the respective data values of the two upper and two lower rows. To do so, the two-dimensional (2D) Cartesian computational matrix of UPC-CHD is divided into a series of smaller sub-domains having a defined number of rows, for which each sub-domain has affinity to a single thread. With T number of threads, a $N \times N$ domain is decomposed into T sub-domains ($D_i, i = 0$ to $T - 1$). The adopted protocol for domain decomposition is as follows: (i) if N is divisible by T , then each D_i contains the data of $\frac{N}{T}$ rows which results in $\frac{N \times N}{T}$ cells, or (ii) if N is not divisible by T , then the first $(T-1)$ sub-domains D_i ($i = 0$ to $T - 2$) contain $(\text{int}(\frac{N}{T}) + 1)$ rows and the last sub-domain D_{T-1} contains the remaining rows. Considering a 8×8 domain example in Figure 4 where N is 8, the mathematical representation described in pointers (i) and (ii) can be illustrated by the use of 4 threads (T) and 3 threads (T) respectively. The former comprises of 4 sub-domains for which each contains 2 rows whereas for the latter, the first 2 sub-domains, as measured from the top boundary, comprise of 3 rows each and the last sub-domain contains 2 rows. For a rectangular domain of $L \times B$, the number of sub-domains will be solely dependent on the division of L by the number of threads (T). The respective threads assigned to the first and last row are termed as $thread_{start}$ and $thread_{end}$, and the domain decomposition is first performed on thread 0.

Data storage algorithm

The stored data of sub-domain D_i are assigned to the thread T_i using the blocked-cyclic technique which enables T_i to access the data having the direct affinity. The only exceptions for T_i to access outside of D_i are restricted to the first and last rows, which result in shorter computational time as compared to that of $(\frac{N}{T} - 2)$ rows for the Case of N being divisible by T , and $(\text{int}(\frac{N}{T}) - 1)$ rows for the Case of N not being divisible by T . The proposed blocked-cyclic technique is shown in Figure 5 and further discussed in Section 4.

Work-sharing function

The computations within the nested loops are distributed using a work-sharing function, termed as *upc_forall*, in the pseudo-form of Algorithm 3.2 shown in Appendix C. In UPC, the total number of threads is determined with a UPC identifier, *THREADS*. Each thread is identified by using another identifier, *MYTHREAD*. With *upc_forall*, all threads with *MYTHREAD* from 0 to *THREADS-1* undergo the identical code run (i.e. the nested loop). Each thread is designed to compute the fluxes on the different sub-domains which are identified by using different $thread_{start}$ and $thread_{end}$. The adopted approach is termed as the single-program multiple-data method (SPMD).

4. Model verification and performance evaluation of UPC-CHD

To validate the implemented numerical scheme in UPC-CHD, the numerical predictions derived for Cases A to C were compared with the respective analytical solution: (Case A) with the analytical solution of White's (White, 1991), (Case B) with Equation 3 in the

following (Munson et al., 2006), and (Case C) with Equation 4 in the following (Munson et al., 2006).

$$\frac{u_x}{U} = \frac{(y^2 - h^2)}{2 * U * \mu} \left(\frac{\partial p}{\partial x} \right) - (3)$$

$$\frac{u_x}{U} = \frac{y}{h} - \frac{h^2}{2 * U * \mu} \left(\frac{\partial p}{\partial x} \right) \left(1 - \frac{y}{h} \right) \left(\frac{y}{h} \right) - (4)$$

where u_x is the horizontal velocity value obtained (m/s), U is the freestream velocity (m/s), y is the respective y -distance (m), h is the total vertical height of the domain (m), μ is the dynamic viscosity of the fluid in the domain (kg/m.s), x is the total horizontal distance of the domain (m) and p is the pressure (kg/m.s²). The physical dimensions of the deployed numerical domains and the initial flow conditions for Cases A to C are summarized in Table 1, which includes the respective Reynolds number (Re) based on the characteristic length of the domain. It is worth noting that the resulting Re for Case A is close to that of the Stanford's SU2 Open-source CFD code (Kline, 2017), despite the differences in the adopted hydrodynamic flow conditions, i.e. flow velocity and temperature of domain. The implemented Roe scheme for discretizing the convective flux terms in Equation 1 has also been tailored to handle high speed flows in the recent references [Kermani and Plett, 2001].

It can be observed from Figures 6a to 6c that there is a very good agreement between the numerical predictions and respective analytical solutions for the test cases. However, minor differences can still be observed between the two at locations with the largest changes in the velocity gradient, which suggest that the grid sizes still need to be refined at these locations to achieve a higher resolution. An extension of the total simulation run time would also be useful to improve on the accuracy of the numerical values attained.

By using the speedup parameter in Equation 5, the parallelism performance of UPC was compared with that of OpenMP and MPI at their basic designs in a SGI UV-2000 server for Cases A and B of ultra-large numerical domains. The physical dimensions of the deployed numerical domains with its initial conditions for performance evaluation are summarized in Table 2.

$$S(N) = \frac{T(N)}{T_1(N)} - (5)$$

where $T(N)$ is the run time of the parallel algorithm, and $T_1(N)$ is the run time of the model which employs a singular core. The configuration of the SG UV-2000 server is summarized in Table 3.

Comparison of the speedup performance for Cases A and B is summarized in Tables 4 and 5 respectively. Generally, UPC, OpenMP and MPI achieved efficient speedup up to 16 computer cores, which is the number of cores allocated to singular node in SGI server. For a relatively small number of cores deployed, the comparable speedup performance can be ascribed to the following reasons: (a) both UPC and OpenMP exploit the advantages of data locality for reading and writing directly to the local memory Section without incurring any delays, and (b) the amount of time for MPI to query and retrieve the data with the required messages is trivial for the relatively small number of cores. However, beyond 16 and up to 100 cores maximum in this study, UPC and MPI outperformed OpenMP significantly as

shown Figures 7 and 8. UPC's speedup was most significant by having a close ratio of 1:1, and reached nearly 90 times speedup for Cases A and B up to the 100 cores maximum. The observed trend in UPC's speedup demonstrates the potential for further speedup if additional cores are available for allocation.

On the contrary, OpenMP achieved a less-ideal speedup from 16 cores beyond as demonstrated in Figures 7 and 8, which could be attested to its over-accessing to the shared-memory component. The SGI server enables applications to access all available memory in a unified manner via a virtual shared-memory block. However, the memory sections are still physically located in the different nodes which are connected to one another via network cables. Unavoidably, the access to the shared-memory section in OpenMP architecture is subjected to communication delay during the parallelism with multiple nodes. The less than ideal performance of OpenMP indicates its general unsuitability for CHD simulations of ultra-large numerical domains.

Despite having a slower speedup than that of UPC, MPI achieved relatively significant speedup for Cases A and B for the number of cores beyond 16. The distinction of the speedup between Cases A and B is likely ascribed to the obvious difference in the number of computational grids deployed, i.e. 25 million grids for Case A and 100 million grids for Case B, which affected the size of each message to be transmitted within the system. For instance, when running with 32 cores, MPI achieved a speedup of 26.7 and 22.5 for Case A and B respectively. With the MPI architecture, thread T_i transmits multiple messages to the neighboring threads at every time-step which include: (a) velocity data values in x- and y-direction corresponding to thread T_{i-1} and T_{i+1} , (b) convective fluxes data values in x- and y-direction, and (c) updated data to the main thread. At the maximum 100 cores in this study, over 900 messages were processed in the system at each iterative step, despite having only 100 rows of data to be computed for each core. The respective difference of the message size to be transmitted in Case A and B resulted in different processing time for each message. Thus, it was possible that the total message processing time outweighed the actual computational time on each core in this study, which restricted the continual speedup with an increasing number of cores.

UPC-CHD has been designed to avoid the performance penalty due to over-accessing the global memory, which enabled the model to maintain a stable performance on varying sizes of the numerical domain as compared to that of MPI. The advantage of embedded locality consciousness of UPC was further investigated in Case C by examining the impact of affinity on its performance. The computational data of the domain was first stored in-block to gain the memory locality properties, while the global memory accessing activities were overlapped with remote control technique using the split-phase barrier to conceal the synchronization cost. We then evaluated the performance of UPC for Case C under two scenarios: (a) UPC-A, i.e. UPC with optimizations, and (b) UPC-NA, i.e. UPC without optimizations and employs the defaults setting of the GPAS compilers.

UPC-NA's performance was vividly inferior to that of UPC-A's as shown in Figure 9. For instance, at 16 cores, the speedup attained was 15.8 and 4.3 for UPC-A and UPC-NA, respectively. A detailed comparison of the speedup between UPC-A and UPC-NA at the varying number of cores for Case C is summarized in Table 6. The distinction of the attained speedup between UPC-A and UPC-NA can be further inferred from Figure 10, which involves a 3 x 3 numerical domain example having an affinity block of 3. In UPC-NA of

Figure 10, thread 0 contains the fluxes data of element a, d and g in its local memory section whereas in UPC-A, thread 0 contains the fluxes data of element a, b and c in its local memory section. The observed performance inferiority of UPC-NA can be attested to the need for thread 0 to function with non-affinity data, i.e. element b in thread 1 and element c in thread 2, which resulted in longer computational run time for UPC-NA. With 1 core, there was only a singular thread which computed the fluxes in the entire numerical domain and only worked with data having affinity with. With increasing number of cores, the latency issue arose which resulted in less than ideal computational performance. For instance, at 2 and 4 cores respectively, 50% and 25% of the total runtime was attributed to accessing of the non-affinity data by the respective threads. While the addition of cores would reduce the amount of global accessing activity in UPC-NA, optimization is still unlikely to be achieved as observed in Figure 9. Thus, it is recommended to distribute the array of data in contiguous blocks as in UPC-A, which each of the threads attends to a system of elements dependent on the number of available threads in the system. In other words, the implementation of UPC architecture without any affinity optimization is likely to be not recommended notwithstanding its potential advantage in parallelism performance as compared to OpenMP and MPI.

5. Conclusion

A model, termed as UPC-CHD, was developed on the working architecture of PGAS-UPC coupled with the traditional 2-step explicit scheme from the Lax-Wendroff family of predictors-correctors. The accuracy of the implemented numerical scheme in UPC-CHD was first examined on three incompressible, viscous flow cases having moderate flow velocities under laminar conditions. The parallelism performance of UPC-CHD was then evaluated by comparing the total computational runtime with that of MPI and OpenMP at their basic designs on a SGI UV-2000 server. UPC performed better than MPI and OpenMP at their basic designs, with a near 1:1 speedup till 100 cores available in this study. The efficient parallelism performance achieved by UPC-CHD demonstrates its capability to exploit data locality and adopt affinity optimization to ensure maximization of the parallelism performance.

Due to the exploratory nature of this study, we have confined the scope to classical numerical schemes and flow cases having moderate flow velocities under laminar conditions. In order that the model can be useful for practical engineering applications, improvements such as implicit schemes for stability with larger time steps, turbulent flow modelling and unstructured numerical meshes, etc, need to be sought. Nonetheless, we are hopeful that with the further improvement, the model can serve as a viable alternative for large-scale CHD simulations in the future.

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Appendix A

Considering a representative control volume of a single node in Figure 1, Equation 2 is discretized over the control volume (Kermani and Plett, 2001) as shown in Equation A.1. All other nodes within the numerical domain undergo the same discretization procedure.

$$\frac{\partial \bar{Q}}{\partial t} + \frac{F_E - F_W}{\Delta x} + \frac{G_N - G_S}{\Delta y} = \frac{G_{Vx,E} - G_{Vx,W}}{\Delta x} + \frac{G_{Vy,N} - G_{Vy,S}}{\Delta y} \quad (\text{A.1})$$

where $\partial \bar{Q}$ is the discretized form of Q which is defined as either $(Q^{n+\frac{1}{2}} - Q^n)$ for the predictor step, or $(Q^{n+1} - Q^n)$ for the corrector step.

The temporal term in Equation A.1 undergoes the 2-step explicit scheme from the Lax-Wendroff family of predictors-correctors. The predictor step computes the flow condition at the half-time step as shown in Equation A.2, whereas the corrector step follows by central differencing with time at the full-time step in Equation A.3. For the respective computations at the half- and full time step, the convective and viscous fluxes are first computed before computing for $Q^{n+1/2}$ and Q^{n+1} .

$$\frac{Q^{n+1/2} - Q^n}{\Delta t/2} + \left(\frac{F_E - F_W}{\Delta x}\right)^n + \left(\frac{G_N - G_S}{\Delta y}\right)^n = \left(\frac{G_{Vx,E} - G_{Vx,W}}{\Delta x}\right)^n + \left(\frac{G_{Vy,N} - G_{Vy,S}}{\Delta y}\right)^n \quad (\text{A.2})$$

$$\begin{aligned} \frac{Q^{n+1} - Q^n}{\Delta t} + \left(\frac{F_E - F_W}{\Delta x}\right)^{n+\frac{1}{2}} + \left(\frac{G_N - G_S}{\Delta y}\right)^{n+\frac{1}{2}} \\ = \left(\frac{G_{Vx,E} - G_{Vx,W}}{\Delta x}\right)^{n+\frac{1}{2}} + \left(\frac{G_{Vy,N} - G_{Vy,S}}{\Delta y}\right)^{n+\frac{1}{2}} \end{aligned} \quad (\text{A.3})$$

The convective fluxes (F and G) in Equation 4 are computed by the Roe scheme which is represented by Equation A.4 and A.5 respectively (Kermani and Plett, 2001 and Toro, 2006). The computed F_E at node (j, k) equates to F_W of node $(j+1, k)$, and the computed G_N at node (j, k) equates to G_S of node $(j, k-1)$.

$$F_E = 0.5[F_E^L + F_E^R] - 0.5 \sum_{k=1}^4 |\hat{\lambda}_E^k| \delta w_E^{(k)} \hat{T}_E^k \quad (\text{A.4})$$

$$G_N = 0.5[G_N^L + G_N^R] - 0.5 \sum_{k=1}^4 |\hat{\lambda}_N^k| \delta w_N^{(k)} \hat{T}_N^k \quad (\text{A.5})$$

where F_E^L and F_E^R are the inner and outer values of F computed at the east face, G_N^L and G_N^R are the inner and outer values of G computed at the north face, $\hat{\lambda}_E^k$ and $\hat{\lambda}_N^k$ are the respective eigenvalues of the Jacobian matrix determined at the Roe's averaged condition, \hat{T}_E^k and \hat{T}_N^k are the respective eigenvectors corresponding to the determined eigenvalues, and both $\delta w_E^{(k)}$ and $\delta w_N^{(k)}$ are the respective wave amplitudes.

To compute the eigenvalues, corresponding eigenvectors and wave amplitudes of both F and G, similar computational procedures are undertaken. Here, only the computations for the required parameters of F are shown for brevity. For further details, the reader is referred to references (Kermani and Plett, 2001 and Toro, 2006).

For each of the nodes within the numerical domain, the left (L) and right (R) flow conditions are first computed by Equation A.6 and A.7 respectively based on the 3rd order upwind-biased algorithm (Kermani and Plett, 2001).

$$q_E^L = q_{j,k} + 0.25 \left[\left(\frac{2}{3} \right) (q_{j,k} - q_{j-1,k}) + \left(\frac{4}{3} \right) (q_{j+1,k} - q_{j,k}) \right] \quad (\text{A. 6})$$

$$q_E^R = q_{j+1,k} - 0.25 \left[\left(\frac{2}{3} \right) (q_{j+2,k} - q_{j+1,k}) + \left(\frac{4}{3} \right) (q_{j+1,k} - q_{j,k}) \right] \quad (\text{A. 7})$$

where q represents the primitive variables (u, v).

Following which, the Roe's averaged conditions are determined in Equations A.8 to 11 (Kermani and Plett, 2001 and Toro, 2006). Since the fluid is incompressible, no averaged condition is computed for the density (ρ) parameter.

$$\widehat{u}_E = \frac{\sqrt{\rho_W} u_E^R + \sqrt{\rho_W} u_E^L}{2\sqrt{\rho_W}} \quad (\text{A. 8})$$

$$\widehat{v}_E = \frac{\sqrt{\rho_W} v_E^R + \sqrt{\rho_W} v_E^L}{2\sqrt{\rho_W}} \quad (\text{A. 9})$$

$$\widehat{H}_E = \frac{\sqrt{\rho_W} H_E^R + \sqrt{\rho_W} H_E^L}{2\sqrt{\rho_W}} \quad (\text{A. 10})$$

$$\widehat{c}_E = \sqrt{(\gamma - 1)(\widehat{H}_E - 0.5(\widehat{u}_E^2 + \widehat{v}_E^2))} \quad (\text{A. 11})$$

where \widehat{u}_E , \widehat{v}_E , \widehat{H}_E and \widehat{c}_E are the Roe averaged conditions, $\gamma = 1.33$ for the ratio of specific heats applied to water and $\rho_W = 1000 \text{kgm}^{-3}$ for the density of water.

With the computed Roe's averaged conditions from Equations A.8 to A.11, the values of $\widehat{\lambda}_E^k$, \widehat{T}_E^k and $\delta w_E^{(k)}$ are then computed in the following (Kermani and Plett, 2001).

$$\begin{bmatrix} \widehat{\lambda}_E^1 \\ \widehat{\lambda}_E^2 \\ \widehat{\lambda}_E^3 \\ \widehat{\lambda}_E^4 \end{bmatrix} = \begin{bmatrix} \widehat{u}_{\perp E} - \widehat{c}_E \\ \widehat{u}_{\perp E} \\ \widehat{u}_{\perp E} \\ \widehat{u}_{\perp E} + \widehat{c}_E \end{bmatrix} \quad (\text{A. 12})$$

$$\begin{bmatrix} \delta w_E^{(1)} \\ \delta w_E^{(2)} \\ \delta w_E^{(3)} \\ \delta w_E^{(4)} \end{bmatrix} = \begin{bmatrix} \frac{\delta_{PE} - \rho_W \delta_{u \perp E} \hat{c}_E}{2 \hat{c}_E^2} \\ \rho_W \delta u_{||E} \\ -\frac{\delta_{PE} - \hat{c}_E^2 \delta_{\rho E}}{\hat{c}_E^2} \\ \frac{\delta_{PE} + \rho_W \delta_{u \perp E} \hat{c}_E}{2 \hat{c}_E^2} \end{bmatrix} \quad (A.13)$$

$$T_E^{(1)} = \begin{bmatrix} 1 \\ \hat{u}_E - \hat{c}_E \cos \theta_E \\ \hat{v}_E - \hat{c}_E \sin \theta_E \\ \hat{H}_E - \hat{u}_{\perp E} \hat{c}_E \end{bmatrix}, T_E^{(2)} = \begin{bmatrix} 0 \\ -\sin \theta_E \\ \cos \theta_E \\ u_{||E} \end{bmatrix}, T_E^{(3)} = \begin{bmatrix} 1 \\ \hat{u}_E \\ \hat{v}_E \\ \frac{\hat{u}_E^2 + \hat{v}_E^2}{2} \end{bmatrix}, T_E^{(4)} = \begin{bmatrix} 1 \\ \hat{u}_E + \hat{c}_E \cos \theta_E \\ \hat{v}_E + \hat{c}_E \sin \theta_E \\ \hat{H}_E + \hat{u}_{\perp E} \hat{c}_E \end{bmatrix} \quad (A.14)$$

where $\delta_{PE} = p_{j+1,k} - p_{j,k}$, $\delta u_{||E} = u_{||j+1,k} - u_{||j,k}$, $\delta_{\rho E} = \rho_{j+1,k} - \rho_{j,k}$, $\delta_{u \perp E} = u_{\perp j,k+1} - u_{\perp j,k}$ and $u_{||E}^2 = \vec{V}_E \cdot \vec{V}_E - u_{\perp E}^2$.

Lastly, the viscous terms (G_{Vx} and G_{Vy}) in Equation 3 can be discretized using the 2nd order central differencing scheme (Kermani and Plett, 2001) as shown.

$$\frac{G_{Vx,E} - G_{Vx,W}}{\Delta x} = \frac{G_{(i+1,j)} - 2G_{(i,j)} + G_{(i-1,j)}}{(\Delta x)^2} \quad (A.15)$$

$$\frac{G_{Vy,N} - G_{Vy,S}}{\Delta y} = \frac{G_{(i,j+1)} - 2G_{(i,j)} + G_{(i,j-1)}}{(\Delta y)^2} \quad (A.16)$$

Appendix B

Algorithm 3.1 Computational structure of UPC-CFD model

- 1: set $t \leftarrow 0$
- 2: assign initial values to $\vec{u}, p, T, \rho, \dots$
- 3: **while** $t < t_{end}$ **do**
- 4: **for** each row of the 2D domain
- 5: **for** each column of the 2D domain
- 6: compute the convective fluxes at the half-time step with linear approximation of ROE scheme
- 7: compute the ROE's averaged condition, eigenvalues of the Jacobian matrix, wave amplitudes and the eigenvector of the Jacobian matrix for each node
- 8: compute the inner and outer values of the convective fluxes for each node
- 9: compute the viscous term using 2nd order central differencing scheme

```

10:     repeat the process and update the velocity for full-time step
11:   end for
12: end for
13:   set  $t \leftarrow t + \Delta t$ 
14: end while

```

Appendix C

Algorithm 3.2

```

1:  upc_forall ( $t = 0$ ;  $t < \text{THREADS}$ ;  $++t$ ;  $t$ )
2:    for each row from  $thread_{start}(t)$  to  $thread_{end}(t)$ 
3:      for each column of the 2D domain
4:        compute the ROE's averaged condition
5:        compute eigenvalues of the Jacobian matrix
6:        compute wave amplitudes
7:        compute the eigenvector of the Jacobian matrix
8:      end for
9:    end for
10: end upc_forall

```

References

- [1]. Appleyard, J. and Drikakis, D. (2011), "Higher-order CFD and interface tracking methods on highly-Parallel MPI and GPU systems," *Computers & Fluids*, vol. 46 (1), pp. 101-105.
- [2]. Anderson, J. D. (2009), "Governing Equations of Fluid Dynamics," In J. F. Wendt (Ed.), *Computational Fluid Dynamics*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 15 - 51.
- [3]. Berger, M. J., Aftosmis, M. J., Marshall, D. D., Murman, S. M. (2005), "Performance of a new CFD flow solver using a hybrid programming paradigm," *Journal of Parallel and Distributed Computing*, vol. 65 (4), pp. 414-423.

- [4]. Brandvik, T, and Pullan, G. (2008), "Acceleration of a 3D Euler Solver Using Commodity Graphics Hardware," in *46th AIAA Aerospace Sciences Meeting and Exhibit*, American Institute of Aeronautics and Astronautics.
- [5]. Bucs, S. S., Radu, A. I., Lavric, V., Vrouwenvelder, J. S. , and Picioreanu, C. (2014), "Effect of different commercial feed spacers on biofouling of reverse osmosis membrane systems: A numerical study," *Desalination*, vol. 343, pp. 26-37.
- [6]. Djomehri, M. J., Jin, H.H. (2002), "Hybrid MPI+OpenMP Programming of an Overset CFD Solver and Performance Investigations," NASA Ames Research Center, Moffett Field, CA United States, Tech. Rep.
- [7]. El-Ghazawi, T. A., Carlson, W., Sterling, Yelick. T. K. (2005), "UPC: Distributed Shared Memory Programming," John Wiley and Sons, ISBN: 0-471022048-5.
- [8]. Frisch, J. (2014), "Towards Massive Parallel Fluid Flow Simulations in Computational Engineering", (Doctoral dissertation). Retrieved from the Technical University Munich database. (ISBN: 978-3-8440-3164-5)
- [9]. Giovannini, M., Marconcini, M., Arnone, A. (2015), " A Hybrid Parallelization Strategy of a CFD Code for Turbomachinery Applications," in 11th European Conference on Turbomachinery Fluid dynamics & Thermodynamics, Madrid Spain.
- [10]. Gourdain, N., Gicquel, L., Montagnac, M., Vermorel, O., Gazaix, M., Staffelbach, G. (2009), "High performance parallel computing of flows in complex geometries: I. Methods," *Computational Science & Discovery*, vol. 2 (1), p. 015003.
- [11]. Heather, Kline. "Su2code/SU2." *GitHub*. SU2/Open-source CFD Code, 13 Jan. 2017. Web. 31 Mar. 2017.
- [12]. Jajcevic, D., Siegmund, E., Radeke, C., and Khinast, J. G. (2013), "Large-scale CFD–DEM simulations of fluidized granular systems," *Chemical Engineering Science*, vol. 98, pp. 298-310.
- [13]. Jamshed, S. (2015), "Chapter 3 - The Way the HPC Works in CFD," in *Using HPC for Computational Fluid Dynamics*, ed Oxford: Academic Press, pp. 41-79.
- [14]. Johnson, A.A. (2006), "Using Unified Parallel C to Enable New Types of CFD Applications on the Cray X1/E", Cray User Group Conference.
- [15]. Kermani, M. and Plett, E. (2001), "Roe scheme in generalized coordinates. I - Formulations," in *39th Aerospace Sciences Meeting and Exhibit*, ed: American Institute of Aeronautics and Astronautics.
- [16]. Kermani, M. and Plett, E. (2001), "Roe scheme in generalized coordinates. II - Application to inviscid and viscous flows," in *39th Aerospace Sciences Meeting and Exhibit*, ed: American Institute of Aeronautics and Astronautics.
- [17]. Kuo, F. A., Smith, M. R., Hsieh, C. W., Chou, C. Y., and Wu, J. S. (2011), "GPU acceleration for general conservation equations and its application to several engineering problems," *Computers & Fluids*, vol. 45 (1), pp. 147-154.
- [18]. Li, Y .L., Lin, P. J., Tung, K. L. (2011), "CFD analysis of fluid flow through a spacer-filled disk-type membrane module," *Desalination*, vol. 283, pp. 140-147.
- [19]. Munson, B. R., Young, D. F., & Okiishi, T. H. (2006). *Fundamentals of fluid mechanics*. 6th Ed., Hoboken, NJ: J. Wiley & Sons, ch. 6. pp. 263-331
- [20]. Niemeyer, K. E., and Sung, C. J. (2014), "Recent progress and challenges in exploiting graphics processors in computational fluid dynamics," *The Journal of Supercomputing*, vol. 67 (2), pp. 528-564.

- [21]. Rabenseifner, R., Hager, G., & Jost, G. (2009), "Hybrid MPI/OpenMP Parallel Programming on Clusters of Multi-Core SMP Nodes," *Proceedings, 17th Euromicro International Conference on Parallel, Distributed and Network-based Processing*, Weimar, Germany.
- [22]. Rabenseifner, R., Hager, G., Jost, G., & Keller, R. (2006), "Hybrid MPI and OpenMP Parallel Programming. In B. Mohr, J. L. Träff, J. Worringer, & J. Dongarra (Eds.)," *Recent Advances in Parallel Virtual Machine and Message Passing Interface: 13th European PVM/MPI User's Group Meeting*, Bonn, Germany, September 17-20.
- [23]. Salvatore, F., Bernardini, M. and Botti, M. (2013), "GPU accelerated flow solver for direct numerical simulation of turbulent flows," *Journal of Computational Physics*, vol. 235, pp. 129-142.
- [24]. Schalkwijk, J., Griffith, E. J., Post, F. H., and Jonker, H. J. J. (2012), "High-Performance Simulations of Turbulent Clouds on a Desktop PC: Exploiting the GPU," *Bulletin of the American Meteorological Society*, vol. 93, pp. 307-314.
- [25]. Simmendinger, C., Jägersküpper, J., Machado, R., Lojewski, C. (2011), "A PGAS-based Implementation for the Unstructured CFD Solver TAU", Partitioned Global Address Space Programming Models, Galveston Island.
- [26]. Sobieski, W. and Zhang, Q. (2017), "Multi-scale modeling of flow resistance in granular porous media," *Mathematics and Computers in Simulation*, vol. 132, pp. 159-171.
- [27]. Sousa, P., Soares, A., Monteiro, E., and Rouboa, A. (2014), "A CFD study of the hydrodynamics in a desalination membrane filled with spacers," *Desalination*, vol. 349, pp. 22-30, 2014.
- [28]. Toro, E. F. (2009), "The Riemann Solver of Roe," in *Riemann Solvers and Numerical Methods for Fluid Dynamics: A Practical Introduction*, ed Berlin, Heidelberg: Springer Berlin Heidelberg, ch. 11, pp. 345-376.
- [29]. White, F. M. (1991), *Viscous Fluid Flow*, 2nd Ed., McGraw-Hill, ch. 7, pp. 457-528.
- [30]. Yilmaz, E., Payli, R. U., Akay, H. U., and Ecer, A. (2009), "Hybrid Parallelism for CFD Simulations: Combining MPI with OpenMP," in *Parallel Computational Fluid Dynamics 2007: Implementations and Experiences on Large Scale and Grid Computing*, ed Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 401-408.

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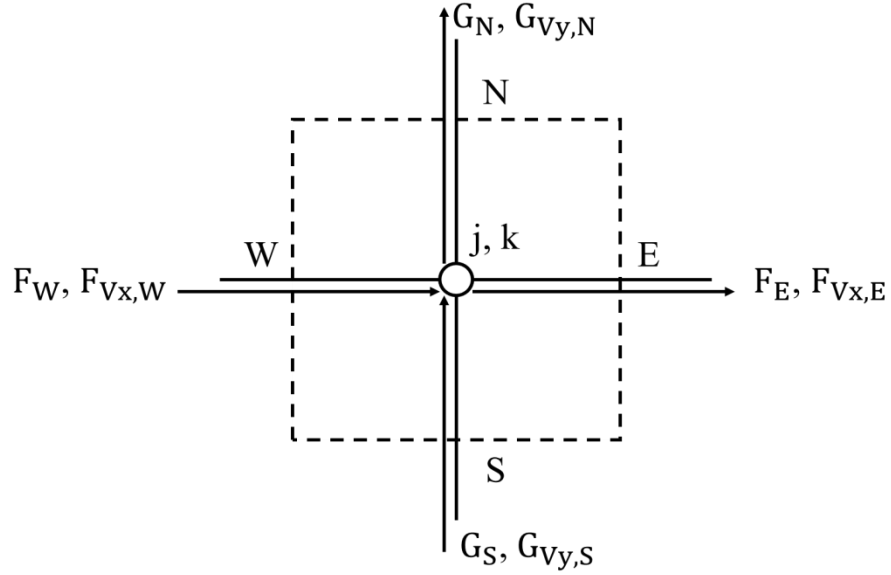


Figure 1: Representative control volume of a single node for discretizing Equation 1

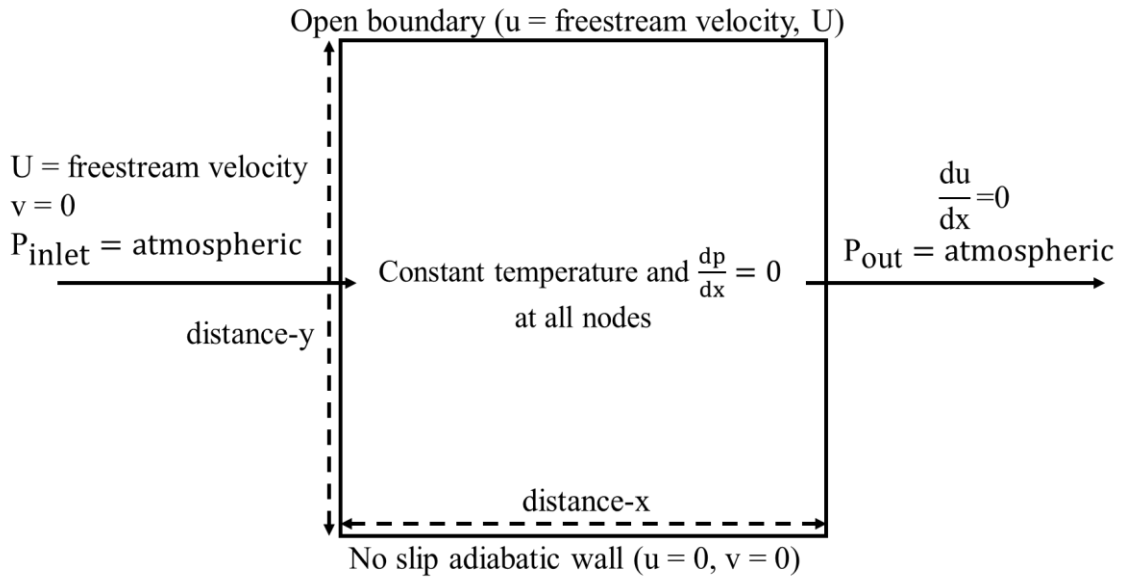


Figure 2a: Numerical domain for Blasius boundary layer flow (Case A)

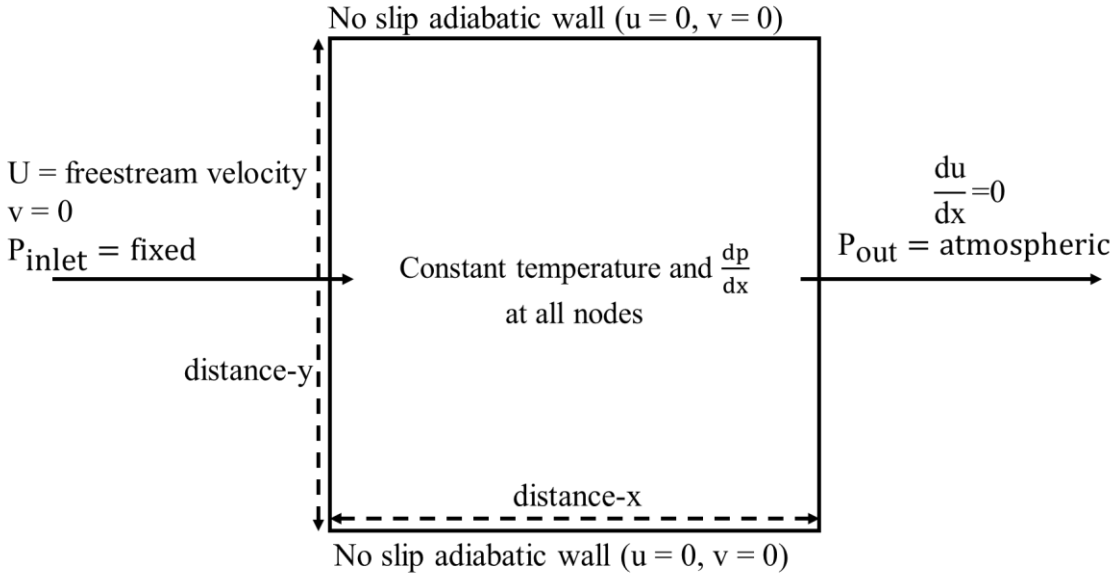


Figure 2b: Numerical domain for Poiseuille's flow (Case B)

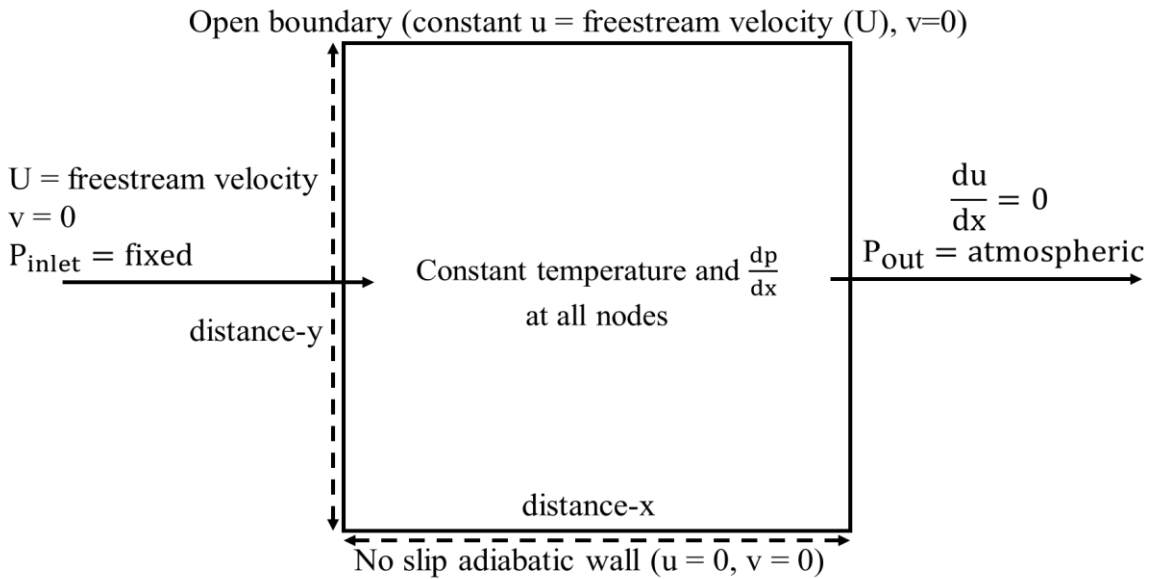


Figure 2c: Numerical domain for Couette's flow (Case C)

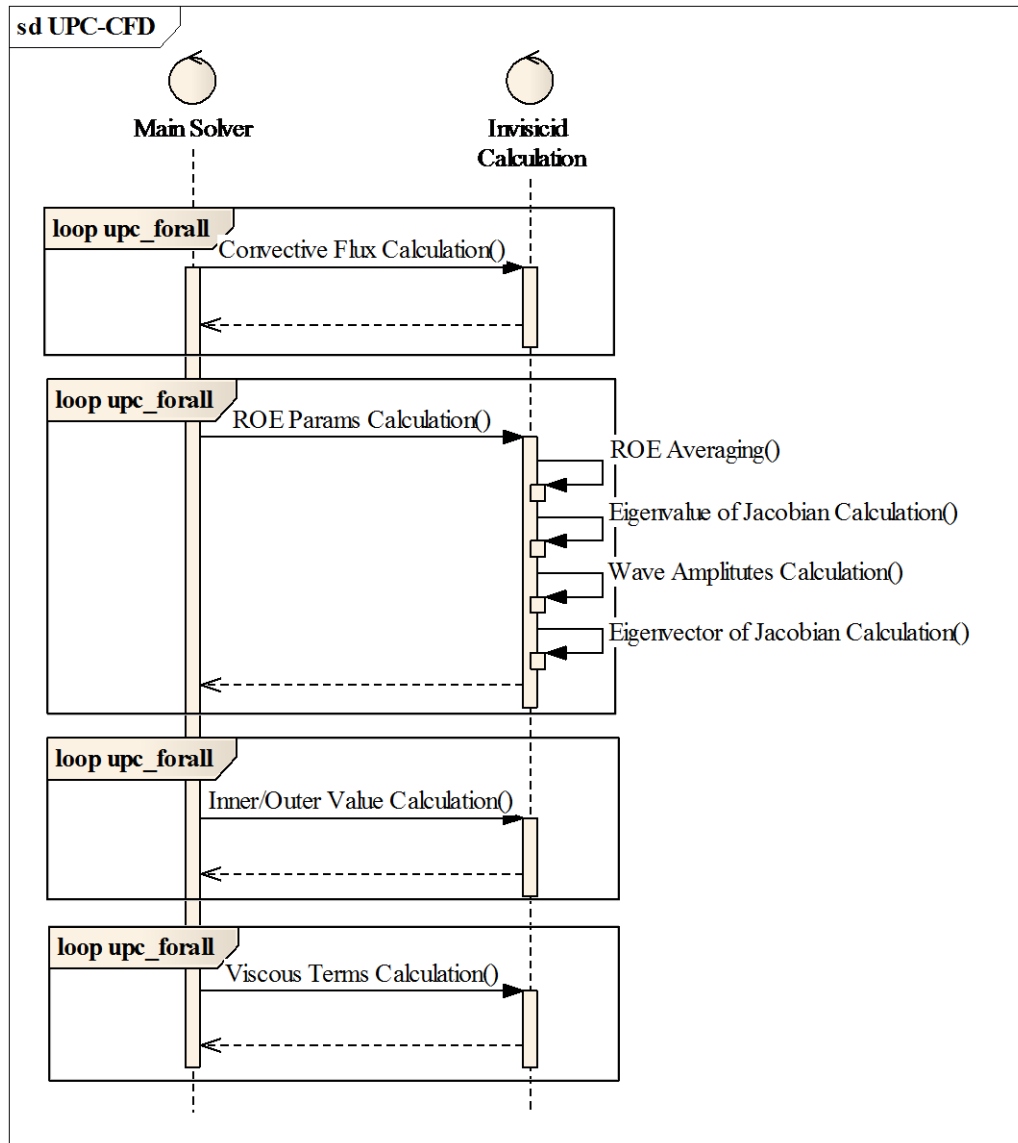


Figure 3: Parallel computational structure for sub-loops of UPC-CHD

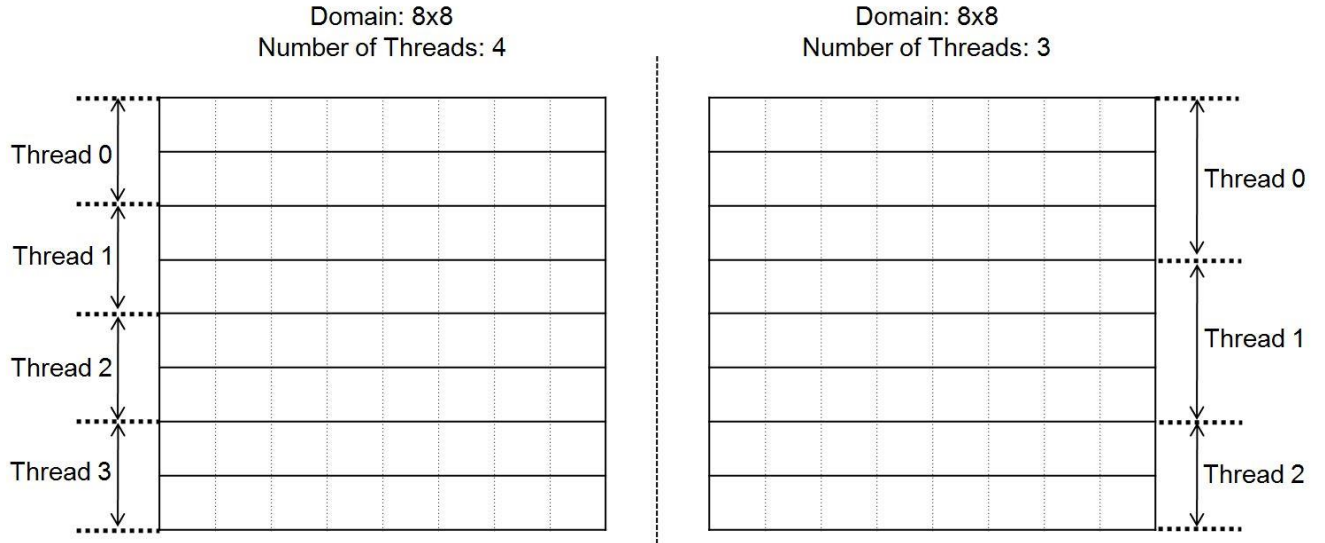


Figure 4: Domain decomposition algorithm for a 8 x 8 numerical domain example with (left) 4 threads and (right) 3 threads

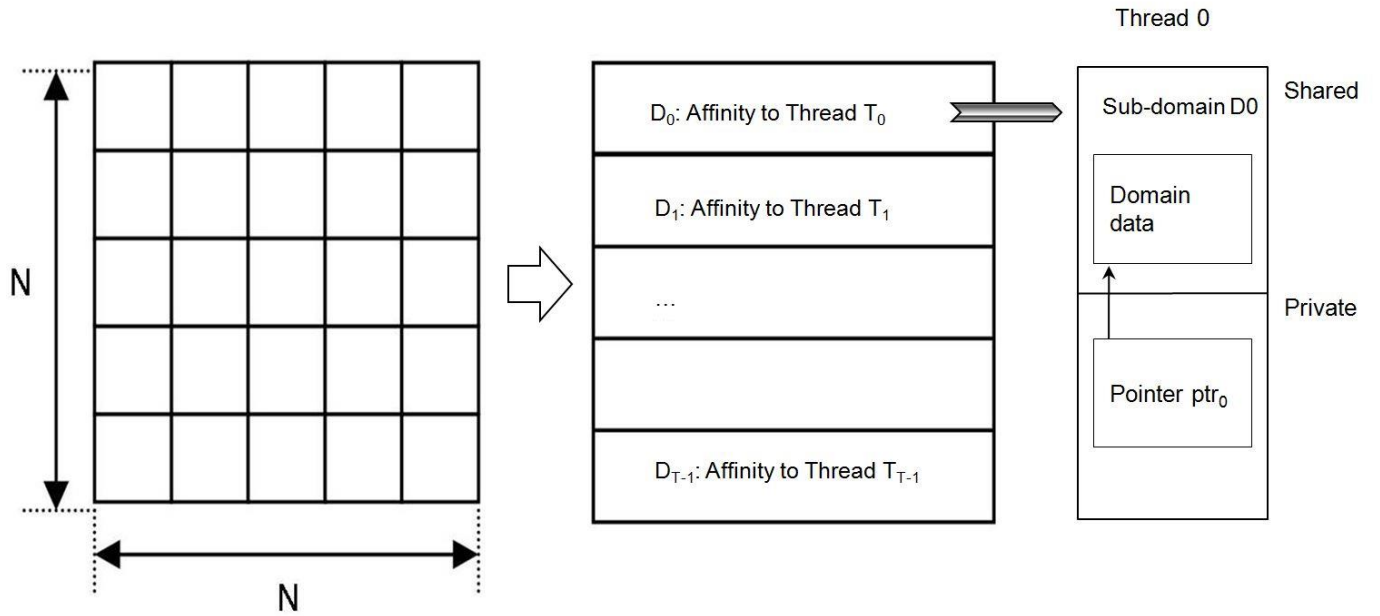


Figure 5: Sub-domains division and data storage algorithm for a $n \times n$ numerical domain example

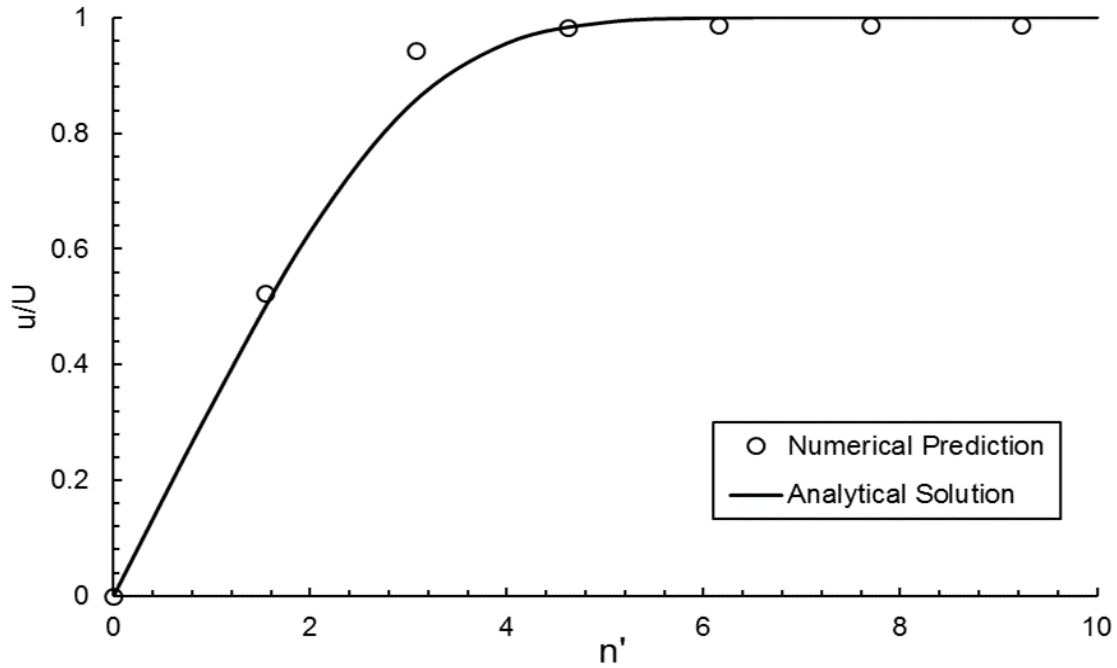


Figure 6a: Comparison between numerical predictions and analytical solutions for Blasius boundary layer flow at location $x = 0.2\text{m}$ (Case A)

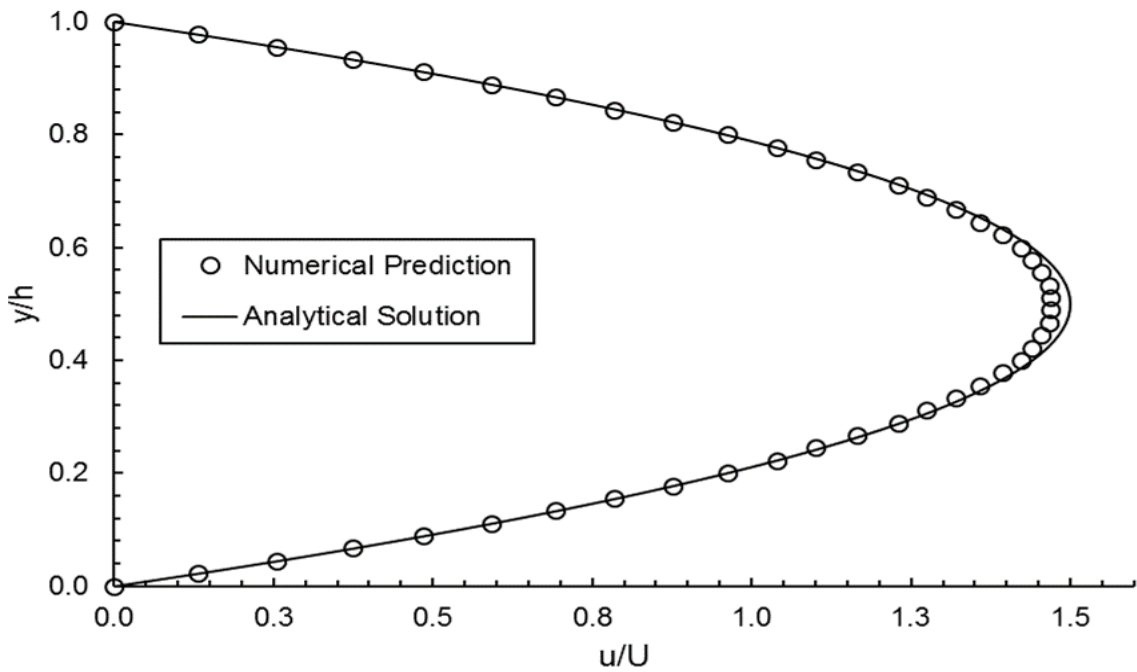


Figure 6b: Comparison between numerical predictions and analytical solutions for Poiseuille's flow at location $x = 0.5\text{m}$ (Case B)

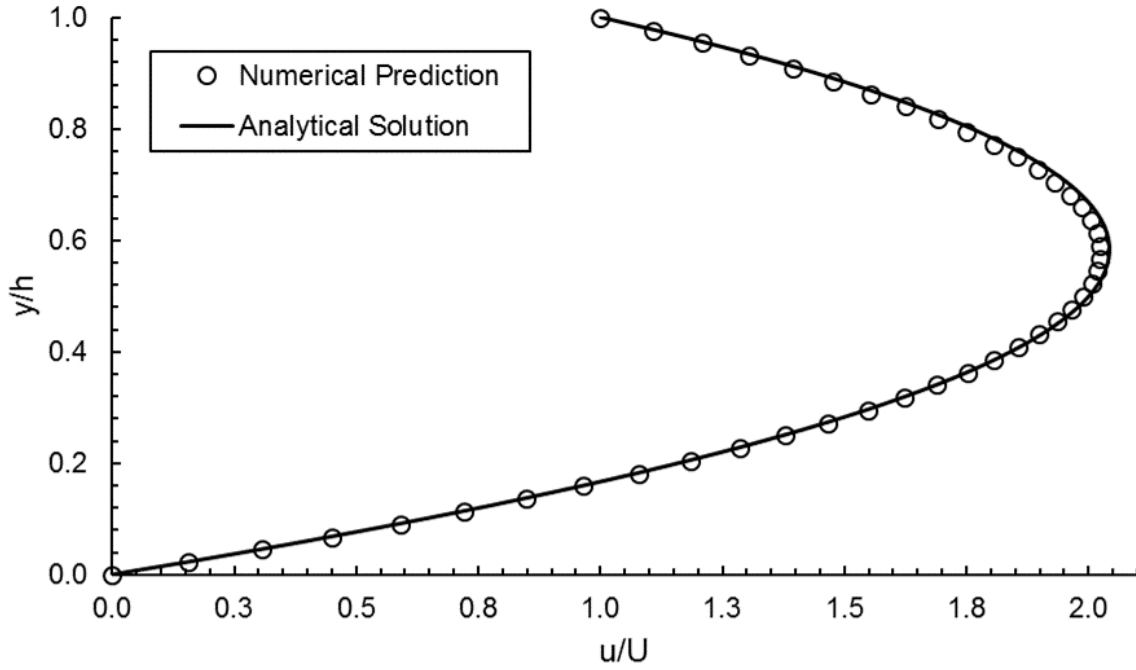


Figure 6c: Comparison between numerical predictions and analytical solutions for Couette's flow at location $x = 0.5m$ (Case C)

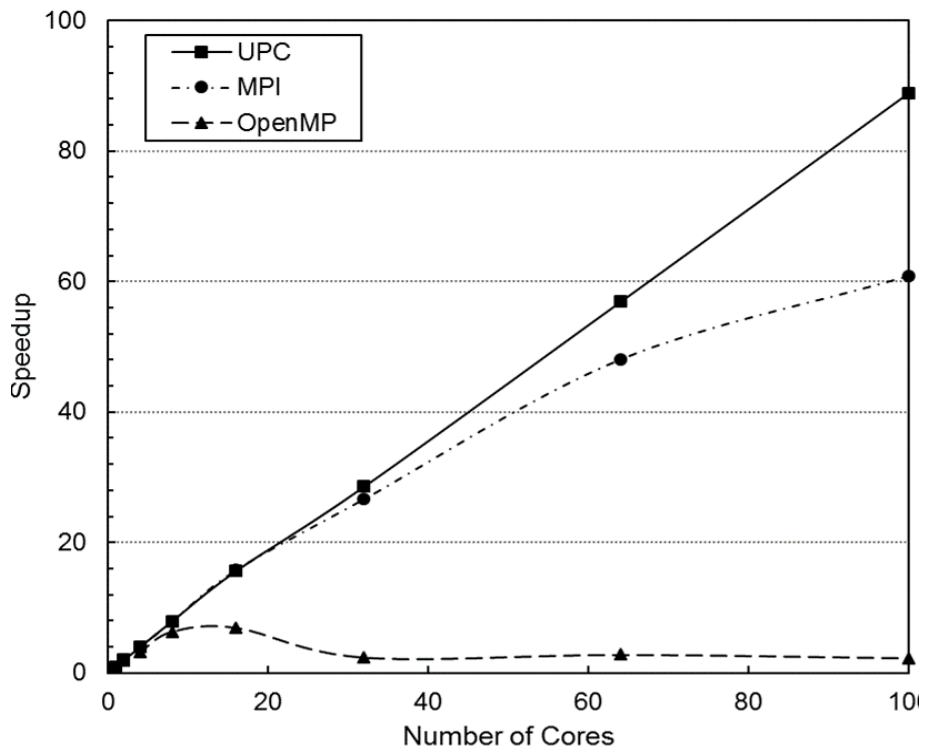


Figure 7: Comparison of speedup among OpenMP, MPI and UPC for Blasius boundary layer flow (Case A) at varying number of computer core

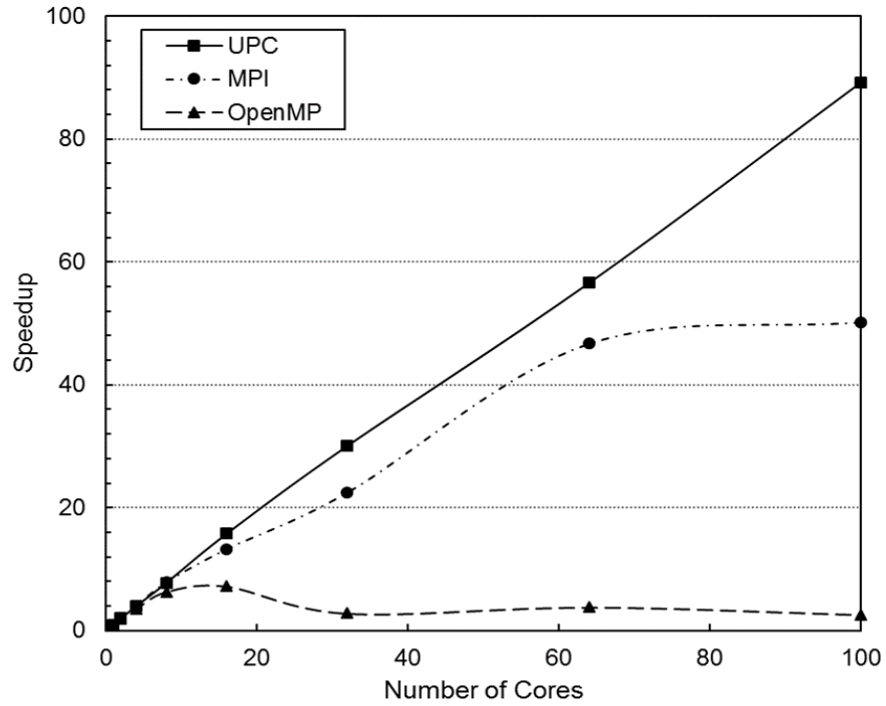


Figure 8: Comparison of speedup among OpenMP, MPI and UPC for Poiseuille's flow (Case B) at varying number of computer cores

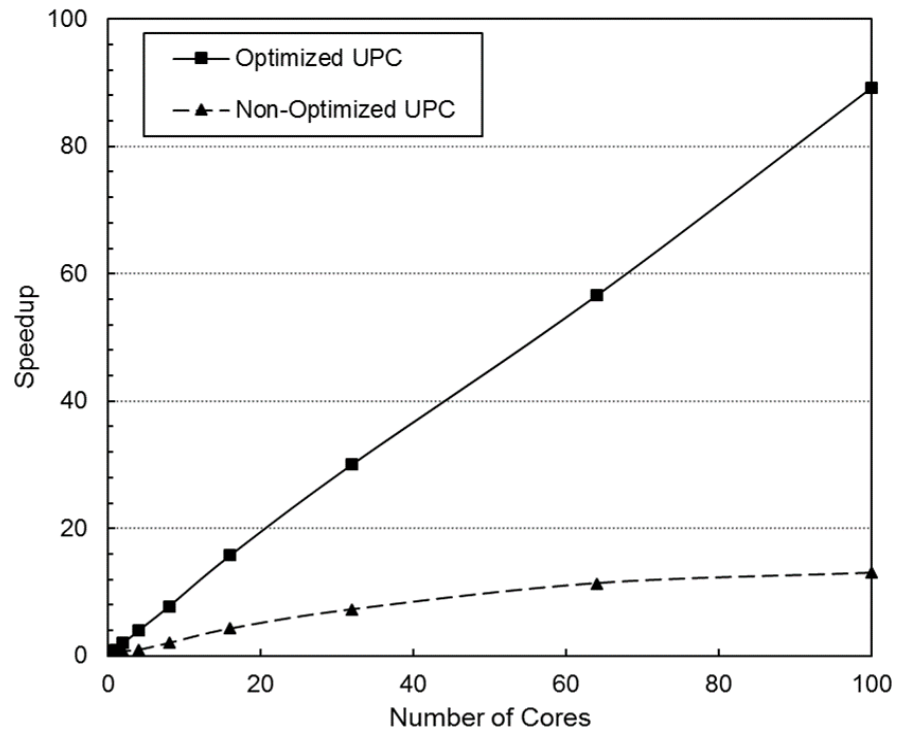


Figure 9: Comparison of speedup between optimized UPC and non-optimized UPC for Couette's flow (Case C) at varying number of computer cores

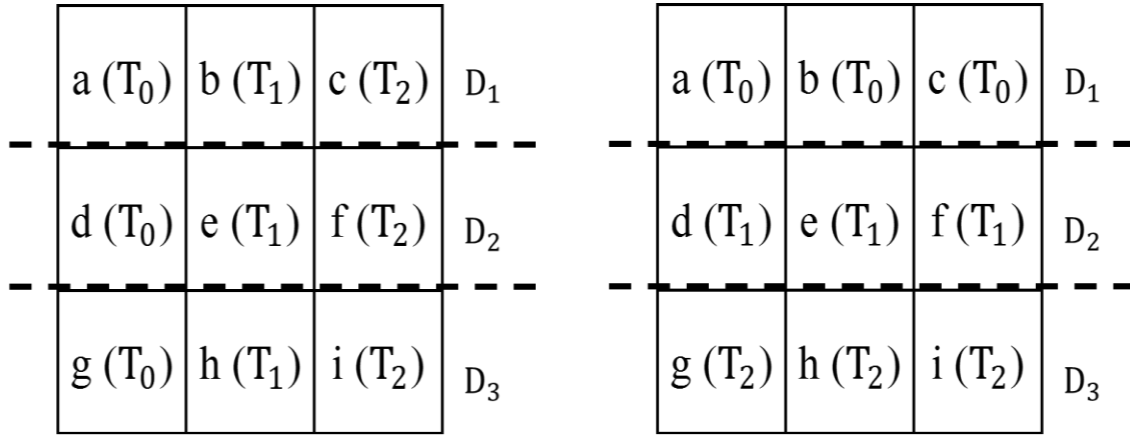


Figure 10: Schematic representation of UPC-NA (left) and UPC-A (right) concepts; T_i refers to thread i , D_i refers to domain i .

Tables

Table 1: Physical dimensions and initial conditions of deployed numerical domains for validating implemented numerical cases in UPC-CHD (Cases A to C)

Parameter	Case A	Case B	Case C
Distance-x, x (m)	0.3	0.5	0.5
Distance-y, h (m)	0.02	0.00016	0.00016
No. of nodes	65 x 65	300 x 45	300 x 45
Freestream velocity, U (m/s)	5	10	10
Re	1,500,000	1600	1600
$\frac{dp}{dx} \left(\frac{Pa}{m} \right)$	0	4.70×10^6	4.70×10^6
delta-t (s)	10^{-6}	10^{-6}	10^{-6}
Total runtime (s)	0.01	0.01	0.01
Temperature (K)	293.15	293.15	293.15
Kinematic viscosity (m^2/s)	10^{-6}	10^{-6}	10^{-6}

Table 2: Physical dimensions and initial conditions of deployed numerical domains for evaluating computational parallelism efficiency of UPC, OpenMP and MPI in UPC-CHD (Cases A to C)

Parameter	Case A	Case B	Case C
Distance-x, x (m)	0.3	0.5	0.5
Distance-y, h (m)	0.02	0.00016	0.00016
No. of nodes	5000 x 5000	10000 x 10000	10000 x 10000
Freestream velocity, U (m/s)	5	10	10
Re	1,500,000	1600	1600
$\frac{dp}{dx} \left(\frac{Pa}{m} \right)$	0	4.70×10^6	4.70×10^6
delta-t (s)	10^{-6}	10^{-6}	10^{-6}
Total runtime (s)	0.01	0.01	0.01

Temperature (K)	293.15	293.15	293.15
Kinematic viscosity (m^2/s)	10^{-6}	10^{-6}	10^{-6}

Table 3: SGI UV-2000 cluster used for model testing

Cluster	Node CPUs	CPU speeds (GHz)	Cores per node	Node RAM (TB)	Available nodes	Communication switch
SGI UV-2000	Intel Xeon E5-4657LV	2.4	8	2	10 (up to 100 cores)	InfiniBand Shared-memory

Table 4: Comparison of run-time and speedup among UPC, MPI and OpenMP for Blasius boundary layer flow (Case A) at varying number of computer cores

Number of Cores	UPC		MPI		OpenMP	
	Run time (hours)	Speed-up	Run time (hours)	Speed-up	Run time (hours)	Speed-up
1	132	1.0	133	1.0	135	1.0
2	66	2.0	66	2.0	71	1.9
4	33	4.0	33	4.0	42	3.2
8	17	7.9	17	7.9	21	6.3
16	8	15.7	8	15.8	19	6.9
32	4	28.6	5	26.7	56	2.4
64	2	56.9	3	48.1	48	2.8
100	1.4	88.9	2	60.9	58	2.3

Table 5: Comparison of run-time and speedup among UPC, MPI and OpenMP for Poiseuille's flow (Case B) at varying number of computer cores

Number of Cores	UPC		MPI		OpenMP	
	Run time (hours)	Speed-up	Run time (hours)	Speed-up	Run time (hours)	Speed-up

1	53	1.0	53	1.0	54	1.0
2	26	2.0	27	2.0	28	1.9
4	13	4.0	14	4.0	15	3.5
8	6.8	7.8	7	7.9	8.5	6.3
16	3.5	15.8	4	13.3	7.4	7.2
32	1.8	30.1	2.4	22.5	19	2.8
64	1.1	56.6	1.2	46.7	14	3.8
100	0.5	89.2	1	50.2	20	2.6

Table 6: Comparison of run-time and speedup between UPC-A and UPC-NA for Couette's flow (Case C) at varying number of computer cores

Number of Cores	UPC-A		UPC-NA	
	Run time (hours)	Speed-up	Run time (hours)	Speed-up
1	53	1.0	53	1.0
2	26	2.0	64	0.8
4	13	4.0	56	0.9
8	6.8	7.8	26	2.0
16	3.5	15.8	12	4.3
32	1.8	30.1	7	7.3
64	1.1	56.6	4.6	11.4
100	0.5	89.2	3.9	13.0

DC PROGRAMMING AND DCA FOR POWER MINIMIZATION PROBLEM IN MULTI-USER BEAMFORMING NETWORKS

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Abstract

The beamforming technique is increasingly used in multi-user relay networks for directional signal transmission. The main purpose of this paper is to design beamforming coefficients to minimize the total relay transmitted power under destination Quality-of-Service (QoS) constraints. There are some techniques have been proposed previously to solve the class of these problems such as: *semidefinite relaxation approach (SDR)* and *convex second-order cone programming form (SOCP)*. We propose another method named *Difference of Convex functions Algorithm (DCA)* and evaluate the performance of this approach.

Keywords

Multi-user relay network, transmitted power, *signal-to-interference-plus-noise ratio (SINR)*, DCA.

1. Introduction

In Multi-user wireless relay network, users assist each other in transmitting their data through the network by means of signal relaying. Several relaying strategies have been proposed, including amplify-and-forward (AF), decode-and-forward (DF), and compress-and-forward (CF) relaying schemes. Due to its simplicity, the AF scheme is of especial interest ([10]-[11]). The purpose is to minimize the total relay transmitted power under destination QoS constraints. There are two different approaches proposed formerly. The first one uses the SDR approach to approximate the original non-convex relay beamforming problem by a convex semidefinite programming (SDP) problem. While using this technique can achieve an optimal solution, its complexity is really high. The detail of this technique was introduced in [1]. By contrast, [2] proposed a new approach, that the original non-convex relay beamforming problem can be approximated by a convex SOCP problem. Although this technique shows the efficiency regarding computation, the optimal solution it brings to is not as good as the approach of [1] does.

In this paper, we propose a more efficient approach to distributed peer-to-peer beamforming in multiuser relay networks that is different from the two approaches presented above. By Difference of Convex functions (DC) technique ([5]-[9]), we approximate the original non-convex relay beamforming problem by a series of convex quadratic problems (QP). Our simulation results show that using DCA to solve the problem can achieve the optimal solution as good as using the technique in [1] but in a more considerable time. In addition, DCA gives the much better solution compared to the algorithm SOCP introduced in [2].

2. Signal model

We refer to the signal model built in the paper [2]. A half-duplex relay network including K source-destination pairs and R relays is considered. There is no direct connection between sources and destinations. Instead, the signal is transmitted through relays which can be divided into two stages: the first stage, the sources transmit signals to the relays and the second one, the signal received at the relays is scaled by complex values and transmitted to the destinations. *The objective is to minimize the total relay transmit power (P_t) subject to the destination QoS constraints. The SINR will be used as a measure of QoS.*

$$\begin{aligned} \min_w \quad & P_t \\ \text{s. t.} \quad & \text{SINR}_k \geq \gamma_k, k = 1, 2, \dots, K \end{aligned} \quad (1)$$

The explicit form of the problem (1):

$$\begin{aligned} \min_w \quad & w^H D w \\ \text{s. t.} \quad & \frac{w^H A_k w}{w^H Q_k w + \sigma_\eta^2 w^H D_k w + \sigma_v^2} \geq \gamma_k, k = 1, 2, \dots, K \end{aligned} \quad (2)$$

Notations:

Lowercase and uppercase represent vectors and matrices, respectively. Superscripts $(.)^*$, $(.)^T$, $(.)^H$ stand for complex conjugate, transpose, and Hermitian transpose, respectively. I_R is the identity matrix of size $R \times R$. $\text{tr}(A)$ denotes the trace of matrix A . $\text{diag}(A)$ is a vector which contains the diagonal entries of A and $\text{DIAG}(a)$ denotes a diagonal matrix with the elements of vector a as its diagonal entries. $\|a\|$ denotes the norm of a vector. $[a]_i$ denotes the i -th entry of vector a and $[A]_{i,j}$ denotes the entry at row i -th and column j -th of A . $A \succeq 0$ means that A is a positive semi-definite matrix. $\text{Re}(\cdot)$ extracts the real part of its argument, and $\text{Im}(\cdot)$ is the imaginary part of its argument. $A \odot B$ denotes the Schur-Hadamard matrix product (A, B can also be vectors).

$w = [w_1, w_2, w_3, \dots]^T$ is the relay weight vector

f_k : channel coefficients between the k^{th} source and the relays

g_k : channel coefficients between the relays and the k^{th} destination

σ_η^2 : variance of the relay noise

σ_v^2 : variance of the noise at destinations

p_m : the transmitted power at m^{th} source

γ_k : the minimal required SINR at the k th destination

$$D_k = \text{DIAG}(\text{diag}(g_k^* g_k^T))$$

$$D = \text{DIAG}(\text{diag}(\sum_{m=1}^K p_m f_m f_m^H + \sigma_\eta^2 I.))$$

$$Q_k = \sum_{m \neq k} p_m (g_k \odot f_m)(g_k \odot f_m)^H$$

$$A_k = p_k(g_k \odot f_k)(g_k \odot f_k)^H$$

Some former works have been carried out to minimize the transmitting power of the relays under signal to noise ratio constraints, such as: SOCP or *SDR approach*.

2.1 SOCP

The problem can be expressed as:

$$\begin{aligned} \min_{\tilde{w}} \quad & |V\tilde{w}| \\ \text{s. t.} \quad & \text{Re}\{\tilde{w}^H \tilde{h}_k\} \geq \sqrt{\frac{\gamma_k}{p_k}} \cdot ||U_k \tilde{w}||, k = 1, \dots, K \end{aligned} \quad (3)$$

Where

$$\begin{aligned} \tilde{w} &\triangleq [1, w^T]^T, & \tilde{h}_k &\triangleq [0, (g_k \odot f_k)^T]^T, \\ V &\triangleq \begin{bmatrix} 0 & 0^T \\ 0 & D \end{bmatrix}^{\frac{1}{2}}, & U_k &\triangleq \begin{bmatrix} \sigma_v^2 & 0^T \\ 0 & Q_k + \sigma_\eta^2 D_k \end{bmatrix}^{\frac{1}{2}} \end{aligned}$$

The problem in (3) is convex and belongs to the class of SOCP problems. It can be solved by modeling on Python via CVXPY (a Python library) and using SCS solver.

2.2 SDR

The problem can be restated as the following form:

$$\begin{aligned} \min_X \quad & \text{tr}(DX) \\ \text{s. t.} \quad & \gamma_k \cdot \text{tr}[(Q_k + \sigma_\eta^2 D_k)X] - \text{tr}(A_k X) + \gamma_k \sigma_v^2 \leq 0, k = 1, \dots, K, \\ & \text{rank}(X) = 1, X \succeq 0 \end{aligned} \quad (4)$$

Where $X = w \cdot w^H$

If the rank constraint in the problem (4) is ignored, (4) is convex and belongs to the class of SDP problems. Thus, it can be solved by modeling on Python via CVXPY (a Python library) and using SCS solver as well. However, the obtained solution may not satisfy the rank constraint. Therefore, a randomization technique is applied to find an approximate solution to (4) satisfying this constraint.

3. The proposed technique

3.1 Difference of Convex functions Program

In optimization programming, the problems are generally in two main classes: the convex optimization problems and the non-convex ones. Non-convex optimization appears much more frequently. The method for problems of this class may be split into global approaches and local approaches. The global approaches give the global solution expensively. In the other hand, local approaches are much faster but difficult to show properties of the obtained solutions. DCA ([3]) is a local approach but sometime gives the global solution.

3.1.1. Difference of Convex functions

In DC approach, we decompose the original non-convex function to the difference of two convex functions ([4]).

A standard DC program generally has the decomposition form as the following:

$$\alpha = \inf\{f(x) := g(x) - h(x) : x \in S\}$$

A general DC program usually has the form as the following:

$$\alpha = \inf\{f(x) := g(x) - h(x) : g_i(x) - h_i(x) \leq 0, i = 1, \dots, m\}$$

Where g, h are lower semi-continuous proper convex functions on \mathbb{R}^n , S is a convex set.

3.1.2. Difference of Convex functions Algorithm

The DCA-based approach is described as follows:

1. First we need to decompose the objective function f into a DC decomposition: $g - h$
2. Then compute subgradients of h
3. Choose x^0 in \mathbb{R}^n as the starting point
4. With standard DCA, we repeat those steps:
 - Compute $y^k \in \partial h(x^k)$
 - Compute x^{k+1}

$$x^{k+1} \in \arg \min_{x \in S} \{g(x) - [h(x^k) + \langle y^k, x - x^k \rangle]\}$$

- Until either $\frac{\|x^{k-1} - x^k\|}{\|x^{k-1}\|+1} < \epsilon_1$ or $\frac{|f(x^{k-1}) - f(x^k)|}{|f(x^{k-1})|+1} < \epsilon_1$

3.2 Apply DCA to the problem:

3.2.1. DC decomposition for this problem

In order not to work with complex numbers in computation, we introduce some new notations:

$$\hat{D} = \begin{bmatrix} \text{Re}(D) & -\text{Im}(D) \\ \text{Im}(D) & \text{Re}(D) \end{bmatrix} \quad \hat{D}_k = \begin{bmatrix} \text{Re}(D_k) & -\text{Im}(D_k) \\ \text{Im}(D_k) & \text{Re}(D_k) \end{bmatrix}$$

$$\hat{A}_k = \begin{bmatrix} \text{Re}(A_k) & -\text{Im}(A_k) \\ \text{Im}(A_k) & \text{Re}(A_k) \end{bmatrix} \quad \hat{Q}_k = \begin{bmatrix} \text{Re}(Q_k) & -\text{Im}(Q_k) \\ \text{Im}(Q_k) & \text{Re}(Q_k) \end{bmatrix}$$

$$x = [\text{Re}(w^T) \quad \text{Im}(w^T)]^T$$

The problem (2) can be equivalently transferred as follows

$$\begin{aligned} \min_x \quad & x^T \hat{D} x \\ \text{s. t.} \quad & \frac{x^T \hat{A}_k x}{x^T \hat{Q}_k x + \sigma_\eta^2 x^T \hat{D}_k x + \sigma_v^2} \geq \gamma_k, \quad k = 1, 2, \dots, K \end{aligned} \tag{5}$$

Which is then equivalent to

$$\begin{aligned} \min_x \quad & x^T \widehat{D}x \\ \text{s.t.} \quad & \gamma_k (x^T \widehat{Q}_k x + \sigma_\eta^2 x^T \widehat{D}_k x + \sigma_v^2) - x^T \widehat{A}_k x \leq 0, k = 1, 2, \dots, K \end{aligned} \quad (6)$$

This equation naturally forms a DC decomposition, then the DCA introduced following will be applied to find the optimal value.

3.2.2. DCA for this problem

Apply DCA scheme for the problem (6)

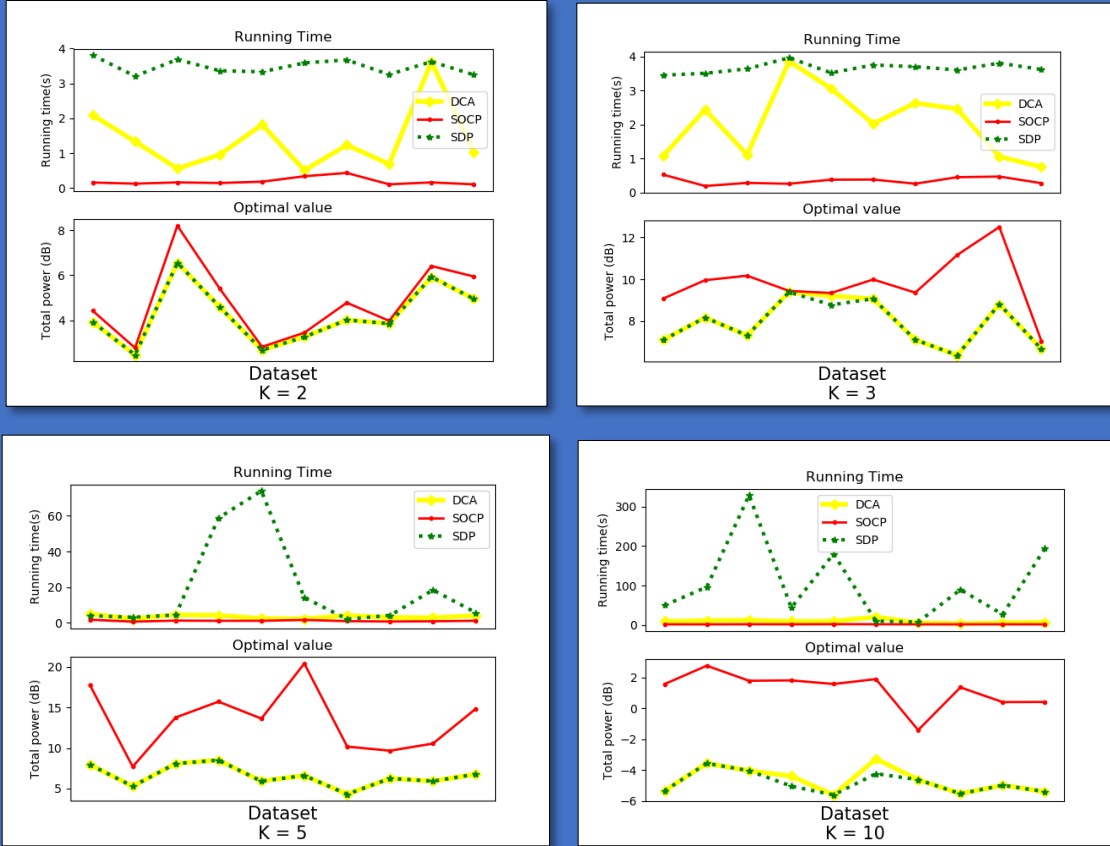
1. Initialization: Choose $u^0 = (x^0, t^0) \in (\mathbb{R}^{2R}, \mathbb{R}^+)$, set value to tolerance ϵ , $l \leftarrow 0$
2. Repeat:
 - Calculate $u^{l+1} = (x^{l+1}, t^{l+1})$ by solving a series of convex subproblems

$$\begin{aligned} \min_x \quad & x^T \widehat{D}x + \tau t \\ \text{s.t.} \quad & \gamma_k (x^T \widehat{Q}_k x + \sigma_\eta^2 x^T \widehat{D}_k x + \sigma_v^2) - \left[2(\widehat{A}_k x^l)(x - x^l) + (x^l)^T \widehat{A}_k x^l \right] \leq t, k = 1, 2, \dots, K \\ & t \geq 0 \end{aligned} \quad (7)$$

- $l \leftarrow l + 1$
- Until $\left(\frac{\|u^l - u^{l-1}\|}{1 + \|u^{l-1}\|} < \epsilon \text{ or } \frac{|F_1(u^l) - F_1(u^{l-1})|}{1 + |F_1(u^{l-1})|} < \epsilon \right)$

The convex subproblem (7) at each iteration of DCA is solved efficiently by some optimization software packages such as: CPLEX-IBM, CVX.

When the value of tolerance ϵ is set up small enough with an appropriate value of penalty coefficient τ , the optimal value found by using DCA is guaranteed that all constraints in (6) will almost absolutely be satisfied.



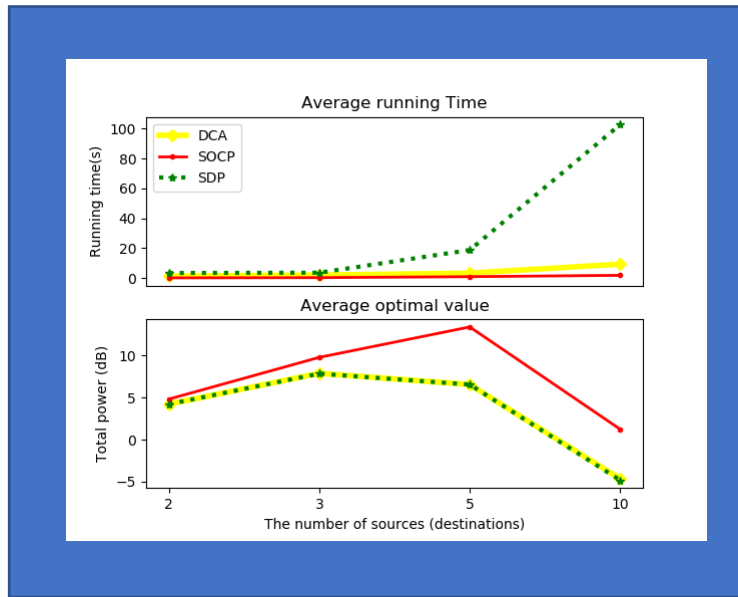
4. Simulation results

In this section, we evaluate the performance of the proposed DCA and compare it with two algorithms proposed in [1] and [2]. Throughout our simulations, we consider a network with the number of relays is 20. The relay and destination noise variances are assumed to be equal to 1. The transmitted power of each source is equal to 10.

Firstly, we evaluate two techniques DCA and SOCP in terms of optimal values and running time. As we can see, the executing time of DCA is higher than of SOCP a bit. But the solution that DCA brings to is far better than SOCP does.

Secondly, we consider the performance of the two techniques DCA and SDP. While both approaches achieve approximately the same solutions, DCA runs up to ten times faster than SDP does in case of the number of pairs of source-destination is 10.

In general, we can see that the proposed approach DCA gives a good solution in a short period of time, which can't be achieved by SOCP or SDP approach. It should be noted that, for some test cases, DCA can find an optimal solution while SOCP cannot since the constraints in SOCP strengthened make it infeasible.



5. Conclusion

In this research we proposed the method of using DCA to minimize the total relay transmit power in the distributed peer-to-peer beamforming network, subject to the destination QoS constraints, which is measured by SINR. In conclusion, the DCA accomplishes an outstanding performance that the two former approaches can't reach to when both time and optimal solutions are regarded.

6. References

- [1] S. Fazeli-Dehkordy, S. Gazor, and S. Shahbazpanahi, "Distributed peer-to-peer multiplexing using ad hoc relay networks," *Proc. IEEE ICASSP'08*, vol.2, pp.2373-2376, Las Vegas, NV, Apr. 2008.
- [2] Haihua Chen, Alex B. Gershman, Shahram, Shahbazpanahi, "Distributed Peer-to-peer Beamforming for Multiuser Relay Networks", *ICASSP-88*. May. 2009.
- [3] Le Thi, H.A., Pham Dinh, T., "DC programming and DCA: thirty years of developments" in "Mathematical Programming" May 2018, Volume 169, Issue 1, pp 5–68
- [4] Le Thi, H.A. "DC programming and DCA - Theory, Algorithms and Applications", <http://www.lita.univ-lorraine.fr/~lethi/index.php/en/research/dc-programming-and-dca.html>
- [5] Le Thi, H.A., Pham Dinh, Tao, "DC programming in communication systems: challenging problems and methods" in "Vietnam Journal of Computer Science" February 2014, Volume 1, Issue 1, pp 15–28
- [6] Pham Dinh T., Le Thi, H. A, "Recent Advances in DC Programming and DCA" in "Transactions on Computational Intelligence XIII" Volume 8342, Pages 1-37, August 01 - 01, 2013
- [7] Tran, T. T., Le Thi, H. A. and Pham Dinh, T., "DC programming and DCA for enhancing physical layer security via cooperative jamming" in "Computers & Operations Research", Volume 87, November 2017, Pages 235-244

[8] Pham Dinh, Tao, Le Thi, Hoai An

“A D.C. Optimization Algorithm for Solving the Trust-Region Subproblem”, *SIAM J. Optim.*, 8(2), 476–505., May 1998

[9] Le Thi, H. A., Pham Dinh, T.

“The DC (Difference of Convex Functions) Programming and DCA Revisited with DC Models of Real World Nonconvex Optimization Problems” in “Annals of Operations Research”, January 2005, Volume 133, Issue 1–4, pp 23–46

[10] Y. Yang, Q. Li, W. K. Ma, J. Ge, P. C. Ching

“Cooperative Secure Beamforming for AF Relay Networks With Multiple Eavesdroppers” in “IEEE Signal Processing Letters”, Volume: 20, Issue: 1, Jan. 2013

[11] H. Shen and W. Xu, C. Zhao

“QoS Constrained Optimization for Multi-Antenna AF Relaying With Multiple Eavesdroppers” in “IEEE Signal Processing Letters” Volume: 22, Issue: 12, Dec. 2015.

DCA-Based Algorithm for Cross-Functional Team Selection

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Abstract

This is a continuing work of Ngo et al, 2018. They have proposed a mixed binary integer quadratic programming (MIQP) model for cross-functional team selection [1]. The model called MDSB. It is not only specific to team selection but also a generic model for other problems that in form of combinatorial search for the best-matched candidate to a predefined target. Ngo et al designed a generic algorithm (GA) for solving MDSB. The GA algorithm is efficient but it also comes with several disadvantages. In this paper, we propose a DCA-based algorithm to solve the MDSB. We compared the proposed algorithm with MIQP-CPLEX and Genetic Algorithm. The numerical results show that our algorithm not only provides the best objective value but also significantly faster than the other compared algorithms.

Keywords

Cross-Functional Team, MDSB, Genetic Algorithms, CPLEX, DCA.

1. Introduction

The Cross-Functional Team (CFT) that defined as a group of members who have different functional expertise working toward a common goal is always worthwhile for any selection process [2]. In the past, there are several researchers have built models for team selection. Many of them use a binary programming model to support decision-making process such as: Bo Feng et al proposed a multi-objective optimization problem for the selection of CTF [3]. A mixed binary integer programming model presented by Wang et al to solve the problem of the developer team selection. They used a heuristic algorithm to solve the model [4]. Das develop a binary integer programming to create optimal sets of cricket teams [5]. Bhattacharjee and Saikia introduced a method of selecting the cricket team from a certain formation using a binary integer programming method [6]. Sharp and his colleagues introduced integer optimization to quantify the performance of a cricket player based on his ability to score points and run wickets [7].

1.1 Background Problem

Many researchers assess the performance of the selected team by defining an objective function in form of: $\max(\sum_{i=1}^k x_i \varphi_i)$. Where x_i is the binary variables is represents the participation of member i^{th} and φ_i is the rating value of performance criteria of member i^{th} . The objective function based on the sum of rating of the members is not yet sufficient to access the predefined performance in both of 'wide' and 'deep'. The two objectives problem can be attributed to the multi-objective optimization [8] problem as following:

$$\max \left(f_1(x) = \sum_{i=1}^k \left(\sum_{j=1}^m C_{i,j} * x_i \right) \right), \max \left(f_2(x) = \sum_{i=1}^k \left(\sum_{j=1}^m R_{i,j} * x_i \right) \right)$$

Where $f_1(x)$ represents the number of skills that the team is proficient in (wide). $f_2(x)$ represents the total score (deep) of the selected team. $C_{i,j} = 1$ if member i^{th} has experience

on skill j^{th} . $R_{i,j}$ is the score of member i^{th} on skill j^{th} . There are many approaches to solve this problem such as:

- Transform problem to single objective problem using weighted sum approach: $\max(\sum_{i=1}^M w_i * f_i(x))$. Where w_i denotes the weight value of objective function $f_i(x)$. M is the number of Objective functions.
- Choosing an optimal solution among many solutions on the Pareto frontier.

These approaches require the decision maker to indicate the weights of the objectives. This is often very difficult. In [1] Ngo et al present the MDSB model to select an effective team.

1.2 Introduction to MDSB

The MDSB can be expressed as follows: Given m skills (types) and k team members. Every exercise is assigned to their classes. R records the scores of the team members when they practice with corresponding exercise that tagged in its skills: $R = \{R_{i,j} \geq 0 \mid i = \{1, \dots, k\}, j = \{1, \dots, m\}\}$

Where $R_{i,j}$ represents the score of member i^{th} for skill j^{th} . The objective is to maximize the number of the score as well as the number of skills, which is subjects to the limitation of team size with h members.

In order to make decisions. We denote x_i is a decision variable which presents the appearance of member i^{th} in the selected team.

$$x_i = \begin{cases} 1 & \text{if member } i^{th} \text{ participate in the team} \\ 0 & \text{otherwise} \end{cases} \quad \forall i = 1..k$$

The constraint of team size can be added as $\sum_{i=1}^k x_i = h$

Define $E \in R^m$ is the bound point. The predefined bound point E will form a boundary box where the optimal solution will be located. E can be simply expressed as: $E = [E_j \mid j = 1..m]$. In [1] Ngo et al define E_j as the sum score of h members who have the highest scores for skill j^{th} . The closest point $O \in R^m$ to E be the optimal solution. O can be defined as:

$$O = \left[\sum_{i=1}^k (R_{i,0} * x_i), \sum_{i=1}^k (R_{i,1} * x_i), \dots, \sum_{i=1}^k (R_{i,m} * x_i) \right]$$

The MDSB model can be formulated as follows:

$$\min \left(distance(E, O) = \sqrt{\sum_{j=1}^m \left(E_j - \sum_{i=1}^k R_{i,j} * x_i \right)^2} \right)$$

Subjects to:

$$x_i = \{0,1\} \quad \forall i = 1..k$$

$$\sum_{i=1}^k x_i = h$$

Figure 1 illustrates the problems in 2 dimension-space, where the black points represent the data points of candidates, the set of available solutions are depicted by the blue points. The bound point E defines the circle that contains the optimal solution.

In [1] Ngo et al proposed a Genetic Algorithm [11] to solve the MDSB as following: The variables N, r, t , and C respectively denote: population size, Crossover rate, mutation rate and convergence condition. Our GA implementation described as following steps:

1. Randomly generate N individuals for the first generation. An individual generated by flipping h unique bits from a zero chromosome.
2. Evaluate the fitness for each individual (team) with the objective function of the MDSB. Select the individual that has the best fitness.
3. Use the best fitness individual of the generation l^{th} to generate the generation $l + 1^{th}$.
4. $N * t$ Individuals are the mutation in the generation $l + 1^{th}$ and the other individuals are randomly generated.
5. If the fitness value of the current generation is no difference with C previous generations then stop the algorithm. Otherwise come back step 2.

The results shown by the authors are good, however, due to the limitations of the GA, the algorithm does not guarantee the optimal solution to other situations as well as the minimal processing time. The proposed model is a Mixed-Integer Quadratic Programming (MIQP) [9], which can be directly solved with a solver such as CPLEX-MIQP [10], Genetic Algorithm [11] and a new algorithm based on DC programming and its algorithm (DCA) [12]. In this paper, we conduct the experiments to compare those algorithms on the MDSB.

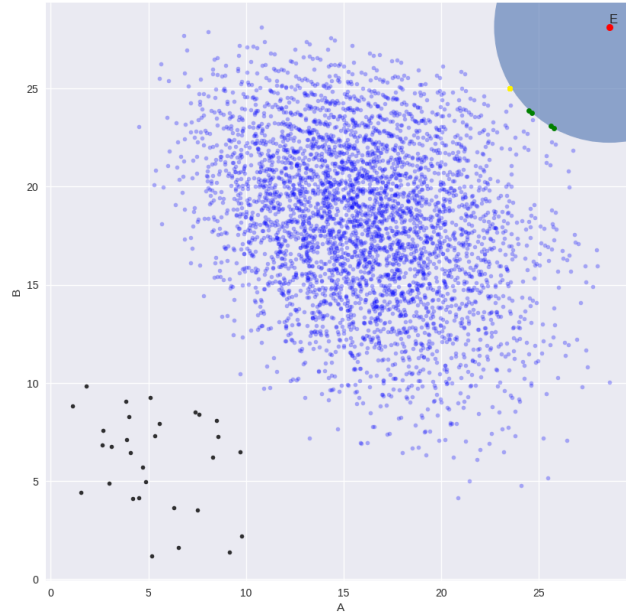


Figure 1: Illustration of the decision-making process from random data on two-dimensional space

2. DC programming and DCA

2.1 DC Programming

DC programming addresses the problem of minimizing a function f which is the difference of two convex functions $g(x) - h(x)$ on the whole space R^d or on a convex set $C \subseteq R^d$. DC programming can be described in the form:

$$\alpha = \inf(f(x) = g(x) - h(x): x \in R^d) \quad (P_{dc})$$

Where g, h are lower semi-continuous proper convex functions on R^d . The function f is called a DC function, and $g - h$ is the DC decomposition of function f while g and h are the DC components of function f . The convex constraint $x \in C$ can be incorporated in the objective function of (P_{dc}) as follows:

$$\inf(f(x) = g(x) - h(x): x \in C) = \inf(\chi_C(x) + g(x) - h(x): x \in R^d),$$

Where χ_C denotes the indicator function on C and is defined by $\chi_C(x) = 0$ if $x \in C$, and $+\infty$ otherwise.

A point x^* is said to be a critical point of $g - h$ if it satisfies the generalized KKT condition: $\partial h(x^*) \cap \partial g(x^*) \neq \emptyset$. x^* is a local minimizer of $g - h$ if $g(x^*) - h(x^*)$ is finite and there exists a neighborhood U of x^* such that $g(x^*) - h(x^*) \leq g(x) - h(x) \quad \forall x \in U$. The necessary local optimality condition for (primal) DC program (P_{dc}) is given by:

$$\emptyset \neq h(x^*) \subset \partial g(x^*).$$

This condition is also sufficient for local optimality in many important classes of DC programs. [13, 14, 15, 16].

2.2 DCA

DCA is an optimization approach based on local optimality and the duality in DC programming for solving DC programs. The main idea of DCA is quite simple. It consists in approximating a DC program by a sequence of convex programs: each iteration k of DCA approximates the concave part $-h$ by its affine majorization and minimizes the resulting convex function. The generic DCA scheme can be described as follows:

1. Let $k = 0$, Choose x^k in R^d , and ϵ is small enough
2. Calculate y^k in $\partial h(x^k)$,
3. Calculate $x^{k+1} \in \operatorname{argmin}\{g(x) - h(x^k) + \langle x - x^k, y^k \rangle: x \in R^d\}$
4. If $|f(x^{k+1}) - f(x^k)| > \epsilon$ come back step 2.

Convergence properties of DCA and its theoretical basics have been described in [13], [14], [15]. However, it is worthwhile to report the following important properties of DCA.

- i. The sequences $\{g(x^k) - h(x^k)\}$ is decreasing.
- ii. If the optimal value α of DC program is finite and the infinite sequences $\{x^k\}$ and $\{y^k\}$ are bounded, then every limit point x^* of sequence $\{x^k\}$ is a critical point of $(g - h)$, i.e. $\partial g(x^*) \cap \partial h(x^*) \neq \emptyset$.
- iii. DCA has a linear convergence for DC programs

A deeper insight into DCA has been described in [13], [14], [15], and [16]. As mentioned in the introduction, it is crucial to note the main features of DCA: DCA is constructed from DC components but not the DC function f itself which has infinitely many DC decompositions, and there are as many DCA as there are DC decompositions. Such decompositions play a critical role in determining the speed of convergence, stability, robustness, and globality of sought solutions. Hence, it is important to study various equivalent DC formulations of a DC program. This flexibility of DC programming and DCA is of particular interest from both a theoretical and an algorithmic point of view. Moreover, with suitable DC decompositions DCA generates most standard algorithms in convex and nonconvex optimization.

3. Proposed method

3.1 DC Programming for MDSB

We are concerned with the following non-convex constraints: $x_i = \{0,1\}, i = 1 \dots k$. According to Le Thi et al [17], the exact penalty for these constraints is formulated as:

$$p(X) = \sum_{i=1}^k x_i(1 - x_i)$$

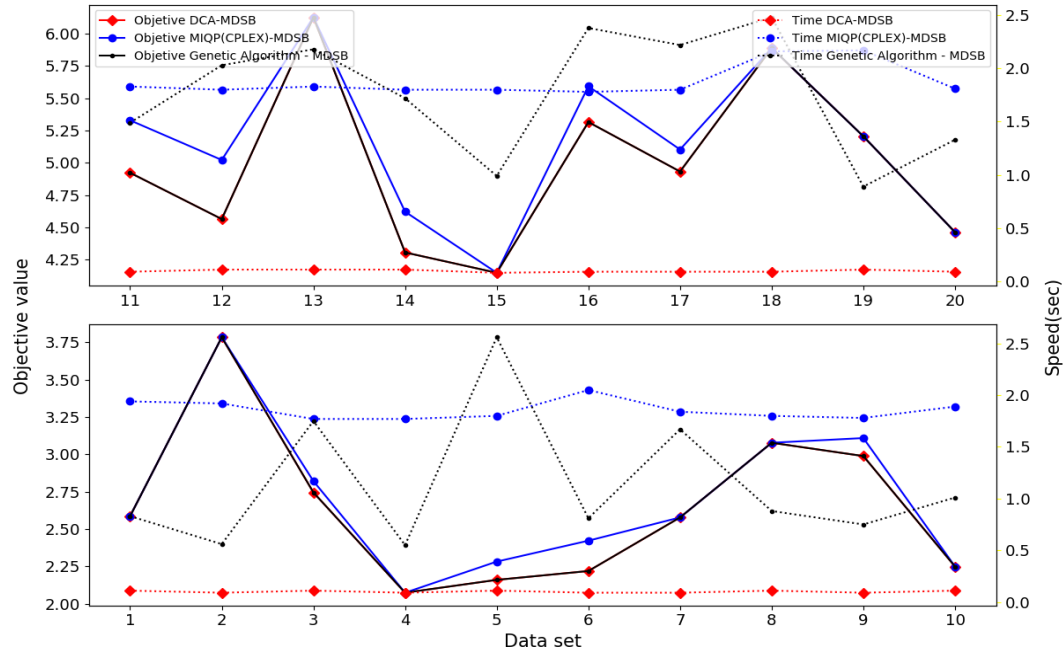


Figure 2: Results of the implemented algorithms on random generate data

Clearly, $p(X)$ is a concave quadratic function and $p(X) \geq 0$ for every $X = \{x_1 \dots x_k \mid 0 \leq x_i \leq 1 \forall i = 1 \dots k\}$, and $p(X) = 0$ if and only if $x_i \in \{0,1\}, \forall i = 1 \dots k$. It follows that MDSB can be replaced by an equivalent Penalized MDSB (PMDSB) with continuous relaxation constraints, for $x_i > 0$:

$$PMDSB = \min \sum_{j=1}^m \left(E_j - \sum_{i=1}^k R_{ij} x_i \right)^2 + \tau \sum_{i=1}^k x_i(1 - x_i)$$

Subjects to:

$$x_i \in [0,1] \forall i = 1 \dots k$$

$$\sum_{i=1}^k x_i = h$$

The solution sets of MDSB and PMDSB are identical if penalty parameter τ is appropriately chosen and sufficiently large enough. Consider now the second term of PMDSB is not convex, it can be expressed as:

$$PMDSB = \min\{g(X) - h(X)\}$$

$$= \min \underbrace{\sum_{j=1}^m \left(E_j - \sum_{i=1}^k R_{ij} x_i \right)^2}_{g(X)} - \underbrace{\tau \sum_{i=1}^k x_i (x_i - 1)}_{h(X)}$$

Subjects to:

$$x_i \in [0,1] \forall i = 1 \dots k$$

$$\sum_{i=1}^k x_i = h$$

Both of $g(X)$ and $h(X)$ are convex functions on R^n . With a suitable value of τ , (2) is a D.C. program equivalent to MDSB model.

3.2 DCA for PMDSB

Since MDSB Model has been reformulated as an equivalent DC decomposition (PMDSB), we propose the method to solve this optimization based on general DC Algorithm:

1. Randomly select $X^0 = \{x_i^0 \mid 0 \leq x_i^0 \leq 1 \forall i = 1 \dots k\}$, and ϵ is small enough and suitable value of τ
2. Calculate the approximation of $h(X)$ at X^l
3. Compute X^{l+1} by solving the sub-problem:

$$\min \sum_{j=1}^m \left(E_j - \sum_{i=1}^k R_{ij} x_i \right)^2 - \tau \sum_{i=1}^k 2x_i^l (x_i - 1)$$

4. If $\|f(X^{l+1}) - f(X^l)\| > \epsilon$, come back step 2

Although we can guarantee convergence in the infinite limit of l , complete convergence may take a long time in a large-scale data, so ϵ was used as a predetermined bound for obtaining an optimal solution.

4. Experiments and results

We implement three algorithms: the DCA, CPLEX-MIQP, and Genetic Algorithms in C++ and run on an Intel i5 5200U 2.20 GHz of 8 GB DDR3L. We performed two experiments to

evaluate the performance of the algorithms. The results of the algorithms depend on the parameters such as DCA needs the τ , we have to define limited time constraint for MIQP (CPLEX) and when running GA we have to specify the population size, crossover rate, terminate condition. So we only show the results of the best run of each implemented algorithm. The analysis part of the comparison only focused on the objective value and execution time of each algorithm.

4.1 Experiment on Randomly Generated Data

In the first experiment, we generated 2 groups of datasets in random uniform distribution (low = 1000, high = 100 000). Each group contains 10 datasets with $k = 1000$, $m = 3$. We then params the model with respectively $h = 3$ and $h = 5$. Figure 1 shows the objective value and time consumptions corresponding to the implemented algorithms after executing them on 20 datasets. The DCA executed with a random τ in range of $[0.1 - 10^6]$ and vector $X^0 = \{1\}$. We set the time limit to 5 seconds for running the MIQP (CPLEX) with MDSB problem.

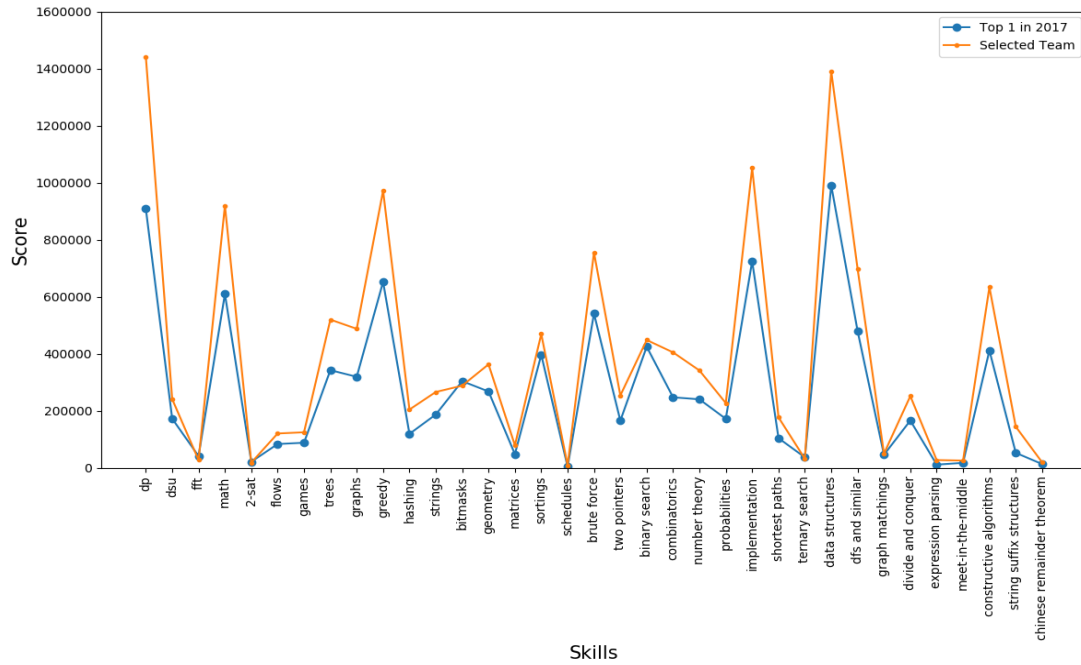


Figure 2: Score of Champion Team (2017), Selected Team

Finally, the Genetic Algorithm runs with $N = 30$, $r = 30\%$, $t = 50\%$ and $C = 150$.

Figure 2 exhibits the results after executing 3 algorithms 20 datasets, DCA, and Genetic Algorithm completely provide the better solution with the lowest objective value. Meanwhile, MIQP (CPLEX) give several local solutions. DCA's processing time is stable. It is easy to observe that DCA's processing speed is about 18 times faster than MIQP (CPLEX) and 15 times faster than the Genetic Algorithm. Genetic Algorithm randomly creates the next generations to obtain the solution, however, the most fortunate is 5 times slower than the DCA.

4.2 Experiment on Codeforces Data

In the second experiment, we conducted experiments on 2 datasets: The first dataset is downloaded data of top 500 highest rating members from codeforces.com (last crawled 30-June, 2018). Contestants joined the programming contests and solve problems. Problems are tagged into 36 different types of classes. The system gives the score for the solved problems. A member's score on a particular skill is calculated by summing the scores of the solved problems by the member on that skill.

*Table 1: The obtained results of **DCA**, **MIQP (CPLEX)** and **GA** after execution on the dataset of top 500 on Codeforce*

Algorithm	Time(sec)	Objective	Selected Members
DCA ($\tau=1000$)	3.374	912185.5725	I_love_Tanya_Romanova , MrDindows, uwi
MIP (limit time = 10s)	65.051	912185.5725	I_love_Tanya_Romanova , MrDindows , uwi
GA ($N = 150$, $r = 30\%$, $t = 50\%$ and $C = 300$)	5.838	912185.5725	I_love_Tanya_Romanova, MrDindows , uwi

We select the best team from the 500 members by 3 implemented algorithms. Calculation results are shown in Table 2. All three algorithms produce the same objective value, but the DCA shows that its computation time is several times faster than GA and MIQP (CPLEX) and can be easier applied on a large scale.

The second dataset crawled by Ngo et al in [1] on codeforces. It contains score of 36 members in the top 12 ACM-ICPC teams in 2017. We used all of three algorithms to compare the results we had done with GA before. The dataset only has 35 classes, missing "*" special" from recently crawled data. The data in Table 2 shows that the selected team obtained when running all three algorithms. The result is the same as what we obtained earlier. However, the DCA still stands out in terms of speed.

Figure 3 illustrates the scores over 35 skills of the selected team and 2017 champion. We can observe the selected team is superior to the champions on most skills.

*Table 2: The obtained result of **DCA**, **MIQP (CPLEX)** and **GA** on the dataset of top 12 teams in 2017*

Algorithm	Objective	Time(sec)	Selected Members
DCA ($\tau = 1000$)	127490	0.0017	Belonogov; - XraY-; Hogloid

MIP (limit_time = 10s)	127490	0.0542	Belonogov; - XraY-; Hogloid
GA ($N = 150$, $r = 30\%$, $t = 50\%$ and $C = 300$)	127490	0.1994	Belonogov; - XraY-; Hogloid

5. Conclusion

In this research, we proposed the DCA-based algorithm for solving the MDSB model that allows efficient selection of a CTF in both deep and wide aspects. The MDSB model is a generic model for search the best-matched candidate to a predefined target problem. It avoids the multiple-objectives problem for accessing the team performance, which requires the choice of additional parameters for ranking the objective functions in the decision-making process.

On the other hand, we did not solve the problem that Ngo et al previous encountered related to social skills, our experiment only illustrates the superiority in the selection of technical skills. Chen et al examine the knowledge of many functional areas, good teamwork skills, and good working relationships that are important criteria for selecting members for a CFT beside technical skills [18]. These social skills have not been tested by the model due to lacking data.

The considered team selection problem MDSB has been recast as a DC program by introducing the penalty for binary-variable constraints. The MDSB then be replaced by an equivalent Penalized MDSB (PMDSB) with continuous relaxation constraints. This great feature is suited to applying DCA, including addressing a chain of approximate convex programs whose solutions clearly exist. Preliminary randomized data and real data experiments show that DCA is robustness, efficiency, and superiority over MIQP (CPLEX) and Genetic Algorithms.

For the future works, we are exploring ways of scoring teamwork skills. The MDSB model is being upgraded to match the assessment process that requires special skill requirements. We also perform the code refactor to eliminate the issues related to lack of programming skills.

6. References

- [1] Ngo Tung Son, Le Van Thanh, Tran Binh Duong, and Bui Ngoc Anh. 2018. A decision support tool for cross-functional team selection: case study in ACM-ICPC team selection. In *Proceedings of the 2018 International Conference on Information Management & Management Science (IMMS '18)*. ACM, New York, NY, USA, 133-138. DOI: <https://doi.org/10.1145/3277139.3277149>

- [2] Márcio Lopes Pimenta, Andrea Lago da Silva, and Wendy L. Tate: Developing and Managing Cross-Functional Teams: A Multi-Case Study of Brazilian Manufacturing Companies. *J. Technol. Manag. Innov.* 2014, Volume 9, Issue 2.
- [3] Feng, Bo and Jiang, Zhong-Zhong and Fan, Zhi-Ping and Fu, Na (2010) A method for member selection of cross-functional teams using the individual and collaborative performances. *European Journal of Operational Research*, 203. pp. 652-661. ISSN 0377-2217.
- [4] Wang, Z., Yan, H.S., Ma, X.D., 2003, a quantitative approach to the organization of crossfunctional teams in concurrent engineering, *International Journal of Advanced Manufacturing Technology* 21, 879–888.
- [5] Das, D: Moneyballer: an integer optimization framework for fantasy cricket league selection and substitution. <http://debarghyadas.com/files/IPLpaper.pdf> (2014). Accessed 24 March 2018.
- [6] Bhattacharjee, D. & Saikia, H. *OPSEARCH* (2016) 53: 225. DOI: 10.1007/s12597-015-0228-3.
- [7] GD Sharp, WJ Brettenny, JW Gonsalves, M Lourens and RA Stretch, Article: Integer optimisation for the selection of a Twenty 20 cricket team ,*Journal of the Operational Research Society* (2011) 62, 1688–1694. doi: 10.1057/jors.2010.122.
- [8] David A. Van Veldhuizen, Gary B. Lamont, *Multiobjective Evolutionary Algorithms: Analyzing the State-of-the-Art* (2000), DOI: 10.1162/106365600568158.
- [9] Lazimy, R. *Mathematical Programming* (1982) 22: 332.
<https://doi.org/10.1007/BF01581047>.
- [10] Christian Blik, Pierre Bonami and Andrea Lodi: Solving Mixed-Integer Quadratic Programming problems with IBM-CPLEX: a progress report, *Proceedings of the TwentySixth RAMP Symposium Hosei University, Tokyo, October 16-17, 2014*.
- [11] K.F. Man, K.S. Tang and S. Kwong: Genetic algorithms: concepts and applications [in engineering design, *IEEE Transactions on Industrial Electronics* 43(5):519 - 534, DOI: 10.1109/41.538609.
- [12] Pham Dinh Tao, Nam Nguyen Canh, Le Thi Hoai An: An efficient combined DCA and B&B using DC/SDP relaxation for globally solving binary quadratic programs. *J. Global Optimization* 48(4): 595-632 (2010).
- [13] Le Thi, H.A., Pham Dinh, T.: The DC (Difference of Convex Functions) Programming and DCA Revisited with DC Models of Real World Nonconvex Optimization Problems. *Annals of Operations Research* 133, 23–46 (2005).
- [14] Pham Dinh, T., Le Thi, H.A.: Convex analysis approach to DC programming: Theory, algorithms and applications. *Acta Mathematica Vietnamica* 22(1), 289–357 (1997).
- [15] Pham Dinh, T., Le Thi, H.A.: Optimization algorithms for solving the trust region subproblem. *SIAM J. Optimization* 8, 476–505 (1998).
- [16] Pham Dinh, T., Le Thi, H.A.: *Recent Advances in DC Programming and DCA*, vol. 8342. Springer Berlin Heidelberg (2014).
- [17] Le Thi Hoai An, Pham Dinh Tao, and Le Dung Muu: Exact Penalty in D.C. Programming, *Vietnam Journal of Mathematics* 27:2 (1999) 169-L78.
- [18] Chen, S.J., Lin, L., 2004. Modeling team member characteristics for the formation of a multi-functional team in concurrent engineering. *IEEE Transactions on Engineering Management* 51, 111–124.

IoT Platform for Safety, Security and Surveillance

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Abstract

Demands of quality life is higher day by day in the world and following with the rapidly growth of technologies is also support for humans have a better quality. As a part of life, security and safety are fundamental and the most important things. More specifics, computer vision has been advancing rapidly and parallel with huge development Internet of Things, the problems are created that how to apply them to life. This paper introduces a IoT platform for implementing the ecosystem of surveillances, detection and recognition to check for permission on private place and stranger people, early trigger fire alarm, tracking for suspicious object for security and safe. As a first version of product, we implement a platform with methods save video and get image streaming from camera, detect humans face and recognition, check for permission to order smart lock open the door for permitting people. Almost surveillance cameras currently only use to storage and checking criminal after happening. Ours proposed design is flexible and be able to connect a system that already have surveillance cameras that only and can easily to adapt more AI modules.

Keywords

IoT platform, Internet of Things, Security, Safety, Surveillance, Facial Recognition, Face Detection, Features Extraction, Classification.

1. Introduction

There are many solutions have been applied to ensure security in the building, the most prominent of which is the application of technologies such as fingerprint recognition, ID cards. These solutions help people a lot in progress of improving quality of people life and user experiment, but beside, still there some cons. Let take an example when people want to unlock the door by fingerprint, they must be touch the devices, it waste time for waiting the door open and the time of processing about from 5s to 10s. Attendance management system based on Fingerprint on [1], these solutions help many company and organization use these methods for their system on operational, control and manage system. One drawbacks of fingerprint scanning devices, the rating of number using grow up, the life-time working go down. Another technology with top one popular widely is ID cards, this help improves operations in various field likes banks, checking attendances, etc. As an example, ID card based security system for railway applications [2]. But still there exception that affect to security in some case forget bearing ID cards, or worse, any bad thing can happen if that card in hand of bad guys. With safety, fire alarm system has a numbers of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present. The drawbacks of these sensor is that fire is burn enough to the sensors can know. With camera detect smoke in wide area, it will be early recognition the fire and alarm to all people to prevent disaster happens, Zhigang Liu and Andrew K. Kim et al [3] review of development in fire detection technologies. With IoT

platform for safety, security and surveillance, we implement an ecosystem for permission accessing, checking attendance in short time by face recognition, early alarm for disaster with smoke, fire recognitions. The platform can easily connect and adapt to available infrastructure of offices, building.

IoT platform

There are various IoT platform have provide from big companies which lead technologies of the world as Bhumi Nakhuva mention on [4]. The big bake IoT is one of “Future Internet”, who can provide great solutions will lead the trending of technologies. The term ‘IoT’ is wide range of field, it appears to describe make everything to be aware, alive likes animals or humans. The great thing IoT bring for world is make relationship between hardware and software closer and closer. As a popular platform are widely used for IoT solutions, Google Cloud Platform real time streaming processing as cover on [4], they use many of services and technics, connect them together to create a solution for IoT. Google was a big technology company before the trending of IoT, they already have support various kind of service in cloud. To become a top popular IoT platform, they provide services with some key feature: Scalability, higher performance, security and safe cloud. Google IoT solution is implements with all smart and sensor must have internet connection. Another top popular IoT platform prominent can mention is Amazon Web Services (AWS) that develop IoT with global scale by facilitating security, services and support as cover on [4], with start young man on technology landing, AWS grow up quickly and widely because of right deciding in the development of technologies, some key feature on IoT applications likes scalability, pay-as-you go, flexibility, etc. As the same key point with Google IoT, AWS IoT solutions provide services on clouds, and to apply this solutions, all smart devices and sensors also have internet connection. There are still tons of popular IoT platform have cover on [4] likes IBM Bluemix, ThingSpeak, Microsoft Azure Cloud, etc. Each platform has their own pros and cons, depends on problem to handle, we can you an appropriate platform. But the key things these solutions are cloud platform, all devices need to connect to internet. With some places have low internet connection, it become a challenge. One more, almost building have camera system, data from camera is streaming frames are heavy payload on require of small time. Our platform is designed with solution to handle all that things.

2. Proposed platform

The IoT platform for security, safety and surveillance is a system that implemented with flexible modules that allows adapt available systems and infrastructure of building. To achieve that purpose, the platform consists three main modules: Data Collection, Data Analysis and Decision. Beside, to support for platform management system, particularly when it allows information can be edited, modified, deleted and maintained, we also have two more sub modules call Administrator Management and Adapter Module. Figure 1 below show the overview of system architect:

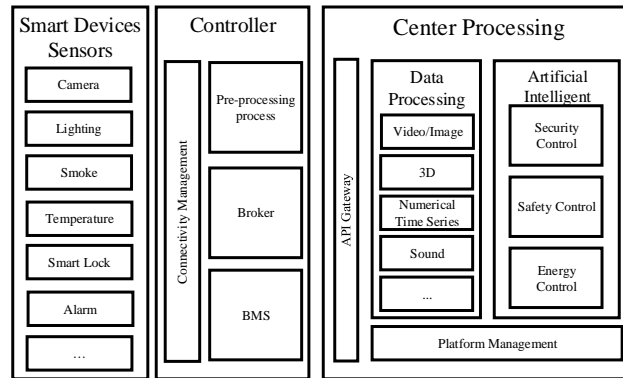


Figure 1: The platform architect

Almost every building has its own management system, Adapter Module have to connect existed management system to platform to create a unified system.

Data Collection

Data collection is a module that facilitate the process data collection, allow specific, structured information to be gathered in a systematic format. There are a lot of smart devices and sensors have its kind of data and values, a collection of them to provide for server all necessary data such as cameras, smart locks, smart lights, temperature sensors, smoke sensor, etc. In the fourth industrial revolution [5], it does not tell what we do, but also who we are which make everything to life, a challenge of data become a problem when millions of devices going to aware. Technic Edge Computing is predicted that is the future of distributed center-processing, as it role on [6]. Take the idea of Edge computing, these smart devices and sensors have smart enough to process pre-processing data to filter information, avoid sending to many unnecessary information to server. For easily to illustrate, camera is a smart device with task streaming data, before sending an image to server for analysis, it first can detect human face by motion detection, with image that it detected, it send to analysis server, avoiding send all the image with almost have no object at all, help decrease payload to analysis server. This solution can help we scale system to a hundred of cameras. There are many of difference type and various size of data: 2D image, 3D image, sound, text data, etc. Picture below show data be handle:

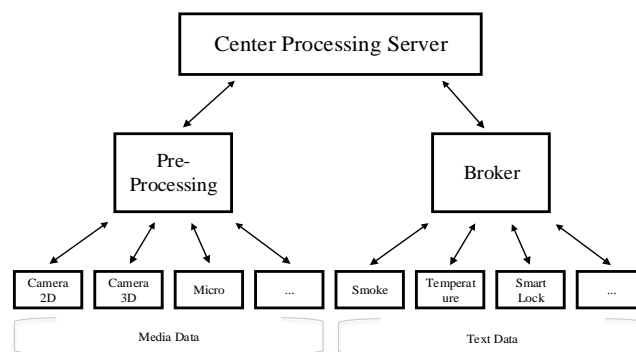


Figure 2: Data collection

With 2D, 3D image and sound data, a strong process of pre-processing always working, anytime it detected target objects, it sends data to server analysis stronger and accurate. Text is a lightweight data, we can easily send to server by a lightweight broker, there are many IoT broker, as an example of evaluate MQTT brokers [7] have significant on message load rate, inspiring on stress testing which can help us easily finish this tasks, broker work as message transfer center, all smart devices and sensor subscribe to channels that they want to get data, broker will broad data to all devices that connected that channel. Now, the picture is clear, all information data are pro-processed and send to analysis module.

Data analysis

This is a heart of platform, this module will proceed receiving, transforming and modeling data with a goal of discovering useful information, informing conclusions and supporting decision making. This module divides into two sub modules: Gateway, Main AI modules. In case the systems scale to hundreds of cameras, smart devices and sensors, so it can reach hundreds of requests send to server at the same time, we use technic Load Balancer on Gateway sub-module to ensure server can handle hundreds of simultaneous requests. Load Balancing used many algorithms support server handle simultaneous by create specific number of process to handle every request asynchronous, as review some of algorithm on [8]. There are many of solution to implement Load Balancing on sever, some popular reverse proxy server (Figure 3): Nginx, Apache, Lighttpd, etc. On test feasibility and performance on web server of these reverse proxy, Nginx show better performance show in on [9].

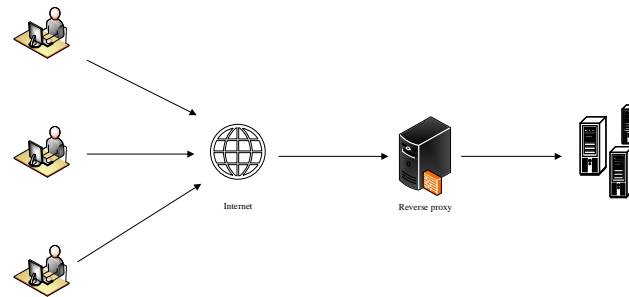


Figure 3: Reverse proxy server

Main AI modules is the brain of decisions, there are a collection of AI modules can be implement such as face recognition, smoke recognition, fire recognition, sound recognition, etc. Every Main AI module is heavy weight and spend a lot of resources, so each module can run independent process. This figure 4 below show a visualize process:

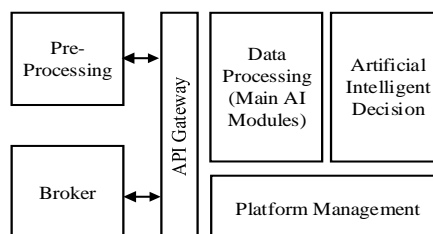


Figure 4: Data process of analysis

This module is design can be easily to adapt more AI sub-modules without effecting the rest. After data analysis and recognition process, conclusions data send to Decision module to control devices.

Decision

This module is center of control smart devices and sensor through brokers. Brokers working as collection data as mention on data collection, it also a center transfer data. There are many broker implement with various protocols. Depend on the infrastructure of existed system, we can easily implement the appropriate broker to help communicate between server, smart devices and sensors. Some popular brokers we can apply for our platform come with its protocol such as Moquistto, HiveMQ brokers come with MQTT protocols, other popular protocols call CoAP, with transport layer runs on UDP that ignore checking error packets, during MQTT run on TCP transport layer [10]. Each technic has each advantages, we can flexible using it on our platform, one more things important is security on communication between smart devices and server, there are few layer security apply on platform: VPN, Transport Layer(TLS), Application Layer (encrypt payload, using username and password). Another aspect, data conclusions coming from Data analysis module will need to verify before broad to devices and sensors. Step to verify base on the data configuration and information store in database. This system is design to compatible with popular database manage systems such as SQL Server, MySql, PostgreSQL, etc.

3. Experiment design

We demonstrate the proposed platform via the application of the security gateway. Many buildings are equipped with CCTV systems for security control. Here we choose Camera IP as the sensor for data acquisition. The Camera IP refers to a digital video camera that can send and receive data via a computer network. Each private access room, office have a IP camera which have it owns publish streaming video, camera can restrict connections from outside and allow some specific server can access for security. Whenever camera connect to LAN, it publishing a port allow specifics server access and get streaming frames in the same LAN. The selected model of Hikvision is DS-2CD2F42FWD-I(W)(S), that have some key features:

- Max. Resolution: 2688x1520
- Frame rate 50Hz: 20fps (2688×1520), 25fps (1920×1080), 25fps(1280×720)
60Hz: 20fps (2688×1520), 30fps (1920×1080), 30fps(1280×720)
- Protocols: TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, Bonjour
- Wireless Standards: IEEE802.11b, 802.11g, 802.11n

The video is then processed by the AI server. The AI server performs the face recognition of the knocker, if the knocker is identified and authorized to enter the server sends an open signal for the smart-lock. The faces in the video frames are extracted by the detector module that is installed in the AI server before sending to the classification module. We installed two approaches of classification:

- **Feature Learning and Face Classification.** In this face detection executed, the human face extracted from the input frames. The framework named SSD applied to do this. SSD does the two in a "single shot", predicting the object location and its class as it processes the image. As it skips the "region proposal" step, it gains significant increase in speed while maintaining high accuracy. SSD has a mAP of 80.0% on PASCAL VOC 2012 test set [11]. The face photo is not directly passed to the classification, but the feature learning where the landmark points extracted [12]. In the feature space the samples are linearly separable. KNN is selected as the classifier.

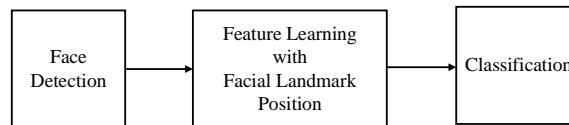


Figure 5: Feature Learning and Face classification

- **Deep convolutional neural network for face classification:** [13]. For this approach, similar to the first approach, the human is also extracted from the photos but CNN provides both of feature extraction and classification in the network. Here we setup 3 convolutional layers for face detection.

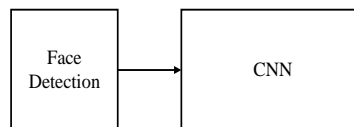


Figure 6: CNN for face classification

A smart lock is an electromechanical lock which is designed to perform locking and unlocking operations on a door when it receives such instructions from an authorized device using a wireless protocol and a cryptographic key to execute the authorization process.

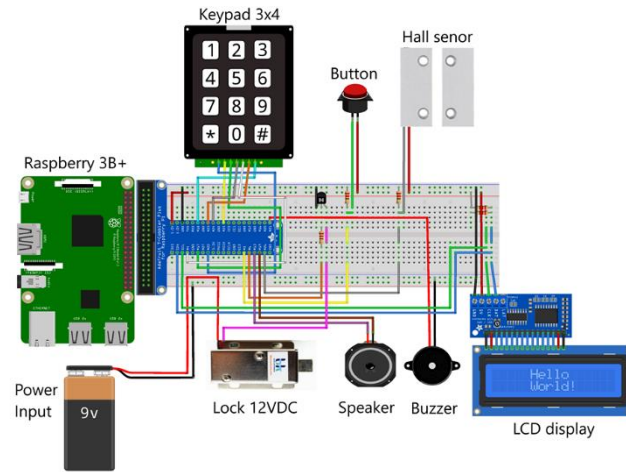


Figure 7: Design of the Smart Lock

4. Result and analysis

With experiment design above, we implement a system to start testing the accurate. This platform has core is classification problems, so we base on ‘Confusion matrix’ also known as an error matrix, is a table with two rows and two cols that reports the number of true positives, true negatives, false positives and false negatives. This table show visualization of performances algorithms and the accurate of systems:

Face Recognition		Predict	
		Positive	Negative
Actual	Positive	TP	FN
	Negative	FP	TN

Base on this table, we can calculate precision that is talk about how precise/accurate your model is out of those predicted positive, how many of them are actual positive:

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

Also base on confusion table, we extract Recall is number answer for how many of the Actual Positive our model capture through labeling it as Positive:

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

As a result, Precision and Recall may have a huge difference value, we need a better measure to seek a balance between them. To event of F1 score to help us on this kind of case. The formula is as follows:

$$F1 = 2 \frac{Precision * Recall}{Precision + Recall}$$

Base on the difference feature of system and algorithm, we divide the test into two main of testing base on F1 score: Performance of systems and Accurate of algorithm.

With Performance of systems, we test set includes with 10 user trained with capturing 1205 faces and 5 users outside with capturing 516 faces. This test is designed with camera stick in the door and the performance is affected directly by user behavior. Following table is result of this case:

Face Recognition		Predict	
		Positive	Negative
Actual	Positive	707	464
	Negative	72	478

From this, we calculate Precision is 0.908 and Recall is 0.604 and so, F1 Score is 0.725. Base on these value, we can say that the accurate of recognition is safety with higher than 90%. Because be affected by user behavior and system, the user faces are not always look directly to cameras, from that Recall number is smaller but it's still accurate by checking user with required high correcting of algorithm. We can adjust parameters of recognition to make Recall higher but that is not real and not accurate for all system. So, Recall can small and we can design system following user behaviors to helps system capture comprehensive of user face. From this experiments, we have F1 score is 0.725.

With Accurate of algorithm test, we test set include with 10 user trained with capture 1567 faces and 5 users outside with capturing 545 faces. This test is designed with 15 videos have length about 26 seconds, we use express 80/20 with 80% for training and 20% for testing. Base on that, each video in the 15 videos divide into 2 shorter video, the first video with length from 20s to 21s second for training and the second video with length from 5s to 6s for testing. Average of each second more than 20 frames, base on the design, the face recognition only run when pre-processing (SSD) detect face, so not all of frame in testing video send to server for recognition. Following table is result for this case:

Face Recognition		Predict	
		Positive	Negative
Actual	Positive	1522	42
	Negative	170	378

From that we calculate Precision is 0.9 and Recall is 0.973 and so, F1 Score is 0.934. Base on these value, we can say that the accurate of recognition is safety with higher than 90%. Compare with Performance of systems on previous phase, we see that Recall is totally

higher, because of designing of testing, faces directly intend to camera. So the server capture covers of face and easier for recognition on this case. To improve the accurate of face recognition, we continuous and studying on 3D Image recognition to have a system work perfectly.

5. Conclusion

In this paper, we have overview of IoT cloud platform of some big software company which are leading trending of technologies in over the world. We brief our IoT platform for safety, security and surveillance to build an ecosystem for permission accessing, checking attendance in short time by face recognition, early alarm for disaster with smoke, fire recognitions. This is the trend of the development of application technologies to apply to the real life: Computer vision, Artificial Intelligent, Internet of Things. To demonstrate our platform, we also have experiment design with IP camera for capturing user face and AI server for recognition, and to determine the accurate of system, we proceed testing base on tw phase and bring a bright result. As mention, our purpose is design a platform, so every part of platform is flexible, easy for adaptive, maintain and even replace by a new component. As we implemented of popular language programming, library, framework, technologies, etc. The platform can easily connect and adapt to available infrastructure and existed system such as BMS of offices, building.

6. References

- [1] Akinduyite C.O, Adetunmbi A.O, Olabode O.O, Ibidunmoye E.O, Fingerprint-Based Attendance Management System, Journal of Computer Sciences and Applications, 2013, Vol. 1, No. 5, 100-105
- [2] Valter Lovati, Guido Palmieri, Stefano Gervasini, Antonio Mario Colombo, "AnID-Card Based Security System for Railway Applications", DOI: 10.1016/j.sbspro.2012.06.1004
- [3] Zhigang Liu and Andrew K. Kim, Review of Recent Development in Fire Detection Technologies, Journal of Fire Protection Engineering, v. 13, no.2, May 2003,pp. 129-149
- [4] Bhumi Nakhuva, Tushar Champaneria,"Study of Various Internet of Things Platforms", DOI:10.5121/ijcses.2015.6605
- [5] Park, H.-A. (2016). Are We Ready for the Fourth Industrial Revolution? IMIA Yearbook, (1), 1–3. doi:10.15265/iy-2016-052
- [6] Hassan, N., Gillani, S., Ahmed, E., Yaqoob, I., & Imran, M. (2018). The Role of Edge Computing in Internet of Things. IEEE Communications Magazine, 1–6. doi:10.1109/mcom.2018.1700906
- [7] Mishra, B. (2018). Performance Evaluation of MQTT Broker Servers. Lecture Notes in Computer Science, 599–609. doi:10.1007/978-3-319-95171-3_47
- [8] Priti Devi, Ritesh Rana. Load Balancing Techniques: A Review, DOI: 10.22214/ijraset.2017.8021

- [9] Rahmad Dawood, Said Fairuz Qiana, Sayed Muchallil, Kelayakan Raspberry Pi sebagai Web Server: Perbandingan Kinerja Nginx, Apache, dan Lighttpd pada Platform Raspberry Pi, DOI: 10.17529/jre.v11i1.1992
- [10] Thangavel, D., Ma, X., Valera, A., Tan, H.-X., & Tan, C. K.-Y. (2014). Performance evaluation of MQTT and CoAP via a common middleware. 2014 IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP). doi:10.1109/issnip.2014.6827678
- [11] W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. E. Reed, C. Fu, and A. C. Berg, “SSD: single shot multibox detector”, CoRR, vol. abs/1512.02325, 2015. arXiv: 1512 . 02325
- [12] Rawat, W., & Wang, Z. (2017). Deep Convolutional Neural Networks for Image Classification: A Comprehensive Review. *Neural Computation*, 29(9), 2352–2449. doi:10.1162/neco_a_00990.
- [13] Park, Y. T., Sthapit, P., & Pyun, J.-Y. (2009). Smart digital door lock for the home automation. TENCON 2009 - 2009 IEEE Region 10 Conference. doi:10.1109/tencon.2009.5396038.

Comparison Survey of Hyperledger's Blockchain Frameworks: Case Study in FPT University's Cryptocurrency Wallets

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Abstract

There are many blockchain frameworks have been introduced to user, developer, and customer and they have to make a decision which one is most suitable for them in order for developing their applications. This paper describes an empirical research to benchmark the properties of frameworks in Hyperledger family. The purpose is to show the advantage & disadvantage of each framework. We apply the deeply study inside the framework and do the experiment to measure the properties as well as give literature and numerical review of each framework. Our results show the status of tested frameworks and do not demonstrate how to employ the framework as well as apply to the detail application. The main contribution of this paper is a statistical analysis of the effectiveness of Hyperledger frameworks as a tool for developer to develop their applications.

CCS Concepts

• **Information systems** → **Data analytics**

Keywords

Fintech, Blockchain, Distributed Ledger Technology, Consensus, Cryptocurrency Wallets, Decentralized Ledger, Hyperledger, Fabric, Sawtooth, Iroha, Indy, Burrow.

1. Introduction

Blockchain is becoming a new technology trend, growing hot and predicting in the future there are plenty of potential applications in other areas not just in the financial sector. Starting with the idea of creating a free cryptographic currency, in order for solving the double-spending problem that is depending on a third party namely bank or intermediary financial institutions, Bitcoin [1], based on the early blockchain technology that created a revolution in the financial sector has made it the center of the world over the past several years. Bitcoin investment fever has invaded the world and turned it into a magical and incredible investment channel, an average person just need to invest a certain amount of Bitcoin early can also become millionaires. A labyrinth of cryptocurrency currencies has surfaced the world financial markets with salient names such as Litecoin, Dogecoin, Blackcoin, Freicoin, Peercoin, Myriad, etc... In order for continuing and improvement of incumbent weaknesses, some of the new derivative technologies built on Bitcoin's fork or its blockchain technology as Namecoin [2], Colorcoin [3], Mastercoin [4] appearing to address Bitcoin's limited issues in other areas of application. However, it has not solved the problem completely until the arrival of Ethereum [5] along with the smart contract concept that it actually created a new revolution in blockchain application, blowing a new breath into the field of crowdfunding and crowdinvesting, creating a booming tsunami for startup companies with blockchain technology like the dotcom phenomenon in the 90s.

Blockchain technology is constantly being improved and it is rapidly applied to a wide range of industries including finance, services, industry, agriculture, and so on. However,

both Bitcoin and Ethereum are public blockchain so they expose the restriction such as the need for transaction fees to pay for the nodes (miners) participating in the consensus network. Moreover, some transactions require privacy as well as processing the block faster in order for conveying more transactions & smart contracts. Blockchain platform also needs to be more open, faster, scalable, flexible allowing kindly developers to contribute more utilities to the blockchain system. For that reason, Hyperledger [6], an open source collaborative effort created to advance cross-industry technologies combining various open source blockchain technologies, incorporates under the auspices of the Linux Foundation, which includes many leading companies in various fields such as finance, banking, IOT, supply chain, manufacturing and technology.

Hyperledger is a block of five open source blockchains, including Fabric [7] (IBM), Sawtooth [8] (Intel), Iroha [9] (Soramitsu), Burrow [10] (Monax), and Indy [11] (Sovrin). These 5 blockchains can be applied to develop applications for different areas, but the accurate assessment of strengths and weaknesses to help programmers choose the appropriate framework developed for the application is limited. So this paper will be one of the first papers to clarify into detail of the frameworks in Hyperledger family. This assessment will be the premise for us to choose the suitable platform to develop cryptocurrency wallet for FPT University in Vietnam.

2. Overview of hyperledger frameworks

Hyperledger is a large cross-industry collaborative effort that supports the open source blockchain framework under the umbrella of the Linux Foundation, which also sponsored Cloud Foundry, Node.js, and Open Container Initiative platform. The figure 1 below describes the green house of Hyperledger. Hyperledger focuses on permissioned blockchain frameworks instead of permissionless to provide maximum support for companies and organizations that want to use blockchain technology to serve their own applications in the process of forming and developing. These five frameworks are Fabric, Sawtooth, Iroha, Burrow and Indy. Hyperledger also adds support for project utilities that support the maximum developer experience with frameworks such as Cello, Composer, Explorer, Quilt, and Caliper, where Cello is used to simplify the process of operating the framework. In Hyperledger, it provides on-demand "as a service" and dashboard for maintaining statistic and status monitoring of the blockchain system. Composer is a toolset and framework that integrates blockchain applications with built-in business systems that quickly use cases and

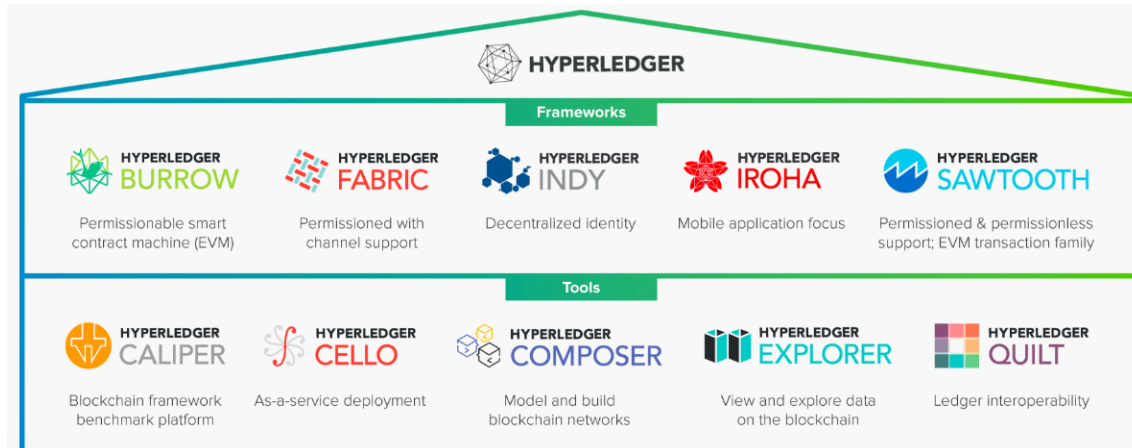


Figure 1: Hyperledger Green House. Images from www.hyperledger.org

solutions, leaving the composer alone. The third tool in the Hyperledger family is Explorer, whose task is to view and retrieve transactions, blocks, node logs, statistic, and smart contracts in the network through the dashboard. Due to lack of the cryptocurrency, the Quilt tool is supplemented to Hyperledger as the payment protocol with the purpose to transfer values across distributed ledger and non-distributed ledgers. The last and most recent member is Caliper, a benchmarking tool that evaluates the performance of frameworks within Hyperledger, giving developers an accurate view of each framework and the ability to choose the framework suitable for the purpose of developing their application. This section will focus on the most prominent features of the five frameworks, Fabric, Sawtooth, Iroha, Burrow and Indy, based on the material provided by Hyperledger as well as from previous researches of other scientists.

A. Fabric

Fabric [12] is a modular and extensible general-purpose permissioned open-source blockchain framework that introduces a new blockchain architecture aiming at resiliency, flexibility, scalability, and confidentiality. Fabric does not use the domain-specific languages and native crypto currency, it is the first blockchain system to support the execution of the distributed applications written in standard programming languages that makes Fabric the first distributed operating system [13] for permissioned blockchain in deed.

The main innovation in Fabric architecture is mixed of hybrid replication design which is passive and active replication in the Byzantine model and the execute-order-validate paradigm. Fabric implements its architecture by containing modular building blocks for their components including ordering service, membership service provider (MSP), peer-to-peer gossip, smart contracts, and append-only blockchain ledger.

Transactions/Smart contracts (Data Model Layer): With respect to a distributed application, Fabric embraces two parts:

- A smart contract in Fabric which is called chaincode, corresponding to Solidity in Ethereum, that is standard program code written by Go or Java implements the application logic as well as runs during the execution phase.
- An endorsement policy which is gauged in the validation phase acts as a static library for transaction validation in Fabric and can merely be parameterized by the chaincode. A client sends transactions to the peer specified by the endorsement policy and each transaction is then executed by specific peers and its output is recorded. After execution, transactions enter the ordering phase that employs a pluggable consensus protocol to produce a totally ordered sequence of endorsed transactions grouped in blocks. Each transaction contains state updates and dependencies computed during the execution phase along with cryptographic signatures of the endorsing peers.

Blocks (Data Model Layer): Fabric's blocks are broadcast to all peers, with the (optional) help of gossip. It orders transaction outputs combined with state dependencies, as computed during the execution phase. Blocks in Fabric chain consists of three segments which are Header, Data, and MetaData.

Nodes/Blockchain (Execution Layer): A Fabric blockchain encompasses a set of nodes that form a network. Fabric is permissioned so all nodes that participate in the network, have an identity as provided by a modular MSP. Nodes in a Fabric network hold one of three roles:

Clients: Submit transaction proposals for execution, and finally broadcast transactions for ordering.

Peers: Execute transaction proposals and validate transactions. All peers maintain the blockchain ledger however only a subset of them called endorsing peers (endorser) execute all transaction specified by the policy of the chaincode to which the transaction pertains.

Ordering Service Nodes (OSN or orderers): The nodes that collectively form the ordering services. In short, they establish the total order of all transactions in Fabric.

Consensus (Consensus Layer): Fabric handles the consensus by Kafka algorithms. The actual atomic broadcast function is provided by an instance of Apache Kafka [14] which offers scalable publish-subscribe messaging and strong consistency despite node crashes based on ZooKeeper. Kafka may run on physical nodes separate from the OSNs.

Distributed Ledger Technology (DLT) (Consensus Layer): The ledger's component at each peer maintains the ledger and the state on persistent storage as well as enables simulation, validation, and ledger-update phases. Broadly, it consists of a block store and a peer transaction manager.

The *ledger block store* persists transaction blocks and is implemented as a set of append-only files.

The *peer transaction manager (PTM)* maintains the latest state in a versioned key-value store that comprises one tuple of the form (key, val, ver).

B. Sawtooth

Sawtooth [8] is a framework for building enterprise-grade distributed ledgers applying in both permissionless and permissioned blockchain. It was designed with a focus on security, scalability, and modularity. The Sawtooth architecture encompasses five core components:

- Peer-to-peer network: passing messages and transactions between nodes
- Distributed log: contains an ordered list of transactions
- State machine/smart contract logic layer: processing the content of those transactions
- Distributed state storage: storing the resulting state after processing transactions
- Consensus algorithms: achieving consensus across the network on the ordering of transactions and the resulting state

Sawtooth makes it easy to develop and deploy an application by providing a clear separation between the application level and the core system level. It is the only framework that provides the ability to create adapters for any kind of transaction logic which means, for instance, that you can now run Ethereum Virtual Machine (EVM) code, like Solidity, compile it and then run that on a Sawtooth based network

Transactions/Smart contracts (Data Model Layer): Sawtooth provides smart contract abstraction that allows application developers to write contract logic in a language of their choice. An application can be native business logic or a smart contract virtual machine and multiple types of applications have existed in the same instance of the blockchain network. Sawtooth introduces several example transaction families to serve as models for low-level functions (IntergerKey, Settings, Identity, Smallbank, Blockinfo). Transactions are always wrapped inside a batch. All transactions within a batch are committed to state together or not at all. Thus, batches are the atomic unit of state change.

Blocks (Data Model Layer): Blocks and chains in Sawtooth are managed by Journal, a group of Sawtooth core processes that are responsible for maintaining and extending the blockchain for the validator. The Journal is the consumer of Blocks and Batches that arrive at the validator. These Blocks and Batches arrive via interconnect, either through the gossip protocol or the REST API. The newly-arrived Blocks and Batches are sent to the Journal, which routes them internally. Journal guarantees that the block is completed as well as maintains the unique finality chain and to avoid the fork.

Nodes/Blockchain (Execution Layer): Sawtooth organizations run a node that interacts with the Sawtooth network. Each node runs at least three things:

- The main validator process
- The REST API service listening for requests
- One or more transaction processors

Nodes of Sawtooth are in one of two roles:

Clients: Submit transaction proposals for execution, and finally broadcast transactions for ordering. Sawtooth has SDKs for most of the major languages such as Python, Go, Javascript, Rust, Java, and C++.

Validator: The central entity in this system performing all network and storage operations. When the validator receives a new transaction it is passed to one of the connected transaction processors. The transaction processor is an entity which is communicating to the validator and contains a bunch of transaction handlers (smart contract).

Consensus (Consensus Layer): The interface supports plugging in various consensus implementations. More importantly, Sawtooth allows different types of consensus on the same blockchain. Sawtooth currently supports DevMode, PoET [\[15\]](#) (Nakamoto style), PoET Simulator, and RAFT (under development) consensus implementations. The framework has a built-in implementation of consensus called DevMode for testing purpose and also uses proof-of-elapses-time (PoET), a lottery-like algorithm for the remaining.

Distributed Ledger Technology (DLT) (Consensus Layer): Any data needing to be persisted is stored in the on-chain key-value storage distributed among the network of validators. This storage allows any binary data to be stored in it. Each block on the blockchain is linked by a cryptographic hash to the previous block.

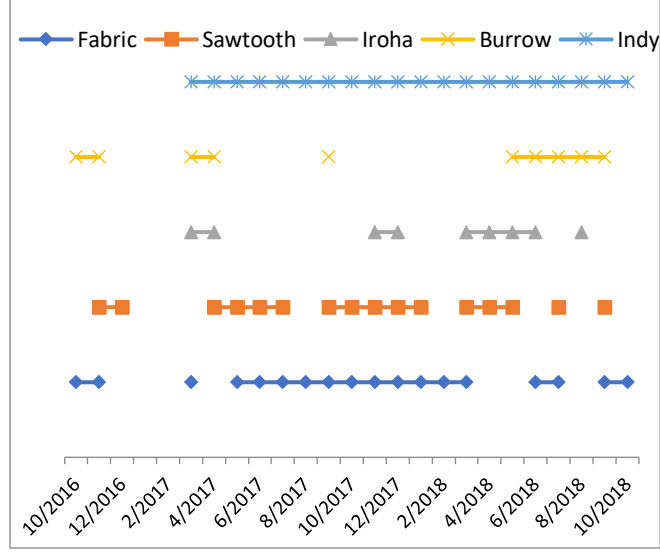


Figure 2: Release frequency of Hyperledger’s frameworks (From top to bottom: Fabric, Sawtooth, Iroha, Burrow, Indy)

C. Iroha

Iroha [9] is a blockchain framework contributed by Suramitsu, Hitachi, NTT Dat and Colu in order to simple and easy to incorporate into infrastructure project requiring distributed ledger technology. Iroha features a simple, modern construction, has a domain-driven C++ design, with an emphasis on mobile application development, and it comes with the YAC [16] consensus algorithm called Sumeragi. Iroha architecture can be revised by 4 layers following:

- API level: *Torri* (gate) provides the input and output interfaces for clients. *Model* classes are system entities.
- Peer interaction level: *Network* encompasses interaction with the network of peers. The *Consensus* is in charge of peers agreeing on chain content in the network.
- Chain business logic level: *Simulator* generates a temporary snapshot of storage to validate transactions. *Validator* classes check the business rules and validity (correct format) of transactions or queries. *Synchroniser* helps to synchronize new peers in the system or temporarily disconnect peers.
- Storage level: *Ametsuchi* is the ledger block storage which consists of a block index, block store, and a world state view component.

Transactions/Smart contracts (Data Model Layer): Iroha supports both push and pull interaction mode with a client. A client that uses pull mode requests status updates about transactions from Iroha peer by sending transaction hashes and awaiting a response. In contrary push, interaction is done over the listening to an event stream for each transaction. In any of these modes, the set of transaction statuses is the same. Iroha also provides a batch of transactions that allows sending several transactions to Iroha at once preserving their order. Batch can contain transactions created by different accounts. There are two kinds of atomic and order batch.

Blocks (Data Model Layer): Transaction data is permanently recorded in files called blocks. Blocks are organized into a linear sequence over time (also known as the blockchain). Blocks are signed with the cryptographic signatures of Iroha peers, voting for this block during consensus. Signable content is called payload, so the structure of a block looks to consist of outside (hash, signatures) and inside (height, timestamp, body, transaction quantity, previous hash) payload.

Nodes/Blockchain (Execution Layer): There are three main participants in an Iroha network. *Clients:* can query data, perform a state-changing action or transaction.

Peers: maintain the current state and their own copy of the shared ledger. A peer is a single entity in the network and has an address, identity, and trust.

Ordering service: orders transactions into a known order. There are a few options for the algorithm used by the ordering service.

Consensus (Consensus Layer):

Iroha currently implements the YAC consensus algorithm, which is based on voting for block hash. The YAC performs two functions: ordering and consensus.

Distributed Ledger Technology (DLT) (Consensus Layer): Iroha introduced the Ametsuchi that is Iroha storage component, which stores blocks and a state generated from blocks, called World State View. There is no way for the client to directly interact with Ametsuchi.

D. Burrow

Burrow [10] is a permissioned blockchain framework that executes Ethereum EVM smart contract code (Solidity) on a permissioned virtual machine. Burrow provides transaction finality and high transaction throughput on a proof-of-stake Tendermint [17] consensus engine. Burrow as a node is constructed out of three main components: the consensus engine, the permissioned Ethereum virtual machine, and the rpc gateway. Burrow is the open-source blockchain framework that is incomplete since managing multiple chains has to be purchased from Monax [20].

Transactions/Smart contracts (Data Model Layer): Transactions are validated and applied to the application state in the order that the consensus engine has finalized them. The application state consists of all accounts, the validator set, and the name registry. Accounts in Burrow have permissions and either contain smart contract code or correspond to a public-private key pair.

Blocks (Data Model Layer): Blocks in Burrow is built in part to the specification of Ethereum Virtual Machine (EVM).

Nodes/Blockchain (Execution Layer): Nodes in Burrow is also using the same as Ethereum.

Consensus (Consensus Layer): Burrow currently employs the Tendermint consensus engine which implements documented consensus and p2p protocols. The Tendermint consensus engine is a separate project which utilized as a dependency of Burrow. Burrow is focusing on to be the user of consensus engines and go forward to support “pluggable consensus”.

Distributed Ledger Technology (DLT) (Consensus Layer): Burrow can be deployed in any environment but almost focussed on deploying related sets of validators (or validator pools) using Kubernetes/Helm.

E. Indy

Indy [\[11\]](#) is a distributed ledger, purpose-built for decentralized identity. It provides tools, libraries, and reusable components for creating and using independent digital identities rooted on blockchains or other distributed ledgers so that they are interoperable across administrative domains, applications, and any other “silo.” Indy code is dependent from but commonly associated with Sovrin Foundation that built on top of this code base. However, it is possible to use Indy Node with a different network.

Transactions/Smart contracts (Data Model Layer): Indy support client to send transaction as well as a batch of transactions.

Blocks (Data Model Layer): Indy provides zero-knowledge proof a revocation model for cases where those verifiable claims are no longer true.

Nodes/Blockchain (Execution Layer): Node in Indy consists of one of three roles:

Client: Submit transaction proposals for execution.

Validator: The leader which determines the order of transactions and communicates it to the rest of the nodes

Observer: Follower, the node that follows the communication.

Consensus (Consensus Layer): Indy has its own distributed ledger based on RBFT [\[18\]](#).

Distributed Ledger Technology (DLT) (Consensus Layer): Ledger in Indy is managed and controlled by Sovrin [\[19\]](#).

3. Related works

Table 3: Feature comparison of Hyperledger blockchain frameworks

	Fabric	Sawtooth	Iroha	Burrow	Indy
Interfaces	Based on SDK of Fabric to develop API or using Composer tool. ***	Supported using REST API Separate between Application Level and Core System. ***	Supported by Torii, a single gRPC server. *	Supported rpc gateway (need to clarify more)	Supported indy-sdk
Network Deployment	Installing through Docker, need to install Docker Swarm. **	Installing through Docker, Ubuntu, or Kubernetes. ***	Installing through Docker. **	Using Kubernetes (need to clarify)	Installing the network through Docker using with new libindy-based CLI.
Transaction Hashes	Merkle tree (SHA256) *	Radix Merkle tree (SHA512) **	Merkle tree (SHA3 512) **	Patricia Tree (Ethereum) **	Merkle Patricia Trie (SHA256) *
Transaction Privacy	Supported across channels but not within a channel even when using privateDB *	Transaction privacy is controlled in validator *	No	No	No
Multi-tenancy	Supported using channels **	Supported using Journal **	Supported using Ordering Gate *	No	No
Smart-Contract	Chaincode (Golang, Java, NodeJS) ***	Transaction Processor Can be coded arbitrary languages (Go, Python, Node.js, Solidity) ***	No	Solidity (EVM) Based on Ethereum *	No
Consensus	- Pluggable - Trusted Solo - Crash fault tolerant Kafka **	- Pluggable - PoET - PoET Simulator - Dev mode	Sumeragi (YAC) Voting-based *	- Tendermint - support pluggable in coming time	- Pluggable - RBFT

In the past, many researchers were conducted to evaluate the literature and numerical review in different blockchain frameworks. In a related work, Croman et. al. [21] proposed and divided blockchain into several planes: network, consensus, storage, view, and side plane. However, Croman only focusses on the public or permissionless blockchain framework such as Bitcoin, Ethereum that discussed cryptocurrency applications and did not take into account the execution of smart contract. Based on the experiment of Croman, T. T. A. Dinh et. al. [22], [23] developed a benchmark framework called Blockbench that is used to compare and analysis private or permissioned blockchain frameworks. They employ the layer terminology and divide the blockchain frameworks into four layers following: Consensus, Data Model, Execution, and Application layer. They also collect and define more smart contracts which are used to test the performance of permissioned blockchain frameworks. The workload is separated into two parts: Macro (YCSB, Smallbank) and Micro (IOHeavy, CPUHeavy, Analytics, and DoNothing) benchmark. They did the test on Ethereum, Parity, and Hyperledger and got several decisions about Hyperledger:

- Hyperledger performs consistently better than Ethereum and Parity across the benchmarks. But it failsto scale up to more than 16 nodes and the main bottlenecks in Hyperledger are the consensus protocols.
- Hyperledger’s data model is low level, but its flexibility enables customized optimization for analytical queries of the blockchain data.

Refined from both Blockbench and [27], Parth et. al [24] also performed a comprehensive empirical study to characterize the performance of Hyperledger Fabric and identify potential performance bottlenecks to gain a better understanding of the Fabric’s system. They had got identified three major performance bottlenecks of Fabric: (i) crypto operation, (ii) serial validation of transactions in a block, and (iii) multiple REST API call to CouchDB.

Our contribution in this study is also based on the continuing of the studies above. However, we focus on comparing the performance of five blockchain frameworks instead of for each one. We only focus on the permissioned blockchain framework instead of permissionless one and we also do the researches on Hyperledger family only.

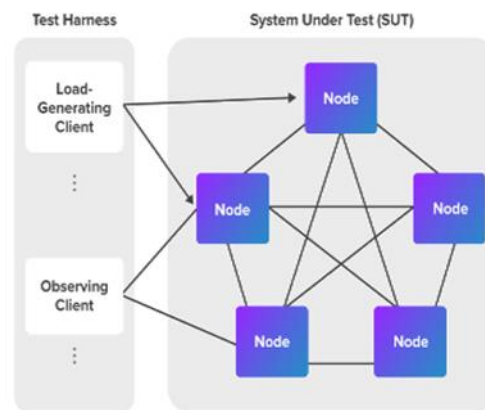


Figure 3: Typical Configuration for a Blockchain Performance Evaluation. Image from HPSWG.

4. Experimental design

In this study, we also apply similar benchmark metrics based on the Parth et. al.'s method, however, we not only focus on Fabric, but also do the research and benchmark on Hyperledger family's frameworks and lean upon Hyperledger's Caliper [25] tool to measure the performances. We try to evaluate performance for each framework and make a comparison in both literature and numerical review.

Non-technique metrics

All these blockchain frameworks have been designed to allow a user to create and manage their own blockchain applications. However, these frameworks are diversity so developers

Table 4: Computer Configuration

Computer 1	Computer 2	Computer 3	Computer 4	Computer 5	Computer 6
core i7-4720hq 2.6~3.6GHz, 16Gb ram, 128Gb HDD, Ubuntu 18.04, Docker 18	core i7-4720hq 2.6~3.6GHz, 16Gb ram, 90Gb HDD, Ubuntu 16.04, Docker 18	core i7-4710U 1.7GHz, 6Gb ram, 30Gb SSD, Ubuntu 16.04, Docker 18	i5-5200U 2.20Ghz,8GB RAM, 140GB HDD, Ubuntu 16.04, Docker 18	i7-7500U 2.70Ghz, 8GB RAM, 140GB HDD, Ubuntu 16.04, Docker 18	core i7-7600U 2.8Hz,16GB RAM, 80GB SSD, Ubuntu 16.04, Docker 18

are difficult to be considered how to choose a suitable framework. Thus we are going to provide a qualitative comparison of a selected number of essential features supported by each one. We define a list of non-technique metrics:

- Interfaces
- Network deployment
- Transaction hashes
- Transaction privacy
- Multi-tenancy
- Smart contract
- Consensus
- Zero knowledge proof
- Access control
- PrivateDB within a chain
- Database & Query
- Storage/Blocksize
- Release frequency
- License

Technique metrics

There are two kinds of measurement the characteristics of a blockchain framework that is performance evaluation and benchmarking [26]. Performance evaluation is the process of measuring the performance of a system under test (SUT). This evaluation covers system-wide measures (latency) or measure-specific activities (throughput) with the goal is to understand and document the performance of the system or the subsystem being tested when dependent variables are altered. On another hand, Benchmarking is the process of making standard measurements to compare one system to another or to previous measurements of the same system.

We employ Benchmarking in this study to compare the performance between frameworks. Because of the five frameworks we tested, the Caliper tool supports only three frameworks Fabric, Sawtooth, Iroha. Iroha framework cannot be measured due to an error with Node.js inside, so we temporarily announce the experimental results of both Fabric and Sawtooth.

We use two types of metrics Throughput and Latency to do experiments.

Transaction Latency

$$\text{Transaction Latency} = (\text{Confirmation time @ network threshold}) - \text{submit time}$$

Transaction Latency is a network-wide view of the amount of time taken for a transaction's effect to be usable across the network. The measurement includes the time from the point that it is submitted to the point that the result is widely available in the network. This includes the propagation time and any settling time due to the consensus mechanism in place.

To account for both of those factors and give the network-wide view, the delay should be measured using all nodes in the SUT. Eyal et al [28] provide a helpful definition for the amount of time for a percentage of the network to commit the transaction.

Transaction Throughput

$$\text{Transaction Throughput} = \text{Total committed transactions} / \text{total time in seconds @ \#committed nodes}$$

Transaction throughput is the rate at which valid transactions are committed by the blockchain SUT in a defined time period. Note that this is not the rate at a single node, but across the entire SUT, i.e. committed at all nodes of the network. This rate is expressed as transactions per second (TPS) at a network size.

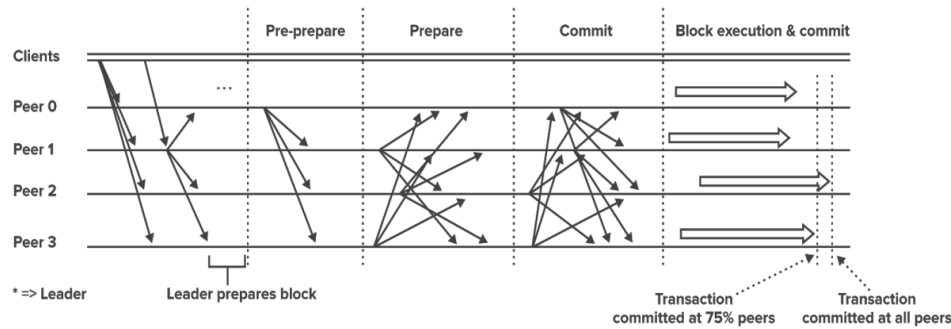


Figure 4: Transaction Flow for Blockchain Platforms using Consensus. Image from HPSWG.

Our test framework consists of 6 computers which are installed frameworks respectively. The configuration of 6 computers is described in Table 2.

5. Results

5.1 Literature reviews

We summarized our finding in Table 1.

Network Deployment. This is the first obstacle that we find when we want to deploy our own blockchain network. In our experience, the easiest to deploy is Fabric because we only need to install Docker image and Docker Swarm on each computer and connect them to a cluster. Sawtooth does not have detailed instructions on how to set up a network, so it is a bit difficult. Iroha has got an error with Node.js so we are going to develop a tool coding by Python to implement the measures. Burrow and Indy will be defined after Iroha is implemented.

Interfaces. Fabric and Sawtooth support the API, Fabric provides an SDK that allows developers to develop APIs, and Sawtooth supports the REST API for blockchain networking applications. Iroha is a bit more complicated than Torii. Burrow and Indy also support the SDK, but are a bit more complicated.

Transaction Hashes. The security and storage of transaction information are important, so all frameworks use cryptographic algorithms. Fabric uses SHA256 and Sawtooth and Iroha all use SHA512. While Burrow and Indy use SHA256 with Patricia Tree in storage.

Multi-tenancy. Fabric supports multi-tenancy through channels. Sawtooth does not split into channels like Fabric that support multi-tenancy through Journal, all types of transactions / smart contracts are included in a common chain. Iroha uses Ordering gate to support multi-tenancy. The two remaining frameworks Burrow and Indy do not support.

Smart Contract. Fabric develops Chaincode based on common languages such as Golang, Java, Node.js to support smart contracts similar to Ethereum's Solidity. Sawtooth introduced the Transaction Processor concept within the Validator to perform the smart contract task, which now allows developers to use Golang, Python, Node.js, and even Solidity. Burrow uses Ethereum's smart contract, while Iroha and Indy are hardly mentioned.

Consensus. Fabric, Sawtooth, and Indy allow for the use of multiple consensus mechanisms what is called pluggable. Fabric mainly support is Kafka, while Sawtooth uses PoET. Iroha is based on Sumeragi and Burrow uses Tendermint. Burrow is intent on developing more pluggable functionality.

Database and query. Only Fabric and Iroha use the database to store the string, the rest of the frameworks use file storage. Fabric supports both CouchDB and LevelDB while Iroha uses PostgreSQL.

License. The frameworks in Hyperledger are open source. Only Burrow is an open-source version not entirely due to being dependent on Monax.

5.2 Numerical reviews

We performed benchmarking on two frameworks, Fabric and Sawtooth. Setting up the blockchain network for the Fabric is relatively well documented as well as some other scientists have done. Sawtooth is more difficult because there have been few or no blockchains network set up guidelines.

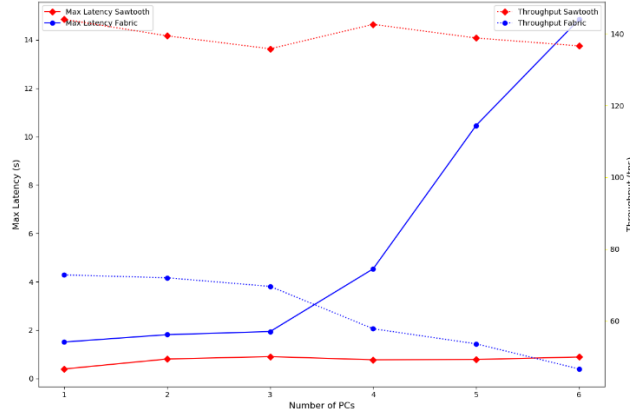


Figure 5: Benchmarking of Fabric vs Sawtooth

Both of our frameworks use Docker as the foundation. Fabric only allows each node to send a maximum of 130 transactions, which makes it difficult to test large numbers of transactions due to the need to mobilize multiple machines. Sawtooth has no limitations on the number of transaction, but is influenced by the protocol passing ports 4004, 8008, which results in a jagged transaction graph. The other 3 frameworks we have not been able to build up the network to test should be temporarily not included. We will update the results in the next update.

Based on the graph showing the results of the two frameworks with two metrics, throughput, and latency, we can draw some conclusions: Fabric's latency increases rapidly as the number of nodes increases, while Sawtooth maintains a stable level. Fabric throughput is slightly reduced by increasing the number of machines, which is explained by the fact that when increasing the number of nodes the network processing capacity increases as well, while Sawtooth retains each processor separately. Not dependent on other validators.

6. Conclusion

This research is one of the first experiments to apply the comparison between frameworks in the Hyperledger family. The purpose of this study is to look at the strengths and weaknesses of each framework and then, depending on the applications, select the appropriate framework for developing specific applications.

Comparison between the two charts of the two frameworks shows that Sawtooth has a better performance when increasing the number of nodes. However, this does not say too much about Sawtooth's advantages over Fabric since the experiment cannot test sending transactions from different machines. The previous IBM research labs [12] and Qassim et. al. measured Fabric produced the maximum throughput value of 2500 to 3000 tps. However, with respect to set up the blockchain network, the Fabric scored more points than Sawtooth.

The result of the research can contribute to the programmer who wants to make a decision on how to choose a suitable blockchain framework.

This study is limited to measure two frameworks only. The other three remaining frameworks we have not been able to build up the network to test should be temporarily not included. We will update the results in the next update.

In the next phase, it is the need to select the based-framework to construct the FPT University's cryptocurrency wallets. There are several directions to perform the selection process. We are interested in the idea proposed by Ngo et al in their team selection problem [30], they find the solution that is the minimum distance to the pre-defined boundary without adding additional parameters in decision-making process. In the case of framework selection, the bound point is quite simple to be determined.

7. References

- [1] Nakamoto, Satoshi: Bitcoin: A Peer-to-Peer Electronic Cash System. 2008. <http://bitcoin.org/bitcoin.pdf>
- [2] Namecoin. <https://namecoin.org/>. [Accessed: 20-Nov-2018]
- [3] Colorcoin. https://docs.google.com/a/buterin.com/document/d/1AnkP_cVZTCMLIzw4DvsW6M8Q2JC0IIzrTLuoWu2z1BE/edit
- [4] Mastercoin. <https://github.com/mastercoin-MSC/spec>. [Accessed: 20-Nov-2018]
- [5] Vitalik Buterin et al. Ethereum white paper: A next-generation smart contract and decentralized application platform.2013. <https://github.com/ethereum/wiki/wiki/White-Paper>.
- [6] Hyperledger Whitepaper Working Group: An Introduction to Hyperledger. <https://github.com/hyperledger/hyperledgerwp/blob/master/paper.pdf>.
- [7] Fabric documentation. <https://hyperledger-fabric.readthedocs.io/en/latest/whatis.html> [Accessed: 20-Nov-2018]
- [8] Sawtooth documentation. <https://sawtooth.hyperledger.org/docs/core/releases/latest/contents.html> [Accessed:20-Nov-2018]
- [9] Hyperledger Iroha documentation: <https://iroha.readthedocs.io/en/latest/index.html> [Accessed: 20-Nov-2018]
- [10] Burrow documentation. <https://github.com/hyperledger/burrow/blob/master/README.md> [Accessed: 20-Nov-2018]
- [11] Indy documentation. <https://github.com/hyperledger/indy-node#how-to-contribute> [Accessed: 20-Nov-2018]
- [12] Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains. <https://arxiv.org/pdf/1801.10228.pdf>
- [13] Dependable Systems and Networks (DSN), 2018.
- [14] A. S. Tanenbaum. Distributed operating systems anno 1992. what have we learned so far? Distributed Systems Engineering, 1(1):3–10, 1993
- [15] Apache Kafka. <http://kafka.apache.org>. [Accessed: 20-Nov-2018]
- [16] PoET. <https://sawtooth.hyperledger.org/docs/core/releases/latest/architecture/poet.html> [Accessed: 20-Nov-2018]

- [17] YAC: BFT Consensus Algorithm for Blockchain. <https://arxiv.org/pdf/1809.00554.pdf>
- [18] Tendermint: Consensus without mining. <https://tendermint.com/static/docs/tendermint.pdf>
- [19] Pierre-Louis Aublin, Sonia Ben Mokhtar, Vivien Quema. RBFT: Redundant Byzantine Fault Tolerance. <https://pakupaku.me/plaublin/rbft/report.pdf> [Accessed: 20-Nov-2018]
- [20] Sovrin. <https://sovrin.org/wp-content/uploads/2018/03/Sovrin-Protocol-and-Token-White-Paper.pdf>
- [21] Monax. <https://monax.io/platform/> [Accessed: 20-Nov-2018]
- [22] K. Croman, C. Decker, I. Eyal, A. E. Gencer, A. Juels, A. E. Kosba, A. Miller, P. Saxena, E. Shi, E. G. Sirer, D. X. Song, and R. Wattenhofer. On scaling decentralized blockchains. 2016. <https://fc16.ifca.ai/bitcoin/papers/CDE+16.pdf>
- [23] Tien Tuan Anh Dinh, Ji Wang, Gangchen, Rui Liu, Beng Chin Ooi, Kian-Lee Tan. Blockbench: A framework for Analyzing Private Blockchains. <https://www.comp.nus.edu.sg/~ooibc/blockbench.pdf>
- [24] Tien Tuan Anh Dinh, Rui Liu, Meihui Zhang, Gang Chen, Beng Chin Ooi, Ji Wang. Untangling Blockchain: A Data Processing View of Blockchain Systems. <https://arxiv.org/pdf/1708.05665.pdf>
- [25] Parth Thakkar, Senthil Nathan N, Balaji Viswanathan. Performance Benchmarking and Optimizing Hyperledger Fabric Blockchain Platform. <https://drive.google.com/file/d/1OsIoPtlv5X2PWYOAIDn1FCnHCZPyrF57/view>
- [26] Caliper. <https://github.com/hyperledger/caliper> [Accessed: 20-Nov-2018]
- [27] Hyperledger Blockchain Performance Metrics White Paper. <https://docs.google.com/document/d/1c3j8PRcJq99IY05k0QxZbnLRDi6btFqEIdjQaRf20jQ/edit#heading=h.e27dvpmmc47q> [Accessed: 20-Nov-2018]
- [28] Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchain. <https://arxiv.org/pdf/1801.10228.pdf>
- [29] Ittay Eyal, Adam Efe Gencer, Emin Gün Sirer, and R. Van Renesse. Bitcoin-NG: A Scalable Blockchain Protocol. Usenix Conference on Networked Systems Design and Implementation, ser. NSDI'16. Berkeley, CA, USA. USENIX Association. 2016. pp. 45–59
- [30] Qassim Nasir, Ilham A. Qasse, Manar Abu Talib, and Ali Bou Nassif. Performance Analysis of Hyperledger Fabric Platforms. <https://doi.org/10.1155/2018/3976093>
- [31] Ngo Tung Son, Tran Binh Duong, Bui Ngoc Anh, Le Van Thanh. A Decision Support Tool for Cross-Functional Team Selection: Case Study in ACM-ICPC Team Selection. <https://doi.org/10.1145/3277139.3277149>

Combination of Facial Recognition and Interaction with Academic Portal in Automatic Attendance System

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Abstract

The computer vision has been advancing rapidly recently and it has become necessary to use the technology in the education area. As a part of it, the application of facial recognition technology plays an important role in building the intelligent education system, where teaching and learning can be measured to support quality improvement. The required attendance-taking activity at the schools is one of the important parts of the teaching process. The traditional attendance method causes several inconveniences such as waste of time and effort, easy to mistake and difficult to verify. In this paper, we introduce an automatic attendance system based on the combination of facial recognition technology and interaction with the existing academic portal. We conducted a review of several modern methods to select the most suitable open framework for individual tasks. Our proposed design is flexible and be able to apply to the large-scale set of students without compromising predictive accuracy. We have tested the system on more than 2200 freshmen at FPT University in Hanoi, Vietnam. Initial numerical results show the effectiveness in both aspects of the accuracy and performance of the prototype.

CCS Concepts

• Information systems → Database

Keywords

Facial Recognition, Face Detection, Features Extraction, Classification, Automatic Attendance System, Academic Portal.

1. Introduction

In recent years, the significant advances in artificial intelligence technology, especially in computer vision, have increasingly become important in many areas. Teaching activity is not an exception. Demand for computer vision applications to support the teaching activity become indispensable. The computer will support teaching activities such as evaluating learners' attitudes, providing statistics so that trainers can find appropriate strategies to improve the quality of the lecture. Many universities are using the Learning Management System (LMS) for learning management such as Moodle [1] as part of their information systems. The manual approach for attendance taking is mainly maintained by recording in the academic portal. The lecturer has to manually check the presence of the students. There are some problems with the traditional attendance process:

- [32] Time and effort consumption: to gain insight into their perspective on the current attendance system.
- [33] Logging and Verifying: The quality assurance department does not really have the tools to effectively track the class attendance.

1.1 Existing solutions

There are many previous studies that have proposed solutions for the attendance system. For example, Akinduyite et al using fingerprint technology [2]. The attendance taking activity performed by identifying fingerprints, which is biometric technology is high accuracy, but it may be difficult to re-use investment for other purposes in many cases. Some others researcher proposes to identify students using external devices such as Moksini et al introduce a wireless student attendance system [3]. They combine the wireless technology to trace, store and transfer of data to the host computer. Kassim's propose an attendance system based on RFID card. These systems may not be reliable enough, because it does not go a mechanism for validating the bearer of the device as the owner effectively [4]. Noguchi et al [5] introduce a system that works by scanning student ID cards over not only the teacher's terminal device but also the student's personal Android devices. The system is reliable but the time consumption problem we mentioned was not resolved. Jie Yin et al develop a human identification system via unsupervised feature learning use ultra-wideband sensors [6]. This idea is very interesting but it is not suitable for attendance taking due to the system accuracy. Yohei et al introduced an attendance system based on face recognition, they use both of RGB camera and fiscal eye camera to recognize and identify the position of the student [7]. Their solution is matching with the context of attendance talking in the class, however, the accuracy of the proposed method does not satisfy the requirement because they did not consider the combination of the developed system with other available resources. There are many other studies, but after considering different technologies, we found that the attendance system based on facial recognition is suitable for many reasons: (1) the development of deep learning in computer vision allows the system to deliver results with high accuracy. (2) The system provides logs with high reliability that is convenient for verifying the student attendance. (3) The system can operate automatically and suitable for integration with other intelligent systems in the future. (4) A combination of computer vision and LMS can delineate to increasing the recognition accuracy and leverage available resources.

1.2 Face recognition overview

The face recognition [8] is a biometric technology that allows identifying a person through a digital image or a video frame. The face recognition-based systems can work independently and mostly are automatic. Figure 1 shows 4 steps of face recognition:

- 1: *Face detection: Face detection is performed on the input image to locate the faces in the input frame.*
- 2: *Feature extraction: The key features of each detected face are extracted and all redundant data is discarded.*
- 3: *Identification: The classification algorithms are executed on the feature data to assign labels to the unlabeled faces.*
- 4: *Verification: Using the results from the identification phase, this phase reviews how confident the identification was*

There are many open frameworks of face recognition. Most of them showed very good detection and identification results. We made a review of them, to select the appropriate.

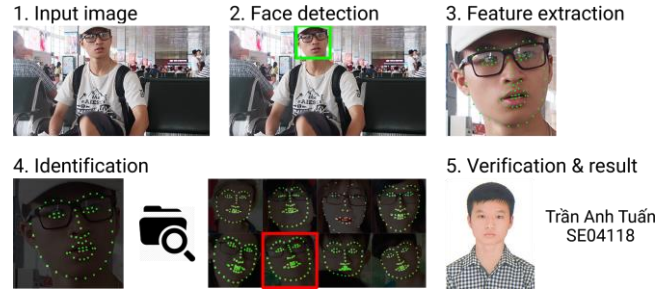


Figure 1: The face recognition process

2. Proposed system

2.1 System architecture

In this paper, we introduce an automatic attendance system interactive with LMS based on face detection and recognition techniques, called FAS. The system is divided into three modules that sorted by the processing steps of the system:

- 1: *Data collection*: Each class will be equipped with IP cameras, which transmit signals to the Streaming Server. This allows not only the FAS Core module to access the image frames but also other sub-systems in the ecosystem. In a different context, other options can be applied for data collection, for example: require the lecturer to have a mobile device capable of taking photographs then uploading the captured photos to the system.
- 2: *FAS Core*: The FAS Core is the heart of FAS, which maintains connection with the Streaming Server to retrieve image frames and then performs the facial recognition process. In order to delineate student sets to identify, the system downloads the list of student t of the class that need to take attendance from the LMS. A training model that is constructed previously from the face data of students in the class is used for predictions. We show the algorithm as follows:

Algorithm: Attendance Taking	
1:	Read a set of frames K from the stream server
2:	Read the class list M from the Portal
3:	Load model P corresponding to M
4:	Initialize the set of attended students S
4:	$F = detectFaces(K)$
5:	For each f_i in F
6:	Begin
7:	$m = extractFeature(f_i)$
8:	$s = Predict(m, P)$
9:	$S.add(s)$
10:	End
11:	Save S to the attendant database

The face detections, feature extraction, and prediction can be applied with different open frameworks that reviewed in the next section.

- 3: *Academic Portal API*: As discussed above, during the prediction step, FAS will need access to the Academic Portal to retrieve the schedule and student list data. The obtained list of present students will be stored in the database of the portal. This requires the development of an API to interact with the portal.

2.2 Reviews of available frameworks

In this section, we introduce the open frameworks and algorithms used in face detection, feature extractions, and classification. The development of deep learning technology in computer vision is rapidly increasing. The Convolutional Neural Network (CNN) was first introduced by LeCun et al [9] is known to be an extremely effective technique in image classification, object detection, localization, etc. Therefore, many frameworks developed based on it, besides that there are some of the other promising frameworks still derived from the traditional image processing techniques.

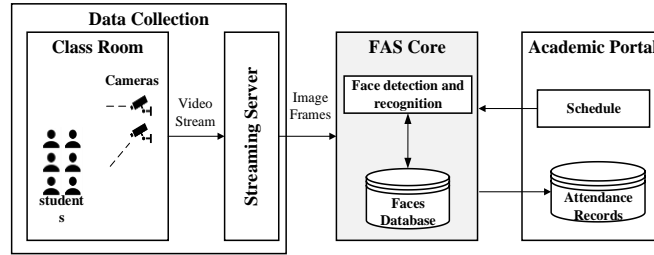


Figure 2: Automatic Facial Attendance System

2.2.1. Face detection

The first step of the process is facial detection. It is important that a face detector can zone out as many faces as possible from a video frame in a limited duration. A face detector is an object detector trained specifically to detect human faces. We have researched the following object detectors that perform well on faces:

Viola-Jones framework [10]: a machine learning-based approach, where a cascade function is trained from a lot of positive and negative images of faces, is proposed by Paul Viola and Michael Jones in 2001. It is the first object detection framework to provide competitive object detection rates in real-time.

YOLO: this method uses a single convolutional network to simultaneously to predict multiple bounding boxes and class probabilities for those boxes. Instead of using sliding windows or region proposal-based technique, YOLO sees the entire image and generate bounding boxes straight from image pixels. Therefore, it significantly improves the runtime for taking real-time detection challenge [11]. YOLO has mAP of 63.4% on PASCAL VOC 2007 test set [12] and runs at 45 frames per second compared to Faster R-CNN 0.5 frames per second.

Tiny Face: built to be able to detect small faces in a large image [13]. It uses a method of creating a coarse image pyramid (including 2X interpolation) and then feeding the scaled input into a convolutional network to predict template responses at every resolution and

applying non-maximum suppression at the original resolution to get the final detection results.

MMOD: optimizes the performance of any linear object detections [14]. *MMOD HOG* is an implementation of MMOD over HOG detector [15], an object detection method based on evaluating well-normalized local histograms of image gradient orientations in a dense grid, and then finding the part of the evaluated image that looks the most similar to a known HOG pattern that was extracted from a training set. MMOD HOG achieves a recall rate of 72% on Fddb test set. *MMOD CNN* is an implementation of MMOD over CNN detector and achieves a recall rate of 87.91% on Fddb test set [16].

Faster R-CNN: aims to be faster than R-CNN [17]. It is a detector built on two modules. The first one is called Region Proposal Network, a convolutional network trained using R-CNN [18], it estimates which regions may contain an object. The second module is the Fast R-CNN detector [19], it uses the proposed regions from the first module to classify objects from those proposal regions. When trained with COCO dataset [20] using VGGNet, Faster R-CNN achieves mAP of 78.8% on PASCAL VOC 2007 test set [12].

R-FCN [21]: like Faster R-CNN, also aims to provide a faster detection method compared to R-CNN. Unlike Faster R-CNN, RFCN improves speed by sharing computations throughout the entire network (Fully Convolutional) and reducing the amount of work needed for each proposal region. R-FCN considers each proposed region, divides it up into sub-regions and iterates over the sub-regions checking whether it contains part of the object or not and repeats this for all possible classes.

MTCNN: improves face detection performance by proposing a framework that leverages a cascaded architecture with three stages of carefully designed deep convolutional networks to predict face location [22]. This method allows MTCNN to achieve superior accuracy over other state-of-the-art techniques while keeping the real-time performance. MTCNN has a recall score of 95.04% on Fddb test set [16].

SSD: like R-FCN, SSD provides enormous speed gains over Faster R-CNN, but does so in a different manner [23]. Unlike Faster R-CNN and R-FCN, who perform region proposals and classifications in two separate steps, SSD does the two in a "single shot", predicting the object location and its class as it processes the image. As it skips the "region proposal" step, it gains a significant increase in speed while maintaining high accuracy. SSD has a mAP of 80.0% on PASCAL VOC 2012 test set [12].

2.2.2. Feature extraction

Feature extraction is an extremely important step in classification. A good set of input vectors can fully support algorithms providing a faster and more reliable result such as Son N.T et al used restricted Bozeman Machine for feature learning before passing it output to the classification [24, 25]; Ngo et al applied the combination of SVD and clustering to extract latent feature for improving the nearest neighbor search in recommender system [26]; The features extraction techniques are also applied to improve the similarity search in music [27]; and many others. In the case of image classification, there are two main trends (1) using traditional image processing, (2) deep learning for feature learning. We selected HOG and the facial landmark for the investigation.

HOG: in the HOG feature descriptor, the distribution (histograms) of directions of gradients (oriented gradients) are used as features. Gradients (x and y derivatives) of an image are useful because the magnitude of gradients is large around edges and corners (regions of abrupt intensity changes) and we know that edges and corners pack in a lot more information about object shape than flat regions [15].

Dlib face descriptor: is trained with a set of labeled facial landmarks on an image. Given this training data, an ensemble of regression trees is trained to estimate the facial landmark positions directly from the pixel intensities themselves (i.e., no “feature extraction” is taking place) [28].

2.2.3. Classifier

There are many classification algorithms, usually, they will operate in two phases: (1) offline training, (2) online prediction. SVM is a well-known algorithm that has achieved good results in many previous studies. In addition, we used a lazy learning approach (the nearest neighbor search) due to the recommendations of the authors of the feature extraction library.

K-Nearest-Neighbor Techniques (KNN) [29]: The determination of the nearest neighbors is based on an arbitrary distance function $d(.,.)$. Then for a new observation (y, x) the nearest neighbor $(y_{(1)}, x_{(1)})$ within the learning set is determined by:

$$d(x, x_{(1)}) = \min_i (d(x, x_i))$$

Here the k closest neighbors are referred for classification instead of only the closest neighbor. The parameter k is selected by the user. Let k_r denote the number of observations from the group of the nearest neighbors that belong to class r : $\sum_{r=1}^c k_r = k$. Then a new observation is predicted into the class l with: $k_l = \max_r (k_r)$.

Weighted K-Nearest-Neighbor Techniques (wKNN) [29]: This is an extension of the KNN. It is based on the idea that such observations within the learning set which are close to the new observation (y, x) , should get a higher weight in the decision that such neighbors that are far away from (y, x) . The algorithm can be described as following:

Algorithm: wKNN

Input: The number of neighbors K

Unlabeled vector x

1: **Find** the $k + 1$ nearest neighbors to x according to a distance function $d(x, x_{(i)})$.

2: $D_{(i)} = D(x, x_{(i)}) = \frac{d(x, x_{(i)})}{d(x, x_{(i+1)})}$

3: $w_{(i)} = K(D_{(i)})$ where $K(.)$ is a kernel function.

4: **Return** $\hat{y} = \max_r (\sum_{i=1}^k w_{(i)} I(y_{(i)} = r))$

The KNN based algorithms work faster with indexing such as KD Tree, Ball Tree...etc. [30].

Support Vector Machine (SVM): was first introduced by Vapnik in [31]. The idea is to find the hyperplane with maximum Euclidean distance to the closest training samples. The hyperplane defined by weight vector w and bias b . The optimization problem of SVM is following:

$$\text{Minimize} \left(\frac{1}{2} (w^T \cdot w) \right)$$

$$\text{Subjects to: } y_i(w^T \cdot x_i + b) \geq 1 \forall i \in 1, \dots, n$$

Using kernel function $K(x_i, x_j)$ the simplest case is $K(x_i, x_j) = x_i^T \cdot x_j$. However, the kernel function can be more complicated, making SVM suitable for non-linearly separable problems. The interesting of SVM is that the normal of the decision surface is a linear combination of examples. The decision function can be written in the following form:

$$f(x) = \text{sign} \left(\sum_{i=1}^n \alpha_i \cdot y_i \cdot K(x_i, x_j) + b \right)$$

α_i is the Lagrangian Multiplier.

3. Experiment and analysis

The system must reach maximum accuracy. Any failures will seriously affect one or more individuals. However, it must also ensure minimum processing time. This section describes the experiment results in two phases. The first phase is the construction phase when we select the appropriate open frameworks. The second phase is the run-time on the large scale.

The experiments have been conducted using a computer with the following specs: CPU: Intel(R) Core(TM) i7-4800MQ CPU @ 2.70GHz, 8 GB RAM.

3.1. Frameworks selection

3.1.1. Face detector

The pre-trained model of 10 frameworks described above has been used. We consider both of accuracy and performance on each individual detector. The test set includes 569 faces of 80 images. The Intersection over Union (IoU) is used to evaluate the detectors:

$$IoU = \frac{\text{area of overlap}}{\text{area of union}}$$

where *area of overlap* is the area that predicted bounding box overlap the ground-truth bounding box (The actual object's bounding box); *area of union* is the area that are joined by predicted bounding box and ground-truth bounding box (The actual object's bounding box) So, the bigger the Intersection over Union is, the more likely the prediction bounding box to be the actual object. Here we set $IoU > 0.80$ to indicate the true positive.

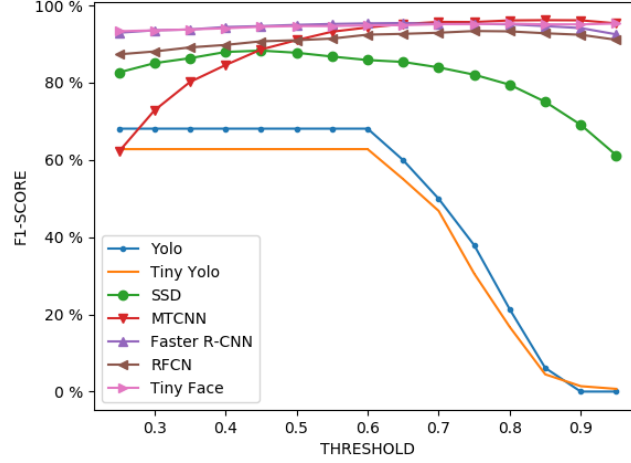


Figure 3: Threshold of the detectors and corresponding F1-Score

Most of the detectors: Faster R-CNN, R-FCN, Tiny Face, YOLO, Tiny YOLO, SSD, and MTCNN have a confidence threshold for predicting faces. We run each detector multiple times with different confidence threshold and measure the F1 score to find the best performing one. Figure 3 shows the F1 score of the Detectors corresponding to the confident thresholds. They are passed as the parameters to execute the algorithms in the next step.

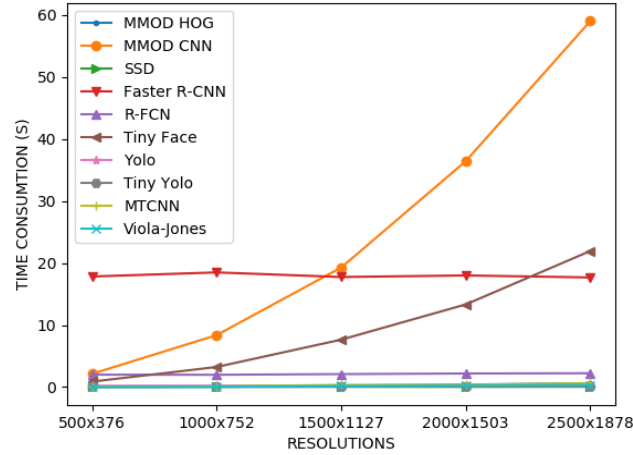


Figure 4: The time consumptions of the detectors at different image resolutions

The speed testing dataset contains images at different resolutions in the range from 500x376px to 2500x1878px. Each test was run 10 times and the mean is calculated to minimize system environmental noise. The results are displayed in figure 4. The decision space for selecting the face detector includes two dimensions: accuracy and performance. We applied the method that Ngo et al introduced for the team selection. Their selection model based on the idea of choosing the closest to the best point [32]. The selection model can be formulated as:

$$\min \left(\sqrt{\sum_{j=\{F1\text{-score}, \text{processing time}\}} (E_j - R_{i,j} * x_i)^2} \right)$$

Where $E = \{100,0\}$, x_i is a binary variable that represents the appearance of the model i-th $\forall i = 1 \dots 10$, $R_{i,1}$ represents the F1-score of the model i-th and $R_{i,2}$ represents the computation time in second of the model i-th. Figure 4 illustrates the algorithms in the decision space.

The MTCNN selected to be the face detector due to its distance to the top left corner (the best point).

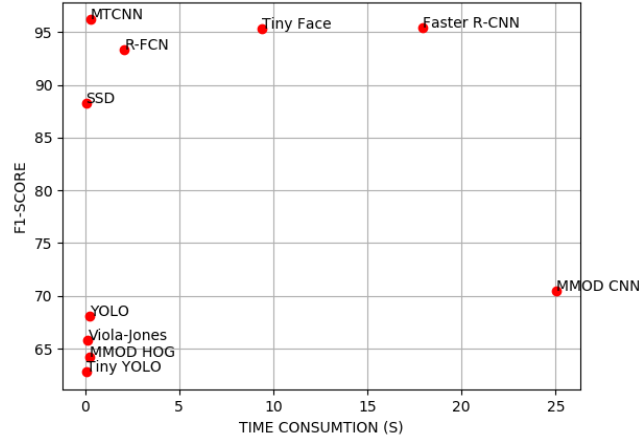


Figure 5: Decision Space of the Face Detectors

3.1.2. Feature Extractor

Each feature extraction method has its own strengths. However, we have chosen specific classification algorithms, and so the feature extraction must also be consistent or modified to fit those classifiers. Euclidean distance-based sorting algorithms work better with linear separable data. We modify the Convex Hull separability algorithm [33] for more convenient use:

Algorithm: Edited Convex Hull separability algorithm

Input: $D = \{D_{dlib}, D_{facenet}, D_{hog}\}$ is set of Datasets in different feature spaces, that dimensional reduced if needed.

Set C of the labels

- 1: **For each** $D_k \in D$
 - 2: **Begin**
 - 3: Initialize the counter of error point $P^k = 0$
 - 4: **For each** $c \in C$
 - 5: **Begin**
 - 6: Compute **convex hull** h_c^k points labeled as c .
 - 7: $P^k := P^k +$ number of points that do not classify in c but bounded by h_c^k
 - 8: **End**
 - 9: **End**
 - 10: **Return:** $\text{armin}_{k=\{dlib, facenet, hog\}}(P^k)$
-

We record videos of 231 students, then 75 face photos cropped for the feature extraction. We use dimensionality reduction and data visualization technique named t-SNE in different feature space [34]. Table 1 shows the linearly separable degree of the particular feature extractors.

Table 1: Numbers of error points in different feature spaces

Dlib	HOG
128	1213755

The data in Facial Learning space is clearly more separable than traditional feature extraction used in image processing. Figure 6 displays the 2D data of different feature spaces after dimension reduction using t-SNE. The Dlib is selected to be the feature extractor due to the lowest value after checking.

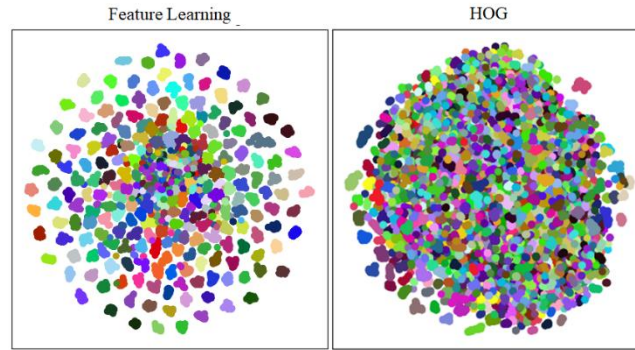


Figure 6: Visualization of the data points in the different feature spaces

3.1.3. Classifier

We continue to use the data of collected 231 students to test the classifiers: KNN, wKNN, and SVM. We use the Radial Basis Function (RBF) kernel for SVM. There are 15 samples were extracted from 75 samples of each class as a test set, the rest is the training set. The predicted face with 80% confidence is considered as true positive. The 3 classifiers seem to produce similar accuracy, the wKNN provides slightly better than the KNN and SVM. Due to the lowest F1-Score generated and some disadvantages such as SVM doesn't perform well when we have a large data set because the required training time is higher; It also doesn't perform very well, when the data set has more noise i.e. target classes are overlapping; SVM doesn't directly provide probability estimates. We decided to select the wKNN as the classifier for the next phase.

3.2.Larger Scale System

We tested more than 2,200 students of 14th generation at FPT University. They are divided into 74 classes. The evaluation method is similar to the selection phase, we build the separated classifier to a particular class. 80% photos are used for training and 20% remaining for the test set. The state of art CNN indicates that the convolutional layers provide hierarchical features which are suitable for classification by the fully connected layer [35]. The approach of CNN can be considered as the traditional image classification, meanwhile, FAS is using facial landmarks position which can be considered as 'more' facial face

classification. In this part, we conduct a comparison between FAS and standard CNN using 3 convolutional layers. The numerical results are shown in figure 8 clearly express the superiority of accuracy of FAS compare to CNN. The CNN requires a huge number of labeled photos to reach high accuracy. However, in the business situation, we did not consider this approach, because it could lead to several difficulties in the data collection phase.

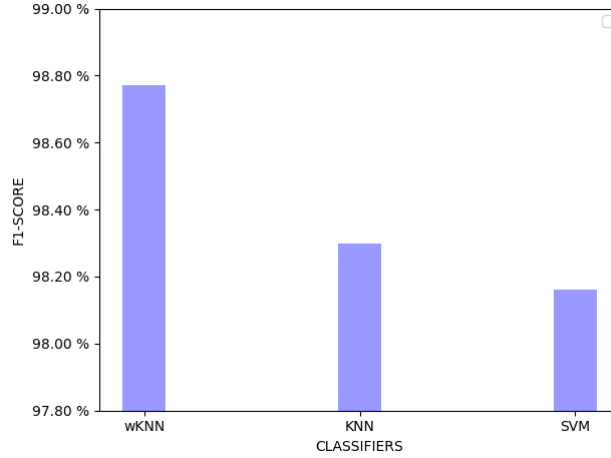


Figure 7: F1 Score of the classifiers

Every single component in the face detection and recognition process archived high accuracy in selection phase. However, as mentioned at the previous section, any system mistakes may affect seriously to the individuals. In the business, the interested indices that most attracted are the rate of correct recognition of the attended student in a particular class. In order to increase the rate of corrections, we set up the cameras to take 5 photos with different angles in the same class as the inputs. Denote $v^i, a^i \in R^{d_i}$ are 2 vectors of appearances, where d_i is the number of students in the class i-th; a_j^i is binary variable represents the actual appearance of student j-th in the input photos; v_j^i is binary variable represents the predicted appearance of the student j-th in the input photos $\forall j = 1, \dots, d_i$; r_i represents the cosine similarity of v^i, a^i [36]. Figure 9 illustrates the similarity of the predictions and corresponding actual attended students in the input photos.

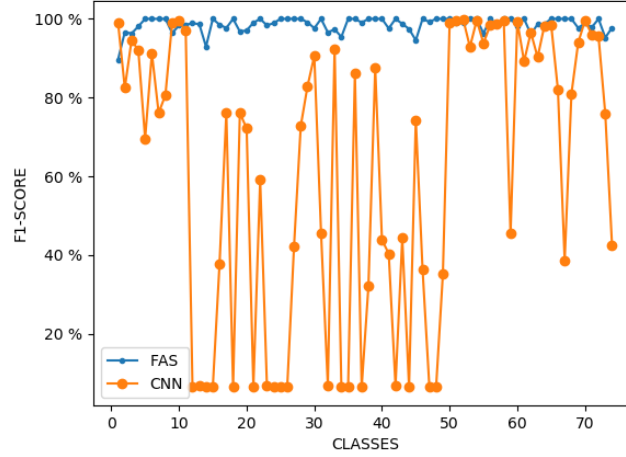


Figure 8: F1 score of the classifiers corresponding to 74 classes

The recognition gives good results in most of the classes. However, there is lack of collaborations between the candidates and students in the data collection phase makes the collected videos were not qualified for use, this leads to those students may not be recognized.

4. Conclusion

In this paper, we have proposed the development of an automatic attendance system based on facial recognition technology. The proposed architecture builds classroom classifiers in combination with a list of students from the Academic Portal so it allows for large-scale expansion without limit to the number of students. The system is also capable of utilizing the hardware and software of existing systems and sharing resources for other intelligent systems developed in the future. Algorithms and open frameworks to build our carefully selected system with a stringent scientific assessment. They provide valuable outputs for the later processes. The MTCNN shows that it is an effective detector both in terms of accuracy as well as processing speed. Meanwhile, the feature learning frameworks provide linear separator data sets, this simplifies the classification tasks. We choose wKNN a lazy model classification, it does not require addition offline training stages when creating additional classes, or any changes of each class. The results of a large-scale system test illustrate the effectiveness of the proposed approach compared to using only traditional image classification techniques.

On the other hand, we have not yet come up with a solution to keep the facial database fresh. The data collection that is easy-to-use but efficient is under consideration. Our next works include further improve the performance and the accuracy of the system. We are exploring the adapters and standard communication mechanism to integrate FAS with other ecosystems.

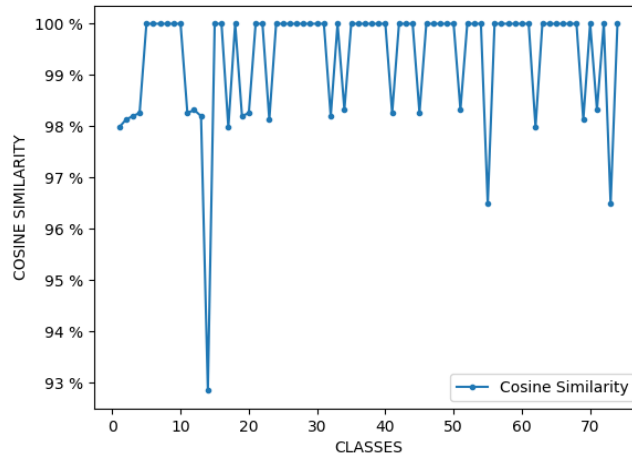


Figure 9: Similarity between the predicted and actual attendances

5. References

- [1] Nadire Cavus, "Distance Learning and Learning Management Systems", *Procedia - Social and Behavioral Sciences*, Volume 191, 2 June 2015, Pages 872-877, <https://doi.org/10.1016/j.sbspro.2015.04.611>.
- [2] Akinduyite C.O, Adetunmbi A.O, Olabode O.O, and Ibidunmoye E.O, "Fingerprint-Based Attendance Management System." *Journal of Computer Sciences and Applications* 1, no. 5 (2013): 100-105, DOI:10.12691/jcsa-1-5-4
- [3] M. I. Moksini and N. M. Yasin, "The implementation of wireless student attendance system in an examination procedure" in *Proc. Int. Assoc. Comput. Sci. Inf. Technol.-Spring Conf., Singapore, 2009*, pp. 174–177.
- [4] M. Kassim, H. Mazlan, N. Zaini, M. K. Salleh, "Web-based student attendance system using RFID technology", *2012 IEEE Control and System Graduate Research Colloquium*, pp. 213-218, 2012.
- [5] Shota Noguchi; Michitoshi Niibori; Erjing Zhou; Masaru Kamada, "Student Attendance Management System with Bluetooth Low Energy Beacon and Android Devices", *2015 18th International Conference on Network-Based Information Systems*, DOI: 10.1109/NBiS.2015.109
- [6] Jie Yin, Son N. Tran, Qing Zhang. Human Identification via Unsupervised Feature Learning from UWB Radar Data. Pacific-Asia Conference on Knowledge Discovery and Data Mining. Melbourne 2018
- [7] Yohei Kawaguchi, Tetsuo Shoji, Weijane Lin, Koh Kakusho, And Michihiko Minoh, "Face Recognition-based Lecture Attendance System", *IEEE Conference Publication*.
- [8] Shang-Hung Lin, "An Introduction to Face Recognition Technology", *Informing Science Special issue on Multimedia informing Technologies - Part 2*, Volume 3, No 1, 2000.
- [9] Yann LeCun, Patrick Haffner, Léon Bottou, and Yoshua Bengio, "object recognition with Gradient-Based Learning", *Proceeding Shape, Contour and Grouping in Computer Vision*, Page 319 ISBN:3-540-66722-9

- [10] P. A. Viola and M. J. Jones, “Rapid object detection using a boosted cascade of simple features”, *IEEE Computer Society Conference on Computer Vision and Pattern Recognition* (CVPR 2001), DOI: 10.1109/CVPR.2001.990517.
- [11] J. Redmon, S. K. Divvala, R. B. Girshick, and A. Farhadi, “You only look once: Unified, real-time object detection”, CoRR, vol. abs/1506.02640, 2015. arXiv: 1506. 02640
- [12] M. Everingham, S. M. A. Eslami, L. J. V. Gool, C. K. I. Williams, J. M. Winn, and A. Zisserman, “The pascal visual object classes challenge: A retrospective”, *International Journal of Computer Vision*, vol. 111, no. 1, pp. 98–136, 2015. DOI: 10.1007/s11263-014- 0733-5
- [13] P. Hu and D. Ramanan, “Finding tiny faces”, CoRR, vol. abs/1612.04402, 2016. arXiv: 1612.04402.
- [14] D. E. King, “Max-margin object detection”, CoRR, vol. abs/1502.00046, 2015. arXiv: 1502.00046. [Online]. Available: <http://arxiv.org/abs/1502.00046>
- [15] N. Dalal and B. Triggs, “Histograms of oriented gradients for human detection”, pp. 886–893, 2005. DOI: 10.1109/CVPR.2005.177.
- [16] V. Jain and E. Learned-Miller, “Fddb: A benchmark for face detection in unconstrained settings”, *University of Massachusetts, Amherst, Tech. Rep. UM-CS-2010-009*, 2010.
- [17] S. Ren, K. He, R. B. Girshick, and J. Sun, “Faster R-CNN: towards real-time object detection with region proposal networks”, CoRR, vol. abs/1506.01497, 2015. arXiv: 1506. 01497.
- [18] R. B. Girshick, J. Donahue, T. Darrell, and J. Malik, “Rich feature hierarchies for accurate object detection and semantic segmentation”, CoRR, vol. abs/1311.2524, 2013. arXiv: 1311.2524.
- [19] R. B. Girshick, “Fast R-CNN”, CoRR, vol. abs/1504.08083, 2015. arXiv: 1504.08083.
- [20] T. Lin, M. Maire, S. J. Belongie, L. D. Bourdev, R. B. Girshick, J. Hays, P. Perona, D. Ramanan, P. Dollár, and C. L. Zitnick, “Microsoft COCO: common objects in context”, CoRR, vol. abs/1405.0312, 2014. arXiv: 1405.0312
- [21] J. Dai, Y. Li, K. He, and J. Sun, “R-FCN: object detection via region-based fully convolutional networks”, CoRR, vol. abs/1605.06409, 2016. arXiv: 1605. 06409.
- [22] K. Zhang, Z. Zhang, Z. Li, and Y. Qiao, “Joint face detection and alignment using multitask cascaded convolutional networks”, CoRR, vol. abs/1604.02878, 2016. arXiv: 1604. 02878.
- [23] W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. E. Reed, C. Fu, and A. C. Berg, “SSD: single shot multibox detector”, CoRR, vol. abs/1512.02325, 2015. arXiv: 1512. 02325.
- [24] Son N. Tran, Emmanouil Benetos and Artur d’Avila Garcez. Learning Motion-Difference Features using Gaussian Restricted Boltzmann Machines for Efficient Human Action Recognition. In *International Joint Conference in Neural Network Beijing*, 2014.
- [25] Hazrat Ali, Son N. Tran, Artur d’Avila Garcez. Speaker Recognition with Hybrid Features from a Deep Belief Networks. *Neural Computing and Applications*. 2016

- [26] Ngo Tung Son, Duong Xuan Hoa, Vu Thanh. Learning Sparse Representation From Multiple-source Data for Relative Similarity in Music. 2018 International Conference on Computational Intelligence and Intelligent Systems, ISBN: 978-1-4503-6595-6.
- [27] Ngo Tung Son, Dao Huy Dat, Nguyen Quang Trung, Bui Ngoc Anh. Combination of Dimensionality Reduction and User Clustering for Collaborative-Filtering, CSAI 2017: Proceedings of the 2017 International Conference on Computer Science and Artificial Intelligence, page: 125-130, DOI: 10.1145/3168390.3168405
- [28] Kazemi, V., & Sullivan, J. (2014). One millisecond face alignment with an ensemble of regression trees. *2014 IEEE Conference on Computer Vision and Pattern Recognition*. doi:10.1109/cvpr.2014.241.
- [29] Hechenbichler Schliep, "Weighted k-Nearest-Neighbor Techniques and Ordinal Classification", *Sonderforschungsbereich 386*, Paper 399 (2004).
- [30] Mohamad Dolatshah, Ali Hadian, Behrouz Minaei-Bidgoli, "Ball*-tree: Efficient spatial indexing for constrained nearest-neighbor search in metric spaces ", arXiv:1511.00628
- [31] Vapnik (1995), the Nature of Statistical Learning Theory. Springer, Berlin.
- [32] Ngo TS, Le VT, Tran BD, Bui NA: A Decision Support System Tools for Cross-Functional Team Selection: Case Study in ACM-ICPC Team Selection, *2018 International Conference on Information Management and Management Sciences (IMMS 2018)*, ISSN: 978-1-4503-6486-7.
- [33] D. Elizondo, "The linear separability problem: Some testing methods, " *IEEE Transactions on Neural Networks*, vol. 17, pp. 330-344, 2006
- [34] Van der Maaten, L. & Hinton, G. E. Visualizing data using t-SNE. *J. Mach. Learn. Research* 9, 2579–2605 (2008).
- [35] Rawat, W., & Wang, Z. (2017). Deep Convolutional Neural Networks for Image Classification: A Comprehensive Review. *Neural Computation*, 29(9), 2352–2449. doi:10.1162/neco_a_00990.
- [36] Santini S., Jain R.: ‘Similarity measures’, *IEEE Trans. Pattern Anal. Mach. Intell.*, 1999, 21, (9), pp. 871–883.

Sentiment analysis of customer (on thegioididong.com)

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Abstract

In this report, we provide a solution to classify natural language into “positive” or “negative”. Specifically, we want to build a program can give the accurate comments of product quality. In order to do this, we use sentiment analysis techniques. We test our program with about 18.000 comments of consumer for mobile phone on Thegioidi-dong.com, then we get the results with accuracy over 95%.

Keywords

Natural language processing for Vietnamese, Sentiment analysis, Product evaluation, Machine learning.

1. Introduction

Today, in the world of information. There are several sources of data for us to process. With a huge amount of information, it's so difficult for people to handle the information without any tools. The requirements of data analysis are growing up day by day. So, we found the importance of sentiment analysis for promotion and sales products. By analyzing user's sentimental, the distributors can improve their products and help their consumer to choose the most suitable one.

Consider a practical case: My friend has an amount of money to buy a new phone, but he doesn't know which one is good. So, he asked me to help him to choose the most relevant for his demand. After searching, I realize the best way to check if a phone is good or not. That is reading feedbacks of the consumer on ecommerce websites. Base on user's attitude, I can judge the quality of the product.



As we can see, on ecommerce websites like Thegioidi-dong.com, the consumer can only see the overall of rate star if they want to know the feedback of everyone who has used and bought this product. But not all rate star is true. We found that some negative comment but these rating is five at all and some positive comment have only one star. So, we want to build a system can give the best rating base analysis the sentence. Instead of spending a lot of time to read hundreds of comments, we only spend a few moments to know all of the product. And with the system, we can evaluate all properties of product, choose the products to have good

properties you want. With this project, we want to find a good solution to handle big information with less time and effort.

2. Problem and solution plan

Problem:

The goal of this project is to analyze comments on ecommerce websites and evaluate if the comment is positive or negative. Based on that, we can calculate the percent of positive comments for each product. After all, we can draw the conclusions that the product is better or worse than the others.

(in this paper, we use data on thegioididong.com).

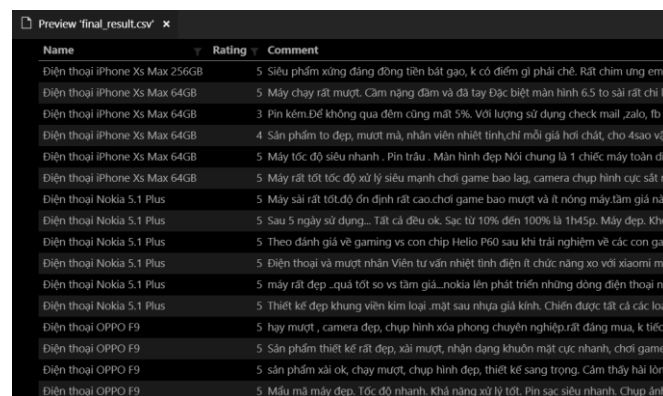
Solution plan:

2.1 Data:

Consumers comments:

First, we have to collect all comments of each mobile phone on thegioididong.com. To do this, we use Selenium with Python to crawl data [1] from the website. (*crawl data*)

Data need to be crawled: Phone name, rating, comments.



Name	Rating	Comment
Điện thoại iPhone Xs Max 256GB	5	Siêu phẩm xứng đáng đồng tiền bát gạo, k có điểm gì phải chê. Rất chim ưng em r
Điện thoại iPhone Xs Max 64GB	5	Máy chạy rất mượt. Cảm nặng đầm và đã tay Đặc biệt màn hình 6.5 to sài rất chỉ là
Điện thoại iPhone Xs Max 64GB	3	Pin kém.Để không qua đêm cũng mất 5%. Với lượng sử dụng check mail ,zalo, fb k
Điện thoại iPhone Xs Max 64GB	4	Sản phẩm to đẹp, mượt mà, nhân viên nhiệt tình chỉ mỗi giá hơi chất, cho 4 sao vậy
Điện thoại iPhone Xs Max 64GB	5	Máy tốc độ siêu nhanh . Pin trâu . Màn hình đẹp Nói chung là 1 chiếc máy toàn diệ
Điện thoại iPhone Xs Max 64GB	5	Máy rất tốt tốc độ xử lý siêu mạnh chơi game bao lag, camera chụp hình cực sắc nê
Điện thoại Nokia 5.1 Plus	5	Máy sài rất tốt.độ ổn định rất cao.chơi game bao mượt và ít nóng máy.tầm giá này
Điện thoại Nokia 5.1 Plus	5	Sau 5 ngày sử dụng... Tất cả đều ok. Sạc từ 10% đến 100% là 1h45p. Máy đẹp. Khôn
Điện thoại Nokia 5.1 Plus	5	Theo đánh giá về gaming vs con chip Helio P60 sau khi trải nghiệm về các con gam
Điện thoại Nokia 5.1 Plus	5	Điện thoại và mượt nhân Viên tư vấn nhiệt tình diện ít chức năng xo với xiaomi mỗ
Điện thoại Nokia 5.1 Plus	5	máy rất đẹp ,quá tốt so vs tầm giá .nokia lên phát triển những dòng điện thoại nh
Điện thoại Nokia 5.1 Plus	5	Thiết kế đẹp khung viền kim loại .mặt sau nhựa giả kính. Chấn được tất cả các loai
Điện thoại OPPO F9	5	hay mượt , camera đẹp, chụp hình xóa phông chuyên nghiệp.rất đáng mua, k tiếc,
Điện thoại OPPO F9	5	Sản phẩm thiết kế rất đẹp, xài mượt, nhận dạng khuôn mặt cực nhanh, chơi game r
Điện thoại OPPO F9	5	sản phẩm xài ok, chạy mượt, chụp hình đẹp, thiết kế sang trọng. Cảm thấy hài lòng
Điện thoại OPPO F9	5	Mẫu mã máy đẹp. Tốc độ nhanh. Khả năng xử lý tốt. Pin sạc siêu nhanh. Chụp ảnh

After crawled data, we export data as. CSV file using Pandas Python library. [2]

Assigning label:

With more than 18.000 comments we crawled on thegioidi-dong.com. We spend our time to assign label for each comment. Each positive comment we assign “tich_cuc” label and each negative comment we assign “tieu_cuc” label. With limited time and only 3 people so we just assigned label for 4000 comments. The assigned data is saved as CSV extension.

2.2 Pre-processing:

Vietnamese word segmentation:

Different from English, the space in Vietnamese just splits a syllable with another syllable, the space not splits the words. So, we must join the syllables to make the correct words. Example: The word “Đất nước” make by two syllable “đất” and “nước”, the two syllables have another mean in the case they are alone, but if we join them, we will get another word. [3]

Convert word to vector:

The computer can process only binary signal, so we must convert all comment to vector. To vectorize sentences, we use Bag of Words (BoW) and Term frequency –Inverse document frequency (TF-IDF) method. [4]

2.3 Using Machine Learning algorithms:

After pre-processing train-data and test-data, we use Machine Learning algorithms to learn from train-data, then it can predict label (Positive/Negative) for test-data. Two algorithms can be used are Naive Bayes and Support Vector Machines.

2.4 Statistic data – Get result:

After processing all comments with label from step 3. We calculate the ratio of positive comment on total comment foreach product.

3. Plan implementation

1) Phase 1: Crawling data:

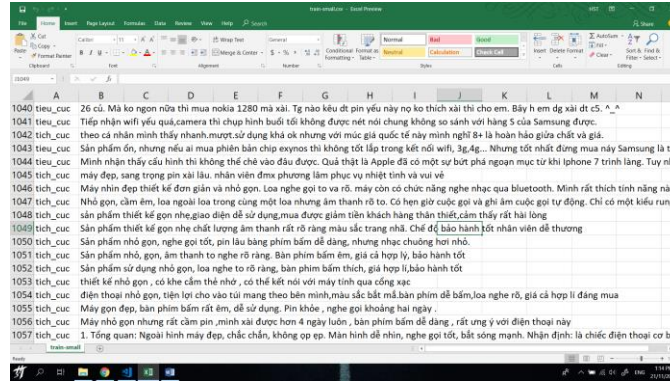
- Programming language: Python.
- Library: Selenium, Pandas.
- Chrome web driver.
- Data source: Thegioididong.com
- Saved data: result file result.csv.

2) Phase 2: Assigning label:

- Purpose: Making training-data with positive comments and negative comments manually.
- Method: Assigning positive or negative foreach comment and save as .CSV file.
- Saved data: Train-data.csv.

Example

Label	Content
tieu_cuc	Giá quá cao mà phí, mua về cũng chẳng làm gì nhiều số tiền vậy bỏ ra mua 1 cái cao cấp của hãng khác đủ xài mà còn rẻ hơn.
tieu_cuc	Pin xài hết nhanh. xài càng ngày càng chậm. mới mua được mấy tháng. máy không hề chơi game chỉ có lướt web nghe và gọi.
tich_cuc	Máy nhìn đẹp thiết kế đơn giản và nhỏ gọn. Loa nghe gọi to và rõ. máy còn có chức năng nghe nhạc qua bluetooth. Mình rất thích tính năng này.
tich_cuc	Máy nhỏ gọn nhưng rất cầm pin, mình xài được hơn 4 ngày luôn, bàn phím bấm dễ dàng, rất ưng ý với điện thoại này.
...	



3) Phase 3: Pre-processing

3.1) Vietnamese word segmentation

- Programming language: Python
- Library: Pyvi [5]
- Input data: Train-data.csv (from phase 2)

Example:

We have a sentence: “Điện thoại có thiết kế rất tuyệt vời”, after using pyvi, the output is “Điện_thoại có thiết_kế rất_tuyệt_vời”. We can see pyvi join make 3 word “Điện_thoại”, “thiết_kế”, “tuyệt_vời” from 6 original syllable.

```
>>> from pyvi import ViTokenizer
>>> ViTokenizer.tokenize(u"Điện thoại có thiết kế rất tuyệt vời")
'Điện_thoại có thiết_kế rất_tuyệt_vời'
>>>
```

3.2) Convert Word to Vector

- Programming language: Python.
- Library: Sklearn.
- Technique: CountVectorizer, TfidfTransformer.

Example:

We have 4 sentences:

```
'This is the first document.',
'This document is the second document.',
'And this is the third one.',
'Is this the first document?'
```

With Bag-of-Word we have a dictionary:

```
['and', 'document', 'first', 'is',
'one', 'second', 'the', 'third',
'this']
```

After Word-to-Vector we have 4 vectors:

```
[0 1 1 1 0 0 1 0 1]
[0 2 0 1 0 1 1 0 1]
[1 0 0 1 1 0 1 1 1]
[0 1 1 1 0 0 1 0 1]
```

After TF_IDF we have 4 vectors:

```
and document first is one second the third this
0 0.000000 0.469791 0.580286 0.384085 0.000000 0.000000 0.384085 0.000000 0.384085
1 0.000000 0.687624 0.000000 0.281089 0.000000 0.538648 0.281089 0.000000 0.281089
2 0.511849 0.000000 0.000000 0.267104 0.511849 0.000000 0.267104 0.511849 0.267104
3 0.000000 0.469791 0.580286 0.384085 0.000000 0.000000 0.384085 0.000000 0.384085
```

4) Phase 4: Using Machine Learning algorithms

+ Programming language: Python.

+ Library: Sklearn.

+ Technique: SGDClassifier, MultinomialNB.

With the vectors from pre-step, we use ML algorithms to learn all vectors, next we use other vectors from test-data to get predict label.

5) Phase 5: Checking ML algorithms from training-data

To get best result, we must have good algorithms. So, we split assigned training-data to 2 part randomly. 90% for training and 10% for testing. We will check the rate of predicted label equal with original label to get score.

Example:

We have a comment “Điện thoại rất tốt” with original label “tich_cuc”, ML algorithms if return predicted label “tich_cuc” is good.

Below is our result after 5 times randomly checking:

	Using MultinomialNB	Using SGDClassifier
1 st	91,9%	93,7%
2 nd	92.9%	95.8%
3 th	94,7%	97,0%
4 th	93,4%	96,5%
5 th	94,1%	95,3%
AVG	92,9%	95,8%

We find that SGDClassifier algorithm is better than MultinomialNB algorithm in our case.

6) Phase 6: Statistic data – Get result:

- Programming language: Python.

- Library: Sklearn, Numpy, Pandas

After phase 5, we decide to use SGDClassifier (Support Vector Machines) algorithm. We have Train-data.csv with 4000 assigned comments to train. The next we will have predicted label for 18000 comments we crawled from Thegioididong. Then we use Numpy library to calculate the rate of positive comment on total comment foreach product. The last, we use Pandas library to write CSV result file.

4. Analysis

After all, we have analyzed about 1800 comments from all mobile phone on the web. And then, we got the result table of: Phone name, Amount comments, Average rating and Positive rate.

Base on the result table, we can speculate the level of interesting from users for each product. Furthermore, we can see the satisfaction level of each.

This is our final result. We just show top 20 cellphones have most comments with average rating and positive rate (Calculated by machine learning algorithm).

Phone	Amount_Comment	AVG_Rating	Positive_Rate
Điện thoại Huawei Nova 2i	795	4.45	66.00%
Điện thoại Nokia 105 Dual Sim (2017)	644	4.71	98.00%
Điện thoại Samsung Galaxy J2 Prime	538	4.15	70.00%
Điện thoại Huawei Nova 3i	432	4.5	76.00%
Điện thoại iPhone 6 32GB	416	4.49	77.00%
Điện thoại Xiaomi Redmi Note 5	374	4.24	53.00%
Điện thoại OPPO A3s	368	4.58	84.00%
Điện thoại Nokia 3	348	3.89	61.00%
Điện thoại Samsung Galaxy J6	339	4.48	81.00%
Điện thoại Samsung Galaxy J7+	327	4.11	61.00%
Điện thoại Huawei Nova 3e	313	4.13	61.00%
Điện thoại iPhone 6s Plus 32GB	310	4.64	81.00%
Điện thoại Nokia 105 Single Sim (2017)	307	4.71	97.00%
Điện thoại Xiaomi Redmi 5 Plus 4GB	307	4.48	58.00%
Điện thoại Itel it2123	302	4.73	98.00%
Điện thoại MOBELL M228	300	4.59	97.00%
Điện thoại Nokia 5	289	3.94	55.00%
Điện thoại iPhone 7 Plus 32GB	257	4.69	81.00%
Điện thoại iPhone 8 Plus 64GB	230	4.78	92.00%
Điện thoại Nokia 6	212	4.14	58.00%

Base on the “Amount_Comment” column, we will easily notice that the more comments of each product, the more attention it gets from user. Otherwise, the “Positive_Rate” column shows that satisfaction level of users about product. If the ratio is low, then the satisfaction of users is low too. That means the quality of the product does not satisfy the user.

Let’s compare “Huawei Nova 2i” to “MOBELL M228”. Although “Huawei Nova 2i” gets more people are interested (795 comments with 300 comments). But its satisfaction level is not higher than “MOBELL M228” (66% and 97%). We can see that “MOBELL M228” has a few users, but almost of them feel satisfied with their mobile phone.

From all of above, we can infer that if a product gets a lot of attention, we still cannot conclude its quality.

5. Experimental results and conclusion

Finally, our system can operate with high precision rate. We can use it to handle comments of consumer. We have test our program with 18.000 comments which we crawl on website Thegioididong. The result we get with all comments after run program about 95% accuracy.

Not only that, our program returns true results when we try to write and give our comments to processing system. With all of results above, we think our project is successful.

6. Development

When we build this system, we don't think our project stop with only can handle the comments of consumer with smart phone. Our goal for this project is that it can handle many different sources of information, not just one topic. The developmental system is capable of evaluating most of the user's comments, analyzing the meaning of the sentence, and making detailed conclusions. This allows users and businesses to process their data quickly and accurately.

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8. References

- [1] Python Selenium: <https://selenium-python.readthe-docs.io/>
- [2] Pandas library: <https://pandas.pydata.org/>
- [3] Le Hong Phuong, "Vietnamese Word Segmentation", 12/2016. Available at: <https://techinsight.com.vn/language/en/vietnamese-word-segmentation-part-i/>
- [4] Tran Trung Thanh, "Bag of Words (Bow) TF-IDF - Xử lý ngôn ngữ tự nhiên" on codetudau.com.
- [5] Pyvi is a python library written by Tran Viet Trung (2016) to solve the problems in Vietnamese word segmentation.

DC programming and DCA for Secure Guarantee with Null Space Beamforming in Two-Way Relay Networks

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Abstract

In this paper, we consider a two-way relay network system which contains multiple cooperative relays transmitting information between two sources with attendance of an eavesdropper. A null space beamforming scheme is applied to ensure the secrecy in system. Our goal is achieving maximal secrecy sum rate with a certain level power transmit. In [1], authors propose an approach to solve Secrecy Sum Rate Maximization (SSRM) problem, whereas we use another approach base on Different of Convex Functions Algorithm (DCA).

Keywords: Two-way relay network, transmitted power, secrecy sum rate (SSR), Difference of Convex Algorithm.

1. Introduction

Physical layer security technique takes advantage the physical characteristic of wireless channel to guarantee secrecy for message being transmitted. In [2], Wyner developed a new direction for creating secure links without relying on the privacy cryptograph. The notation "secrecy capacity" was defined as the maximum rate received at the legitimate receiver, which still kept the eavesdropper completely ignorant of the transmitted messages. Therefore, this method would help reduce the probability of interception.

Notation: Vectors and matrices denote lowercase and uppercase, respectively. $\text{Rank}(\mathbf{X})$ and $\text{Tr}(\mathbf{X})$ stand for rank and trace of matrix \mathbf{X} respectively. \mathbf{I}_N is the identity matrix of size $N \times N$. Superscript $(\cdot)^T$, $(\cdot)^H$ and $(\cdot)^*$ represent transpose, Hermitian transpose and complex conjugate, respectively. $\text{diag}(\mathbf{x})$ is a diagonal matrix that its entries at diagonal are elements correspond to elements of vector \mathbf{x} , while $\text{diag}(\mathbf{X})$ is vector which its elements are diagonal entries of \mathbf{X} . $\text{vec}(\mathbf{X})$ represent a vector containing all matrix \mathbf{X} 's columns - $\text{vec}^{-1}(\mathbf{x})$ is reverse operator. $\mathbf{V}_{\max}(\mathbf{X})$ is an unit-norm eigenvector of the largest eigenvalue of matrix \mathbf{X} . $\mathbb{E}\{\cdot\}$ is statistical expectation. \otimes denotes Kronecker product. $|\cdot|$ denotes the absolute value of a scalar and $\|\cdot\|$ represent norm of a vector. $[\mathbf{x}]_i$ is i -th elements of vector \mathbf{x} and $[\mathbf{X}]_{i,j}$ is (i, j) entry of \mathbf{X} . \mathbf{X} is positive semi-definite matrix then $\mathbf{X} \succeq 0$. $\text{Re}(i)$ and $\text{Im}(i)$ are respectively the real and imagine part of complex number i . $(f)^+$ stands for $\max(f, 0)$.

In the next section, system model and an existed algorithm are given. In Section 3, Difference of Convex Functions Algorithm is introduced then being described in detail and in Section 4 experimental results are presented. Conclusions and further work are discussed in Section 5.

1.1 System Model

Consider a communication system includes two sources S_1 , S_2 , an eavesdropper E and N relay nodes $\{\mathbf{R}_i\}_{i=1}^N$. Nodes are operated in a half-duplex way and there is only one

antenna in each node. It is assumed that the global channel state information (CSI) is available i.e the eavesdropper is active in the network and its transmission can be monitored [3].

In this model, two sources S1 and S2 send and receive private information through reliable relays while trying to keep the eavesdropper ignoring the information as much as possible. The amplify-and-forward (AF) relaying protocol is applied at all relays. There are two phases during information transmission progress, which are: Multiple access channel (MAC) phase and broadcast channel(BC) phase. For simplicity, we assume that channels for the two phases are reciprocal.

During MAC phase, two sources transmit information to relays concurrently. Let $\mathbf{f}_i = \{f_{1i}, f_{2i}, \dots, f_{Ni}\}$ is the channel coefficient vectors from/to S_i to/from the relays. x_i is the information symbols transmitted by S_i with constraint: $E(|x_i|^2) = P_i$, $i = 1, 2$. The signal at relays $\mathbf{r} = \{r_1, r_2, \dots, r_N\}^T$ can be expressed as $\mathbf{r} = \mathbf{f}_1 x_1 + \mathbf{f}_2 x_2 + \mathbf{n}_R$, \mathbf{n}_R is the additive zero-mean noise vector with covariance matrix $\sigma_R^2 \mathbf{I}_N$ at the relays.

During the BC phases, let w_i^* is the complex beamforming weight at i -th relay, then i -th relays multiplies its received signal r_i by w_i^* . The vector of signal s transmitted by all relay is $\mathbf{s} = \mathbf{W}\mathbf{r}$, where $\mathbf{W} = \text{diag}([w_1^*, w_2^*, \dots, w_N^*])$. The received signal at S_i can be expressed as:

$$y_i = \mathbf{w}^H \mathbf{F}_i (\mathbf{f}_1 x_1 + \mathbf{f}_2 x_2 + \mathbf{n}_R) + n_i.$$

where $\mathbf{w} = \text{diag}(\mathbf{W}^H)$ and $\mathbf{F}_k = \text{diag}(\mathbf{f}_k)$, $k = 1, 2$. n_i is additive zero-mean noise vector with covariance matrix σ_i^2 .

Besides, the eavesdropper also can receive the signal transmitted from sources S_1 , S_2 and from relays over two phases. Those signals denotes as y_{1E} and y_{2E} that are given in general vector form as follows:

$$\begin{bmatrix} y_{1E} \\ y_{2E} \end{bmatrix} = \begin{bmatrix} g_1 & g_2 \\ \mathbf{w}^H \mathbf{L} \mathbf{f}_1 & \mathbf{w}^H \mathbf{L} \mathbf{f}_2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_{1E} \\ \mathbf{w}^H \mathbf{L} \mathbf{f}_1 + n_{2E} \end{bmatrix}$$

where g_1, g_2 are the channel coefficient from two sources to the eavesdropper, $\mathbf{L} = \text{diag}(\mathbf{I})$, where $\mathbf{I} = [l_1, l_2, l_3, \dots, l_N]$ is channel coefficient from all relays to the eavesdropper. n_{1E} and n_{2E} are additive zero-mean noise vector at the eavesdropper during two phases with covariance matrix $\sigma_{E,1}^2$ and $\sigma_{E,2}^2$, respectively.

Let $I(x_2; y_1)$, $I(x_1; y_2)$ stand for the maximum rates for the end-to-end link from S_1 to S_2 and that from S_1 to S_2 respectively; $I(x_1; x_2; y_E)$ denotes the information rate at eavesdropper. The achievable secrecy sum rate is:

$$R_{\text{sum}}^S = [I(x_2; y_1) + I(x_1; y_2) - I(x_1; x_2; y_E)]^+. \quad (1)$$

According to reference [1], the formulation (1) can be expressed as:

$$R_{\text{sum}}^S = \frac{1}{2} \left[\log_2 \frac{\left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_R^2}\right) \left(1 + \frac{P_1 |\mathbf{w}^H \mathbf{F}_2 \mathbf{f}_1|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_2\|_2^2 + \sigma_R^2}\right)}{\det(\mathbf{I}_2 + \mathbf{H}_E \mathbf{Q}_E \mathbf{H}_E^H (\mathbf{K}_E)^{-1})} \right]^+$$

where, $\mathbf{Q}_E = \text{diag}(P_1, P_2)$ is diagonal power allocation matrix of two sources and $\mathbf{K}_E = \text{diag}(\sigma_{E,1}^2, \sigma_{E,2}^2 + \sigma_R^2 \mathbf{w}^H \mathbf{L} \mathbf{L}^H \mathbf{w})$ is the equivalent noise covariance matrix at the eavesdropper.

Our goal is to maximize achievable secrecy sum rate with the constraint that total power consuming at relays with P_1, P_2 must not exceed total power of entire system. Therefore, the model of this problem would be:

$$\begin{aligned} & \max_{P_1 > 0, P_2 > 0, \mathbf{w}} R_{\text{sum}}^s. \\ & \text{s.t. } P_1 + P_2 + P_R < P_T. \end{aligned} \quad (2)$$

In the above problem, P_T is total power constraint and P_R is total relay transmit power, which is defined as:

$$P_R = E(\mathbf{s}^H \mathbf{s}) = \text{Tr} \left(E \left((\mathbf{W} \mathbf{r})(\mathbf{W} \mathbf{r})^H \right) \right) = P_1 \mathbf{w}^H \mathbf{D}_1 \mathbf{w} + P_2 \mathbf{w}^H \mathbf{D}_2 \mathbf{w} + \sigma_R^2 \mathbf{w}^H \mathbf{w},$$

where $\mathbf{D}_1 = \mathbf{F}_1 \mathbf{F}_1^H$ and $\mathbf{D}_2 = \mathbf{F}_2 \mathbf{F}_2^H$.

In this model, in order to guarantee secrecy, the relay beamforming vector (\mathbf{w}) is chosen to lie in the null space of the equivalent channel of relay link from two sources to the eavesdropper, i.e., $\mathbf{w}^H \mathbf{Z} = 0$, where $\mathbf{Z} = \mathbf{L}[\mathbf{f}_1, \mathbf{f}_2]$ is the $N \times 2$ equivalent matrix. Accordingly, the formula for R_{sum}^s is reduced to:

$$R_{\text{sum}}^s = \frac{1}{2} \left[\log_2 \frac{\left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_1^2} \right) \left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_2^2} \right)}{1 + \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_{E,1}^2}} \right]^+$$

and the problem (2) is recast as:

$$\begin{aligned} & \max_{P_1, P_2, \mathbf{w}} \frac{1}{2} \left[\log_2 \frac{\left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_R^2} \right) \left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_R^2} \right)}{1 + \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_R^2}} \right]^+ \\ & \text{s.t. } P_1 + P_2 + P_1 \mathbf{w}^H \mathbf{D}_1 \mathbf{w} + P_2 \mathbf{w}^H \mathbf{D}_2 \mathbf{w} + \sigma^2 \mathbf{w}^H \mathbf{w} \leq P_T \\ & \quad \mathbf{w}^H \mathbf{Z} = 0, \\ & \quad P_1 > 0; P_2 > 0. \end{aligned} \quad (3)$$

Denote $\mathbf{R}_1 = \mathbf{F}_1 \mathbf{f}_2 \mathbf{f}_2^H \mathbf{F}_1^H$, $\mathbf{R}_2 = \mathbf{F}_2 \mathbf{f}_1 \mathbf{f}_1^H \mathbf{F}_2^H$, $\mathbf{A}_1 = P_2 \mathbf{R}_1 + \sigma_R^2 \mathbf{I}$,

$\mathbf{A}_2 = P_1 \mathbf{R}_2 + \sigma_R^2 \mathbf{I}$, $\mathbf{B}_2 = \sigma_R^2 \mathbf{I}$.

The problem (3) can be reformulated as follows:

$$\begin{aligned} & \max_{P_1, P_2, \mathbf{w}} \frac{1}{2} \left[\log_2 \frac{\left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_1^2} \right) \left(1 + \frac{P_2 |\mathbf{w}^H \mathbf{F}_1 \mathbf{f}_2|^2}{\sigma_R^2 \|\mathbf{w}^H \mathbf{F}_1\|_2^2 + \sigma_2^2} \right)}{1 + \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_R^2}} \right]^+ \\ & \text{s.t. } P_1 + P_2 + P_1 \mathbf{w}^H \mathbf{D}_1 \mathbf{w} + P_2 \mathbf{w}^H \mathbf{D}_2 \mathbf{w} + \sigma^2 \mathbf{w}^H \mathbf{w} \leq P_T \\ & \quad \mathbf{w}^H \mathbf{Z} = 0, \\ & \quad P_1 > 0; P_2 > 0. \end{aligned} \quad (4)$$

2.2 Optimization of Relay Beamforming Vector (OBV)

In [1], the model (4) was solved as the following way:

We aim to find the maximization value of secrecy sum rate while values of P_T , P_1 , P_2 are fixed.

Let \mathbf{G} be the column-orthogonal matrix of matrix \mathbf{Z}^H .

Utilizing $\mathbf{w} = \mathbf{G}\mathbf{c}$.

Denote $\mathbf{P}_1 = \mathbf{G}^H \mathbf{A}_1 \mathbf{G}$, $\mathbf{Q}_1 = \mathbf{G}^H \mathbf{B}_1 \mathbf{G}$, $\mathbf{P}_2 = \mathbf{G}^H \mathbf{A}_k \mathbf{G}$, $\mathbf{Q}_2 = \mathbf{G}^H \mathbf{B}_2 \mathbf{G}$, the first constraint of (4) can be expressed as:

$$\begin{aligned} P_1 + P_2 + P_1 \mathbf{w}^H \mathbf{D}_1 \mathbf{w} + P_2 \mathbf{w}^H \mathbf{D}_2 \mathbf{w} + \sigma^2 \mathbf{w}^H \mathbf{w} &\leq P \\ \Leftrightarrow \mathbf{c}^H \mathbf{A}_0 \mathbf{c} &\leq P_T - P_1 - P_2 \end{aligned}$$

where $\mathbf{A}_0 = \mathbf{G}^H (P_1 \mathbf{D}_1 + P_2 \mathbf{D}_2 + \sigma^2 \mathbf{I}_N) \mathbf{G}$.

Since $P_T - P_1 - P_2$ is constant value so (4) becomes:

$$\begin{aligned} \max_{\mathbf{c} \in \mathbb{C}^{2(N-2)} \times 1} \quad & \frac{\mathbf{c}^H \mathbf{P}_1 \mathbf{c} + \sigma_1^2}{\mathbf{c}^H \mathbf{Q}_1 \mathbf{c} + \sigma_1^2} \cdot \frac{\mathbf{c}^H \mathbf{P}_2 \mathbf{c} + \sigma_2^2}{\mathbf{c}^H \mathbf{Q}_2 \mathbf{c} + \sigma_2^2} \\ \text{s.t.} \quad & \mathbf{c}^H \mathbf{A}_0 \mathbf{c} \leq P_T - P_1 - P_2 \end{aligned} \quad (5)$$

Define $\mathbf{c} = \mathbf{A}_0^{-\frac{1}{2}} \cdot \tilde{\mathbf{c}}$, then we get:

$$\tilde{\mathbf{P}}_k = \left(\mathbf{A}_0^{-\frac{1}{2}} \right)^H \mathbf{P}_k \mathbf{A}_0^{-\frac{1}{2}}, \tilde{\mathbf{Q}}_k = \left(\mathbf{A}_0^{-\frac{1}{2}} \right)^H \mathbf{Q}_k \mathbf{A}_0^{-\frac{1}{2}}, k=1,2, \mathbf{c}^H \mathbf{A}_0 \mathbf{c} = \tilde{\mathbf{c}}^H \tilde{\mathbf{c}}$$

Formulation (5) is equivalent to:

$$\max_{\tilde{\mathbf{c}} \in \mathbb{C}^{(N-2)} \times 1} \quad \frac{\tilde{\mathbf{c}}^H \tilde{\mathbf{P}}_1 \tilde{\mathbf{c}} + \sigma_1^2}{\tilde{\mathbf{c}}^H \tilde{\mathbf{Q}}_1 \tilde{\mathbf{c}} + \sigma_1^2} \cdot \frac{\tilde{\mathbf{c}}^H \tilde{\mathbf{P}}_2 \tilde{\mathbf{c}} + \sigma_2^2}{\tilde{\mathbf{c}}^H \tilde{\mathbf{Q}}_2 \tilde{\mathbf{c}} + \sigma_2^2} \quad (6a)$$

$$\text{s.t.} \quad \tilde{\mathbf{c}}^H \tilde{\mathbf{c}} \leq P_T \quad (6b)$$

In [1] – appendix B section, authors proof that the equality $\tilde{\mathbf{c}}^H \tilde{\mathbf{c}} = P_T - P_1 - P_2$ is the solution of (6).

In case $\tilde{\mathbf{c}}^H \tilde{\mathbf{c}} = P_T - P_1 - P_2$:

$$\tilde{\mathbf{c}}^H \tilde{\mathbf{P}}_1 \tilde{\mathbf{c}} + \sigma_1^2 = \tilde{\mathbf{c}}^H \tilde{\mathbf{P}}_1 \tilde{\mathbf{c}} + \sigma_1^2 \cdot \frac{\tilde{\mathbf{c}}^H \tilde{\mathbf{c}}}{P_T - P_1 - P_2} = \tilde{\mathbf{c}}^H \left(\tilde{\mathbf{P}}_1 + \frac{\mathbf{I}}{P_T - P_1 - P_2} \right) \tilde{\mathbf{c}}.$$

With similar transformation applied for $\tilde{\mathbf{P}}_2, \tilde{\mathbf{Q}}_1, \tilde{\mathbf{Q}}_2$ and denote $\hat{\mathbf{P}}_k = \tilde{\mathbf{P}}_k + \frac{\sigma_k^2}{P_T - P_1 - P_2} \cdot \mathbf{I}_{(N-2)}$,

$$\hat{\mathbf{Q}}_k = \tilde{\mathbf{Q}}_k + \frac{\sigma_k^2}{P_T - P_1 - P_2} \cdot \mathbf{I}_{(N-2)}, k = 1, 2.$$

Substituting $\hat{\mathbf{P}}_k$ and $\hat{\mathbf{Q}}_k$ into (6a):

$$\frac{\tilde{\mathbf{c}}^H \hat{\mathbf{P}}_1 \tilde{\mathbf{c}}}{\tilde{\mathbf{c}}^H \hat{\mathbf{Q}}_1 \tilde{\mathbf{c}}} \cdot \frac{\tilde{\mathbf{c}}^H \hat{\mathbf{P}}_2 \tilde{\mathbf{c}}}{\tilde{\mathbf{c}}^H \hat{\mathbf{Q}}_2 \tilde{\mathbf{c}}} = \frac{\text{Tr}(\tilde{\mathbf{C}} \hat{\mathbf{P}}_1 \tilde{\mathbf{C}}^H \hat{\mathbf{P}}_2)}{\text{Tr}(\tilde{\mathbf{C}} \hat{\mathbf{Q}}_1 \tilde{\mathbf{C}}^H \hat{\mathbf{Q}}_2)} = \frac{\left((\text{vec}(\tilde{\mathbf{C}}))^H (\hat{\mathbf{P}}_1^T \otimes \hat{\mathbf{P}}_2) (\text{vec}(\tilde{\mathbf{C}})) \right)}{\left((\text{vec}(\tilde{\mathbf{C}}))^H (\hat{\mathbf{Q}}_1^T \otimes \hat{\mathbf{Q}}_2) (\text{vec}(\tilde{\mathbf{C}})) \right)}$$

Here, $\tilde{\mathbf{C}} = \tilde{\mathbf{c}}\tilde{\mathbf{c}}^H$. Next, define $\mathbf{x} = \text{vec}(\tilde{\mathbf{C}})$, we can get new problem of \mathbf{x} as:

$$\begin{aligned} \max_{\mathbf{x} \in \mathbb{C}^{2(N-2) \times 1}} \quad & f(\mathbf{x}) = \frac{\mathbf{x}^H (\hat{\mathbf{P}}_1^T \otimes \hat{\mathbf{P}}_2) \mathbf{x}}{\mathbf{x}^H (\hat{\mathbf{Q}}_1^T \otimes \hat{\mathbf{Q}}_2) \mathbf{x}} \quad (7) \\ \text{s.t.} \quad & \mathbf{x}^H \mathbf{x} = 1, \end{aligned}$$

$\text{vec}^{-1}(\mathbf{x}) \succeq \mathbf{0}$, $\text{rank}(\text{vec}^{-1}(\mathbf{x})) = 1$

Calculate $\mathbf{x}_{\text{opt}} = V_{\max}((\hat{\mathbf{Q}}_1^T \otimes \hat{\mathbf{Q}}_2)^{-1}(\hat{\mathbf{P}}_1^T \otimes \hat{\mathbf{P}}_2))$.

If (\mathbf{x}_{opt} is vectorization of Hermitian matrix) then

$$\mathbf{w} = \sqrt{P_T - P_1 - P_2} \mathbf{G} \mathbf{A}_0^{-\frac{1}{2}} \hat{\mathbf{c}} \quad (8)$$

where $\hat{\mathbf{c}}$ is the principal eigenvector of $\tilde{\mathbf{C}}$.

If (\mathbf{x}_{opt} is not vectorization of Hermitian matrix), then we will loop to find approximate solution.

Repeat:

1. $\mathbf{X}_l = \text{vec}^{-1}(\mathbf{x}_{\text{opt}}) \Phi_l$ where Φ_l is i.i.d zero-mean complex Gaussian random matrix with covariance matrix \mathbf{I}_{N-2} . (*)
2. Calculate the eigen-decomposition of $\mathbf{X}_l = \mathbf{U} \Sigma \mathbf{U}^{-1}$ and choose $\tilde{\mathbf{x}}_l = V_{\max}(\mathbf{X}_l)$.
3. Define $\tilde{\mathbf{X}}^l = \tilde{\mathbf{x}}_l \tilde{\mathbf{x}}_l^H$ and $\hat{\mathbf{x}}^l = \text{vec}(\tilde{\mathbf{X}}^l)$ and choose $\tilde{\mathbf{x}}^l = V_{\max}(\mathbf{X}_l)$.
4. $l := l + 1$;

Until

l is equal to size of randomization samples, which is chosen as $60(N-2)$ in this problem.

Choose $\hat{\mathbf{x}}^l$ such that $f(\hat{\mathbf{x}}^l)$ is maximal. Then the beamforming vector is given as (4).

3. DCA for solving problem

3.1 Difference of Convex Program.

Convex problems and non-convex problems are two subfields of optimization programming. Most real-life optimization problems are of nonconvex nature which are more complex. Two popular methods for this problem are local approaches and global approaches. However, the global approaches give a solution expensively while the local approaches are faster and sometimes gives an optimal solution. Difference of Convex Functions Algorithm (DCA) [4] is an optimization approach based on local optimality and the duality in Difference of Convex (DC) programming for solving DC programs.

3.1.1 Difference of Convex Functions

In DC approach, the original non-convex function is decomposed to the difference of two convex functions [5]. A standard DC program is of the form as the following:

$$\alpha = \inf \{ f(\mathbf{x}) := g(\mathbf{x}) - h(\mathbf{x}) : \mathbf{x} \in S \}.$$

A general DC program usually has the form as the following:

$$\alpha = \inf\{f(x) := g(x) - h(x) : g_i(x) - h_i(x) \leq 0, i = 1, \dots, m\}.$$

With g, h being lower semicontinuous proper convex functions on \mathbb{R}^n , S is a convex set.

3.1.2 Difference of Convex Functions Algorithm

Generic scheme of standard DCA is described as following:

Firstly, we decompose the objective function f to a difference of two convex functions $g - h$.

Starting from a primal feasible point x^0 in \mathbb{R}^n . With standard DCA, we repeat those steps for each $k = 0, 1, 2, \dots$:

- Compute $y^k \in \partial h(x^k)$.
- Compute $x^{k+1} \in \operatorname{argmin}\{g(x) - [h(x^k) + \langle y^k, x - x^k \rangle]\}$
- Until either $\frac{\|x^{k-1} - x^k\|}{\|x^{k-1}\| + 1} < \epsilon$ or $\frac{|f(x^{k-1}) - f(x^k)|}{|f(x^{k-1})| + 1} < \epsilon$

3.2 DC decomposition for Optimization of Relay Beamforming Vector - Real Form.

We modify the formulation (4) equals to:

$$\min_{P_1, P_2, \mathbf{w}} F(P_1, P_2, \mathbf{w}) = -\frac{1}{2 \ln(2)} \left[\ln \frac{\frac{\sigma_1^2 + \mathbf{w}^H \mathbf{A}_1 \mathbf{w}}{\sigma_1^2 + \mathbf{w}^H \mathbf{B}_1 \mathbf{w}} \frac{\sigma_2^2 + \mathbf{w}^H \mathbf{A}_2 \mathbf{w}}{\sigma_2^2 + \mathbf{w}^H \mathbf{B}_2 \mathbf{w}}}{1 + \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_{E,1}^2}} \right] \quad (9)$$

s.t

$$\begin{aligned} P_1 + P_2 + P_1 \mathbf{w}^H \mathbf{D}_1 \mathbf{w} + P_2 \mathbf{w}^H \mathbf{D}_2 \mathbf{w} + \sigma^2 \mathbf{w}^H \mathbf{w} &\leq P_T \\ \mathbf{w}^H \mathbf{Z} &= 0, \\ P_1 > 0; P_2 > 0. \end{aligned}$$

In order to work with complex number in computation, we introduce some notations:

Let $\mathbf{x} = [\operatorname{Re}(\mathbf{w})^T \quad \operatorname{Im}(\mathbf{w})^T]^T$

$$\begin{aligned} \bar{\mathbf{A}}_1 &= \begin{bmatrix} \operatorname{Re}(\mathbf{A}_1) & \operatorname{Im}(\mathbf{A}_1) \\ -\operatorname{Im}(\mathbf{A}_1) & \operatorname{Re}(\mathbf{A}_1) \end{bmatrix}, \quad \bar{\mathbf{A}}_2 = \begin{bmatrix} \operatorname{Re}(\mathbf{A}_2) & \operatorname{Im}(\mathbf{A}_2) \\ -\operatorname{Im}(\mathbf{A}_2) & \operatorname{Re}(\mathbf{A}_2) \end{bmatrix}, \\ \bar{\mathbf{B}}_1 &= \begin{bmatrix} \operatorname{Re}(\mathbf{B}_1) & \operatorname{Im}(\mathbf{B}_1) \\ -\operatorname{Im}(\mathbf{B}_1) & \operatorname{Re}(\mathbf{B}_1) \end{bmatrix}, \quad \bar{\mathbf{B}}_2 = \begin{bmatrix} \operatorname{Re}(\mathbf{B}_2) & \operatorname{Im}(\mathbf{B}_2) \\ -\operatorname{Im}(\mathbf{B}_2) & \operatorname{Re}(\mathbf{B}_2) \end{bmatrix}, \\ \bar{\mathbf{Z}} &= \begin{bmatrix} \operatorname{Re}(\mathbf{Z}^H) & \operatorname{Im}(\mathbf{Z}^H) \\ -\operatorname{Im}(\mathbf{Z}^H) & \operatorname{Re}(\mathbf{Z}^H) \end{bmatrix}, \\ \bar{\mathbf{D}}_1 &= \begin{bmatrix} \operatorname{Re}(\mathbf{D}_1) & \operatorname{Im}(\mathbf{D}_1) \\ -\operatorname{Im}(\mathbf{D}_1) & \operatorname{Re}(\mathbf{D}_1) \end{bmatrix}, \quad \bar{\mathbf{D}}_2 = \begin{bmatrix} \operatorname{Re}(\mathbf{D}_2) & \operatorname{Im}(\mathbf{D}_2) \\ -\operatorname{Im}(\mathbf{D}_2) & \operatorname{Re}(\mathbf{D}_2) \end{bmatrix}. \end{aligned}$$

The problem (9) is equivalent to:

$$\min_{P_1, P_2, \mathbf{x}} F(P_1, P_2, \mathbf{x}) = -\left[\ln \frac{\frac{\sigma_1^2 + \mathbf{x}^T \bar{\mathbf{A}}_1 \mathbf{x}}{\sigma_1^2 + \mathbf{x}^T \bar{\mathbf{B}}_1 \mathbf{x}} \frac{\sigma_2^2 + \mathbf{x}^T \bar{\mathbf{A}}_2 \mathbf{x}}{\sigma_2^2 + \mathbf{x}^T \bar{\mathbf{B}}_2 \mathbf{x}}}{1 + \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_{E,1}^2}} \right] \quad (10)$$

s.t

$$P_1 + P_2 + P_1 \mathbf{x}^T \bar{\mathbf{D}}_1 \mathbf{x} + P_2 \mathbf{x}^T \bar{\mathbf{D}}_2 \mathbf{x} + \sigma_R^2 \mathbf{x}^T \mathbf{x} \leq P_T,$$

$$\bar{\mathbf{z}} \mathbf{x} = 0,$$

$$P_1 > 0, P_2 > 0.$$

$F(P_1, P_2, \mathbf{x})$ can be decomposed into the difference of two convex function as below

$$G_2(\mathbf{x}) = \frac{1}{2} \rho \|\mathbf{x}\|^2 + \ln(C),$$

where $C = \frac{P_1 |g_1|^2 + P_2 |g_2|^2}{\sigma_{E,1}^2}$ and

$$\begin{aligned} H_2(\mathbf{x}) = & \frac{1}{2} \rho \|\mathbf{x}\|^2 + \ln(\sigma_1^2 + \mathbf{x}^T \bar{\mathbf{A}}_1 \mathbf{x}) + \ln(\sigma_2^2 + \mathbf{x}^T \bar{\mathbf{A}}_2 \mathbf{x}) \\ & - \ln(\sigma_1^2 + \mathbf{x}^T \bar{\mathbf{B}}_1 \mathbf{x}) - \ln(\sigma_2^2 + \mathbf{x}^T \bar{\mathbf{B}}_2 \mathbf{x}). \end{aligned}$$

Where ρ is choosen as the maximum eigenvalue of matrix $\left(\frac{\bar{\mathbf{A}}_1}{2\sigma_1^2} + \frac{\bar{\mathbf{A}}_1}{2\sigma_2^2} + \frac{2\bar{\mathbf{B}}_1}{\sigma_1^2} + \frac{2\bar{\mathbf{B}}_1}{\sigma_2^2} \right)$.

Note that the linear approximation of $H(\mathbf{x})$ at the point \mathbf{x}^k is given by:

$$\bar{H}_2(\mathbf{x}; \mathbf{x}^k) = H(\mathbf{x}^k) + \langle \mathbf{y}^k; \mathbf{x} - \mathbf{x}^k \rangle.$$

Where

$$\begin{aligned} \mathbf{y}^k = \nabla H(\mathbf{x}^k) = & \rho \mathbf{x}^k + \frac{2\bar{\mathbf{A}}_1 \mathbf{x}^k}{\sigma_1^2 + (\mathbf{x}^k)^T \bar{\mathbf{A}}_1 \mathbf{x}^k} + \frac{2\bar{\mathbf{A}}_2 \mathbf{x}^k}{\sigma_2^2 + (\mathbf{x}^k)^T \bar{\mathbf{A}}_2 \mathbf{x}^k} \\ & - \frac{2\bar{\mathbf{B}}_1 \mathbf{x}^k}{\sigma_1^2 + (\mathbf{x}^k)^T \bar{\mathbf{B}}_1 \mathbf{x}^k} - \frac{2\bar{\mathbf{B}}_2 \mathbf{x}^k}{\sigma_2^2 + (\mathbf{x}^k)^T \bar{\mathbf{B}}_2 \mathbf{x}^k}. \end{aligned}$$

DCA scheme:

1.Initialization: start with any $\mathbf{x}^0 \in \mathbb{R}^{2N}$, $k = 0$

2.Repeat:

Compute \mathbf{x}^{k+1} by solving the following problem

$$\min \quad G_2(\mathbf{x}) - \bar{H}_2(\mathbf{x}; \mathbf{x}^k) \quad (11)$$

$$\text{s.t} \quad P_1 + P_2 + P_1 \mathbf{x}^T \bar{\mathbf{D}}_1 \mathbf{x} + P_2 \mathbf{x}^T \bar{\mathbf{D}}_2 \mathbf{x} + \sigma_R^2 \mathbf{x}^T \mathbf{x} \leq P_T,$$

$$\bar{\mathbf{z}} \mathbf{x} = 0,$$

$$P_1 > 0, P_2 > 0.$$

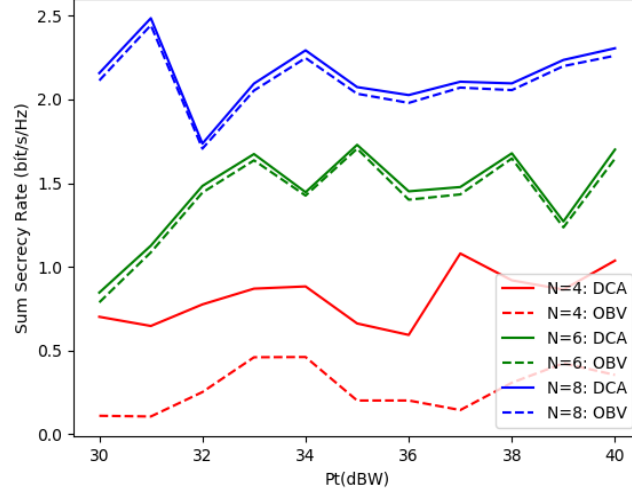
3.Until stopping condition is satisfied, i.e

$$\frac{\|\mathbf{x}^{k+1} - \mathbf{x}^k\|}{1 + \|\mathbf{x}^k\|} < \epsilon \text{ or } \frac{\|F(\mathbf{x}^{k+1}) - F(\mathbf{x}^k)\|}{1 + \|F(\mathbf{x}^k)\|} < \epsilon$$

We can solve efficiently the convex sub-problem (8) at each iteration of DC algorithm by some optimization software packages such as: CVX, CPLEX, etc...

4. Simulation results

In this section, we will compare performances of DC algorithm and Optimization of Beamforming Vector (OBV) algorithm. We consider the secrecy sum rate achieved by approaches with set of power $P_t = [30 : 1 : 40]$ (dBW), the number of relays $N \in \{4, 6, 8\}$, $P_1 = P_2 = \frac{P_t}{4}$ (dBW), $\sigma_1^2 = \sigma_2^2 = 1$ dB. Each pair of P_t and N we use 10 sets of randomized data, then getting the average.



We implement both two algorithms: the OBV and the DCA in Python language, and run on an Intel i7 7500U 2.70 GHz of 8 GB. Solver CVX is used for DC algorithm.

Overall, DCA solves the problem better than OBV algorithm in all test cases. Especially, when $N=4$, the results obtained by DCA are far better than those of OBV algorithm. In other cases, DCA is still superior to OBV but the gap is small. Specially, there are a lot of test sets that OBV gives solution that is zero while DC algorithm can give much better results in both three cases $N=2$, $N=4$ and $N=6$. The analysis part of the comparison only focused on the objective value and execution time of each algorithm.

5. Conclusions

In this paper, we proposed an algorithm base on DCA in order to solve a problem which is finding maximal secrecy sum rate of a two-way relay network system and compare it with an existed algorithm. The first algorithm, Optimization of Beamforming Vector (OBV) can find quite good solutions in a short amount of time. However, DC algorithm even do the job better. In a reasonable amount of time, the algorithm is able to find more optimum solutions compared to its competitor. Another significant factor is that while DC algorithm guarantees convergence, OBV cannot due to the fact that it has a randomization step.

The DC algorithm can be used to improve the objective value and execution time of this model in order to get larger gap between two algorithms for further research.

6. References

- [1] Y. Yang, C. Sun, H. Zhao et al., “Algorithms for secrecy guarantee with null space beamforming in two-way relay networks”, *IEEE Trans. Signal Process.*, vol. 62, no. 8, pp. 2111-2126, 2014.
- [2] A. Wyner, “The wire-tap channel” *Bell. Syst. Tech. J.*, vol. 54, no. 8, pp. 1355-1387, Jan.1975.
- [3] M. Bloch, J. O. Barros, M. R. D.Rodrigues, and S. W.McLaughlin, “Wireless informaion-theoretic security” *IEEE Trans. Inf. Theory*, vol. 54, no. 6, pp. 2515-2534, Jun.2008.
- [4] Le Thi, H.A., Pham Dinh, T. DC programming and DCA: thirty years of developments, *Math. Program.* (2018) 169: 5 -- 68.
- [5] Le Thi, H.A., Pham Dinh, T. DC programming and DCA - Theory, Algorithms and Applications: <http://www.lita.univlorraine.fr/~lethi/index.php/dca.html>.

The teaching system with gesture recognition using Microsoft Kinect version 2 and Holographic

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Abstract

In this paper, we propose a gestures recognition system based on Microsoft Kinect version 2 sensors. Our research identifies 6 gestures applied to control the slideshows support for teaching. We tested this system about 1800 samples. The results show that the identification system with over 95% accuracy, even in difficult conditions such as poor lighting, many garbage objects, etc. Combine with holographic, the research brings the most visual feeling about teaching a presentation, especially in 3D-related lessons. Thereby enhancing the ability to acquire and create strong interest for learners.

Keywords

Microsoft Kinect, Holographic, Gesture recognition, Teaching System, Supporting education, Visual presentation.

1. Introduction

Every day, students must research a lot of subjects, resulting in students difficult to acquire new knowledge. To attract students' interest in the subjects of the lecture, the teacher needs to innovate the way of teaching, how to make the lecture interesting to help students access the best knowledge. Visualization is one of the most effective methods. The lectures are visually displayed and attract students' interest. However, it is still possible to enhance the efficiency of visualization to a new level by changing the presentation control method by direct interaction. Gesture-recognition is a promising technology that brings new breakthroughs in direct instructional support.

The system we propose consists of two parts, a gesture sensor and a holographic. The cost of investing in this system is not higher than normal projectors, but the benefits bring immensely, so applying this technology in practice is perfectly feasible. The use of dedicated motion detection sensors is more efficient than using motion detection algorithms on conventional cameras. As a result, the system is very fast and accurate. Kinect - a device developed and supported by Microsoft that can do so, provides a wide range of identification. What's more, our solution requires the use of Kinect version 2 - an upgraded version with more new technology with higher accuracy [1], so that the gesture control signal of the instructor will be more accurate. Combined with the presentation on the holographic, the lecture will become more attractive, making learners feel new and exciting to absorb new knowledge. Especially in lectures related to 3D, holographic will make it easier for learners

to understand the lesson, rather than take hours to hear the teacher presenting in the traditional way.

With the efficiency that the solution brings as well as the exigence, the solution promises to have more potential for use and development. Can conclude that "The teaching system with gesture recognition Using Microsoft Kinect version 2 and Holographic" is an essential and viable solution.

Related research in the field of using Kinect to support the presentation

In the gesture recognition system, the earliest method was to use 2D imaging devices combined with image-processing algorithms. In 1994, Davis J. and Shah M. developed a system for Recognizing hand gestures [2] with an accuracy of 94% based on the FSM (Finite State Machine) model. The characteristic of this method is that the accuracy is only high when the image is obtained in good conditions. The identification accuracy of this method is very low when the image is captured in low light or near-color conditions with coat color and background color.

In 2012, with the introduction of the Microsoft Kinect sensor [3], a new research direction was opened to solve the problem of gesture recognition. With a reasonable price, the ability to apply this type of device is in fact feasible.

A research by Yi Li on Hand gesture recognition using Kinect (2012) [4] shows the high effectiveness of the Microsoft Kinect sensor in hand-gesture recognition. Based on the ability to receive infrared images and the ability to strip the background supported on this sensor, the gesture recognition system achieves high accuracy when shooting in darkness, when the skin color matches the color of the outfit or background color. The accuracy of this system is from 84% to 99% with single-hand gestures, and from 90% to 100% if both hands perform the same gesture at the same time.

In the solution Using gesture recognition to control PowerPoint using Microsoft Kinect sensor was developed by Chang, Stephen M (2013) [5], this system uses a Hidden Markov Model (HMM) to classify the performed gestures in conjunction with a Support Vector Machine (SVM) to perform real-time segmentation of gestures. The fusion of these two models allows the system to classify gestures in real time as they are being done instead of waiting until completion. The incorporation of speech statements gives the user an additional level of precision and control over the system.

In Vietnam, the researchers Nguyen Cong Tin, Ha Kim Tung, Vo Thanh Nghia, and Le Thanh Cong (2016) development research Applying Kinect to presentation documents [6] show that the minimum distance between the operator and the Microsoft Kinect for sensor recognition is 1.5 m, command response time is 0.03s. However, this research only works on Windows 7 and Microsoft Office PowerPoint 2007.

In general, the application of Microsoft Kinect to gesture recognition has been studied extensively. However, the previous researches used only the Microsoft Kinect version 1 sensors to control PowerPoint slides on the screen. No research yet combined the use of Microsoft Kinect sensor version 2 and Holographic to support teaching.

2. Problem and solution plan

2.1 Problem

This solution is based on the Microsoft Kinect version 2 sensor to recognize the user's hand gestures. The PowerPoint slides are controlled based on the input data that is hand gestures of the user. PowerPoint slideshow controlled for instance are turn off slides, turn on slides, slide transitions... Moreover, the presentation content is displayed on the hic, aiming to increase the attractiveness of lectures, create new experiences for users.

2.2 Solution Plan

2.2.1 The research about Kinect and operational principle of Kinect

a) Compare Kinect version 1 and version 2[7, p. 2]

As you can see from the table, the Kinect v2 is equipped with a full HD resolution color camera and a higher resolution depth camera. As a result, the quality of images captured by the version 2 is much better than the version 1.

Feature	Kinect version 1	Kinect version 2
Color Camera	640x480 @30fps	1920x1080 @30fps
Deep Camera	320x240	512x424
Max Depth Distance	~4.5m	8m
Min Depth Distance	40cm	50cm
Depth Horizontal Field of View	57 degrees	70 degrees
Depth Vertical Field of View	43 degrees	60 degrees
Tilt Motor	yes	no
Skeleton Joints Defined	20 joints	25 joints
Full Skeleton Tracked	2	6
USB Standard	2.0	3.0
Supported OS	Windows 7, 8	Win 8 or higher

Table 1: Technical information of Kinect v1 and Kinect v2

Kinect version 2 can handle 2 gigabytes of data per second, USB 3 provides almost 10x faster bandwidth for the data transfer, 60% wider field of vision, and can detect and track 25 joints from 6 people's bodies including thumbs. In comparison, the Kinect v1 could only track 20 joints from 2 people. The Kinect v1.0 device doesn't have the fidelity to individually track fingers and stretching and shrinking with hands and arms but the Kinect v2 has these

capabilities. For these reasons, we chose the Kinect v2 to be our main gesture-detecting sensor to reduce wrong-gesture detections.

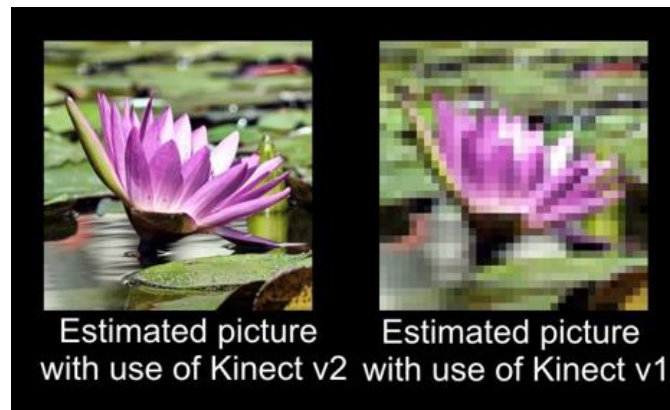


Figure 1: The difference between the qualities of image captured by the Kinect v1 and Kinect v2 [8]

b) Structure and operational principles of the Kinect v2

For the hardware, the Kinect v2 has 2 divisions [1]: the depth and the color. The depth division has two sensors: an infrared (IR) light and a depth image CMOS. Using the Light Coding Algorithm, the Kinect v2 can capture and create a depth map. The Kinect sensor can also draw a skeleton graph from the depth map. The color division has a color image CMOS to capture color images and data. Using data captured from the sensor, the processor then used special algorithms to process data. With the given Kinect libraries in the Kinect SDK, we can program it, extract processed data for our own purposes and in this case, control the Microsoft PowerPoint presentations.

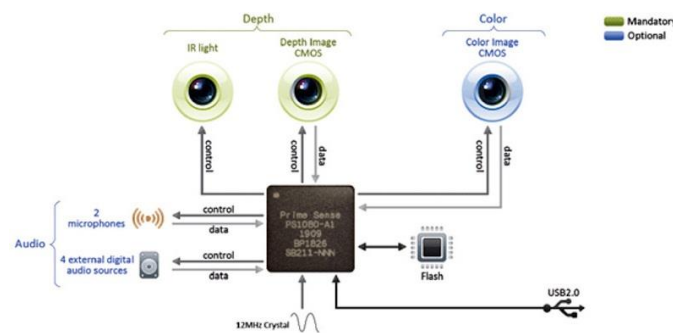


Figure 2: The structure of the Kinect

The software is what makes the Kinect a breakthrough device. Developers for the Kinect gathered an incredible amount of data regarding motion-capture of actual moving things in real-life scenarios. Processing all this data using a special artificial intelligence machine-learning algorithm allows the Kinect to map the visual data it collects to models representing people of different backgrounds (age, height, gender, body type, clothing and more).

a) Introduce the Light Coding algorithm

Kinect uses a Light Coding algorithm[10] to recognize gestures. Kinect is, deep down, a structured light scanner, meaning that it projects an infrared pattern (so invisible for us). First, it projects a known pattern (speckles) in near-infrared light. Then an IR (infrared) camera observes the scene. Based on the projection generated by a diffuser and diffractive element of IR light, the Kinect uses a special algorithm to create a depth map.

1.1. Presentation contents on holographic

Holography is a technique that allows the light scattered from an object to be recorded and later reconstructed so that it appears as if the object is in the same position relative to the recording medium as it was when recorded. There are many new technologies applied for holographic, so there are many types of holograms: transmission holograms, white light reflection holograms, multiple channel holograms, real image holograms[11].

In this research, we used holograms with four sides and one bottom. Depending on the presentation conditions, the size of the holographic will change flexibly to meet the needs of many subjects.

3. Plan implementation

3.1. The structure of the system

As we can from figure 3, Kinect is an input device. After the data had been processed by the program, the computer executes the instructions and then controls the objects (PowerPoint slides). Projector, laptop's screen, holographic, etc. are output devices that display PowerPoint presentations. In this system, the controlling presentation function is configured and include the following actions:

- Change animations/slides (previous animation, next animation, first slide, last slide, etc.)
- Taking note when presenting
- Laser pointer

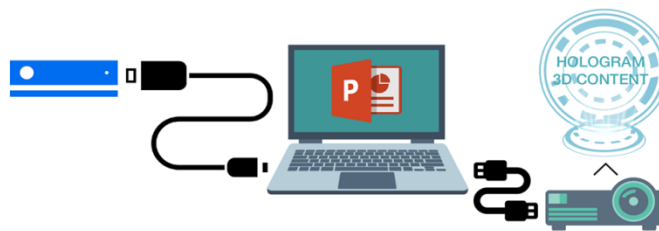


Figure 3: System diagram

3.2 Conventions of the gestures

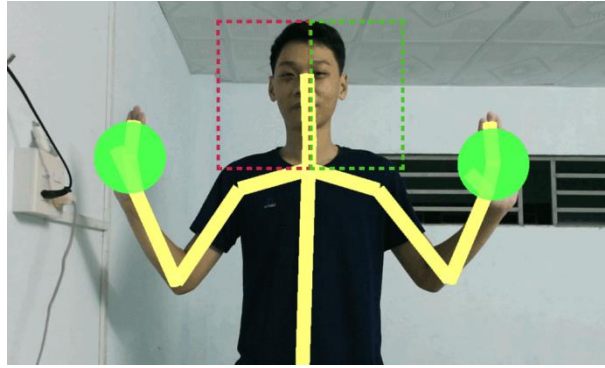


Figure 4: Describe gestures which perform next animation or previous animation in the slide

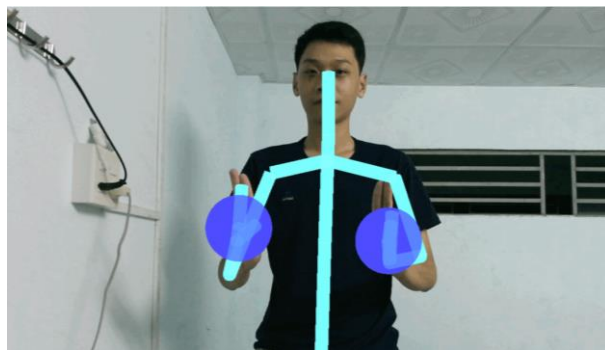


Figure 5: Describe the gesture which performs return to the first slide



Figure 6: Describe the gesture which performs go to last page

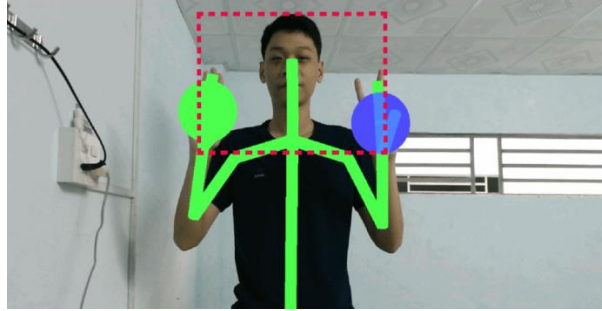


Figure 7: Describe the gesture which performs take note on the slide

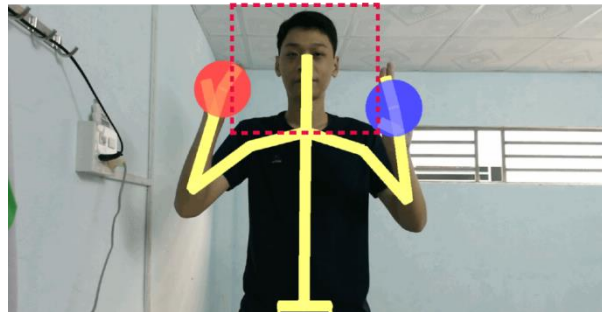


Figure 8: Describe the gesture which performs Laser Pointer

Below is a table of conventions and significances of gestures to control the slide:

#	Function	Description	Picture
1	Back to the previous animation	Open right hand and swipe left in the green zone with a speed $\sim 0.3-0.5\text{m/s}$	Figure 4
2	Switch to the next animation	Open left hand and swipe right in the red zone with a speed $\sim 0.3-0.5\text{m/s}$	
3	Return to the first slide	Both hands in lasso state	Figure 5
4	Go to last page	Close left hand and lasso right hand	Figure 6
5	Take notes on the slide	Left hand open and right hand in lasso state. (Note: both hands must be in the red zone)	Figure 7
6	Laser pointer	Left hand close and right hand in lasso state. (Note: both hands must be in the red zone)	Figure 8

Table 2: The conventions of the gestures

We have researched carefully to make the conventions so that the presenters can comfortably carry out the presentations. Among the most commonly used gestures, we must list the next and previous animation. We chose an open left hand and swipe right will perform the next animation function, open the right hand and swipe left will perform the

previous animation function because they are the most natural and comfortable gestures for presenters. In the return to the first slide function, we require users to lasso both hands. This function is rarely used so we have assigned it a hand gesture and the presenter will never be confused. Accordingly, the move to last page function is performed by grasp the left hand and lasso right hand. To take note, users simply need to raise both hands over the shoulder with the left hand in open state and right hand in lasso state. To use a laser pointer, do as the above but left hand in the closed state.

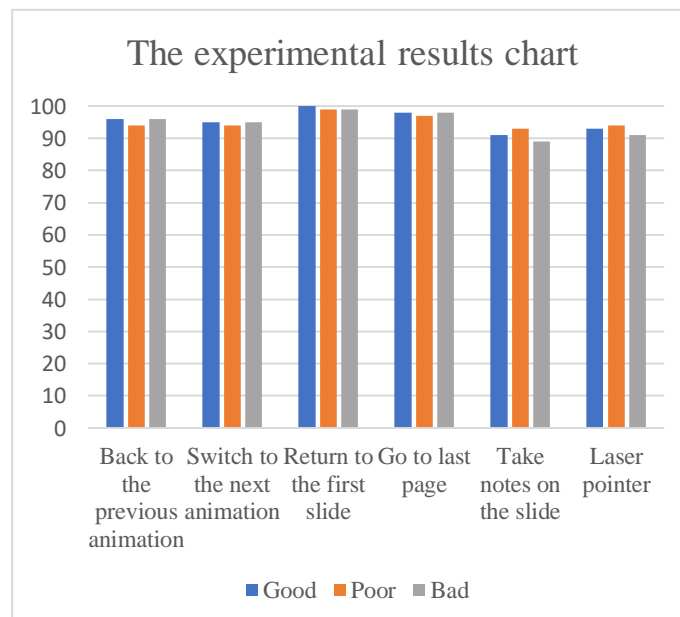
First, the Kinect uses the Light Coding algorithm to collect depth data. Then based on the gathered data, it analyzes and aligns the data with a stored collection of skeleton structure to interpret our movements. This result in a simplified 3D skeleton picture with joints and hand states (if available). The developer can set conventions like the x, y, z coordinates of hands, the distance between joints or hands, etc.... to limit the available zone of a gesture so that the presenter can comfortably perform gestures without the worrying about the misunderstanding and wrong-gestures performing of the Kinect.

Figure 9: The flowchart describes the Algorithm of this solution

	Good	Poor	Bad	Average (%)
Back to the previous animation	96	94	96	95.33333
Switch to the next animation	95	94	95	94.66667
Return to the first slide	100	99	99	99.33333
Go to last page	98	97	98	97.66667
Take notes on the slide	91	93	89	91
Laser pointer	93	94	91	92.66667
Average (%)	95.5	95.16667	94.66667	95.1111

We have conducted the experiment in a 50 square meter classroom in 3 different conditions:

- Good: the illuminance over 400 lux and there were no obstacles between the users and the Kinect sensor.
- Poor: the illuminance from 150 lux to 200 lux with some obstacles like a student, some laptops, bags, notebooks, etc.
- Bad: the illuminance below 150 lux with 2 or more students, many laptops, more bags, notebooks, chairs, desks, etc.



5. Experimental results and conclusion

We have successfully applied Kinect v2 to recognize the 6 gestures that used to control PowerPoint slideshows combine with holographic to create a presentation system which can support the teaching. We have tested this system about 1800 samples. The results show that the identification system perfectly with over 95% accuracy even in difficult conditions such as poor lighting, many garbage objects, etc. We have conducted a survey with 100 students at Cantho FPT University to evaluate the user's interest in a classroom where presenter use gestures to control the presentation being displayed on holographic. The feedback we have received that up to 96 people have confirmed that they were more interested in learning by this method, they appreciate this solution and hope to use this solution to present their presentation.

Development

With many Kinect applications, not only in education but also in other fields. This research has great potential for new developments. For instance, we could integrate voice recognition and facial recognition system to enhance the accuracy and the interaction of the system; Change keyboard shortcuts can control any application on the computer, so the program can become a game system using gestures, the entertainment systems using gestures... If changing holographic to 3D projectors, the presentation content will not be limit at 3D simulations, but 3D augmented reality and the system will perfectly suitable for tasks that need to use holographic such as teaching geometry, biology, designing, ... If the presentation is the image of the medical records, the system will very helpful for surgeons as they can wear gloves while presenting. This system can also be used to control smart devices, smart homes. The development of the topic is not limited to research and lifestyle applications, but also virtual music applications, gesture health systems, or remote mine-clearing robots.

Acknowledgment

First, We would like to acknowledge PhD. Vo Hong Khanh, PhD. Nguyen Hong Chi and Mr. Tran Thanh Danh for their guidance and support throughout the process which made this project possible.

Additional thanks to all of our friends in the Cantho FPT University who have offered constant support and encouragement.

6. References

- [1] Skarredghost, "The difference between Kinect v2 and v1," *The Ghost Howls*, 02-Dec-2016.
- [2] D. James and S. Mubarak, "Recognizing Hand Gestures." 06-Feb-1994.
- [3] "Starting February 1, 2012: Use the Power of Kinect for Windows to Change the World – Kinect for Windows Product Blog." [Online]. Available: <https://blogs.msdn.microsoft.com/kinectforwindows/2012/01/09/starting-february-1-2012-use-the-power-of-kinect-for-windows-to-change-the-world/>. [Accessed: 29-Oct-2018].

- [4] Yi Li, “Hand gesture recognition using Kinect,” in *2012 IEEE International Conference on Computer Science and Automation Engineering*, Beijing, China, 2012, pp. 196–199.
- [5] S. M. Chang, “Using gesture recognition to control PowerPoint using the Microsoft Kinect,” Thesis, Massachusetts Institute of Technology, 2013.
- [6] Tin, N. C., Tung, H. K., Nghia, V. T., and Cong, L. T., “Nghiên cứu và ứng dụng Kinect vào việc trình chiếu tài liệu,” 2016. [Online]. Available: <http://kdientu.duytan.edu.vn/vi-vn/nghien-cuu-khoa-hoc/nghien-cuu-va-ung-dung-kinect-vao-viec-trinh-chieu-tai-lieu/>. [Accessed: 29-Oct-2018].
- [7] O. Wasenmüller and D. Stricker, “Comparison of Kinect V1 and V2 Depth Images in Terms of Accuracy and Precision,” in *Computer Vision – ACCV 2016 Workshops*, 2017, pp. 34–45.
- [8] A. Znagui Hassani, B. van Dijk, G. Ludden, and H. Eertink, “Touch versus In-Air Hand Gestures: Evaluating the Acceptance by Seniors of Human-Robot Interaction,” in *Ambient Intelligence*, 2011, pp. 309–313.
- [9] “What are the different types of holography? How did each evolve? - Quora.” [Online]. Available: <https://www.quora.com/What-are-the-different-types-of-holography-How-did-each-evolve>. [Accessed: 09-Nov-2018].

FU Student Data: Optimizing the Storage and Querying in the context of the number of Student increase significantly with Map-Reduce Framework

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Abstract

Nowadays, data storage and management is an unreplaceable module in most applications, from industrial to academic applications. Usually, data storing and managing is executed using Relational Database (R-DB), which is using B+ Tree as the best data structure for indexing. This mechanism has a major drawback which is slowing down the query speed when data amount increases because of the sequential tree constructing. In this research, we would like to propose a new approach to deal against the current drawback of R-DB: Applying Hadoop Map-Reduce (MR) Framework in Building B+ Tree, in order to not only improve constructing speed but also improve in query speed, apply on available dataset. MR is a software framework which processes vast amounts of data in parallel on large clusters. We separate the B+ Tree constructing process into three phases, where MR Framework is applied in the second phase. We strongly believe that this approach has the potential to be applied in lots of domain, such as industrial, medical, and academic. For instance, we have found that FPT University (FU) has four branches, each branch has about two to three thousands of student, approximately, for a total of almost ten thousands of students. Despite of the huge data, storing and management in FU are still depended on each branch itself; this leads to the difficulty in data collecting and report; nevertheless, in five to ten more years, when the students amounts are increasing significantly, this situations will become more and more worst, posing an urgent question "How to improve the query speed". In that context, our solution is a necessary answer for this performance question, besides that, unify database of these four branches is another question where our solution should be considerable.

Keywords

B Tree, B+ Tree, Hadoop, Map-Reduce, BigData.

1. Introduction

Nowadays, for data storage and management, B+-tree is considered as an optimal data structure that allow fast access data and querying. However, in the context of the data explosion, where the available data is still increasing dramatically, it usually take much time for B+-tree construction in the sequential way. The insertion operation of the traditional B+-tree is shown in the following figure with the fanout 3.

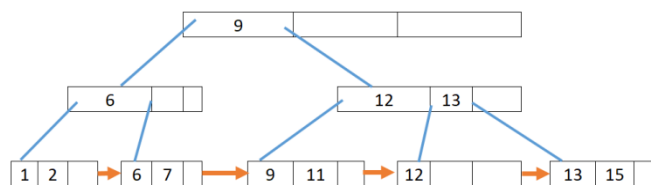


Figure 1: B+ tree with Fanout value is 3

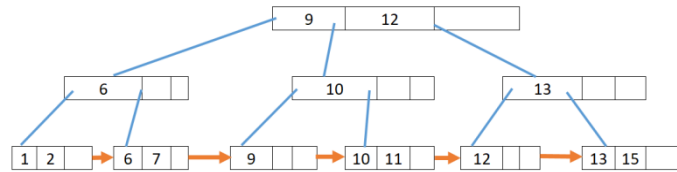


Figure 2: B+ Tree is self-balanced with value 10

As me mentioned above, in fact, in many applications where all data are available, the B+-tree should be built in parallel way with bulk-loading technique, where data first to be grouped into nodes, then a single insertion operation will be called. With this approach, the B+-tree should be built much faster than the traditional way. Besides that, with the advent of Hadoop-MapReduce, a distributed and parallel programming model, that extremely suitable for large-scale data processing, they motivated our Parallel B+-tree construction schema that leverage on the parallelism of the MapReduce model and the bulk-loading technique. Our schema consists of three phases, in which, the second phase is implemented in Hadoop-MapReduce model while the others phases are performed outside the cluster due to their computational processing is not intensive and quite simple. With our schema, the quality of the B+-tree is improved significantly while the construction time is reducing dramatically. Especially, in the context of FPT University Education, where the number of students is still increasing significantly every year on all four campuses (Ho Chi Minh, Hanoi, Da Nang and Can Tho), a consistent and centralized database construction is necessary and inevitable, in which, the storage and the query performance is a real challenge. Therefore, with our method, it is almost an optimal and urgent solution to this problem.

2. Related works

2.1. Hadoop-MapReduce

Traditionally, for data processing, most enterprises had a supercomputer to perform this task. Here data can be stored in an RDBMS such as Oracle, MS SQL or DB2, then the software can be written to interact with database, then send to the users for purpose analysis. But with this approach, when it has to handle a huge amounts of data, it faces many difficulties in processing such data through a traditional database server.

Facing these difficulties, from 2004, an Open source Project called Hadoop was released. It provides a MapReduce model that leverage on the Google File system (GFS), it is a distributed programming model suited for parallel computation, it handles parallelism, fault tolerance, so it can be executed on a large cluster of commodity machines easily. With this model, even it allows the non-expert developers who do not have an intensive knowledge in parallel and distributed system, can develop their program as well as use the resources of the system flexibility.

In general, MapReduce model consists of both a map and reduce which are user-defined function. The input data format is specified by the user and the output is a set of <key, value> pairs, the workflow of the MapReduce is shown in the Figure.3 and Figure.4

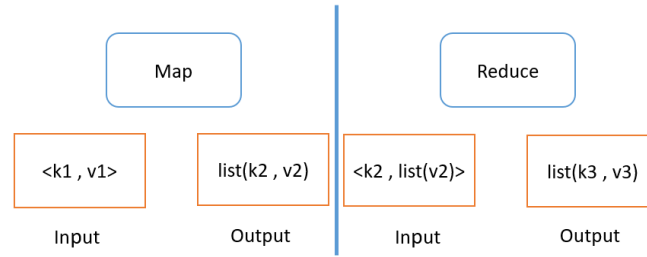


Figure 3: Map Reduce input output

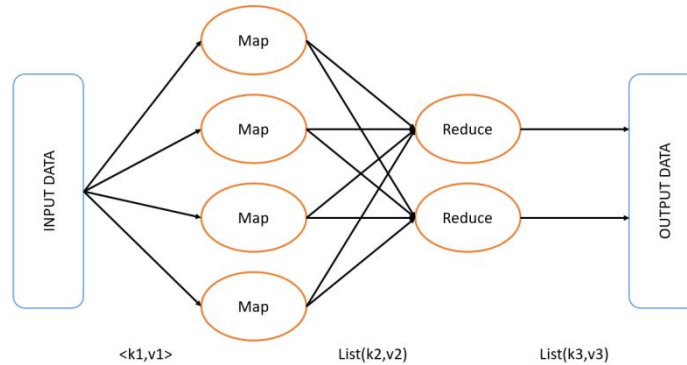


Figure 4: Map Reduce Framework

2.2. Bulk-Loading technique

Typically, in disk-based tree data structure, there are two approaches for tree construction. The first approach is all items will be inserted sequentially as they arrived, but it usually takes much time for a huge volume of available data set, and it's only suite for the database frequent changing. The second approach is all items first are grouped into nodes in order, then then a single insertion operation will be called, which also called “bulk-loading technique”. With this approach, it can improve the quality of the tree and reduce the construction time significantly for the static large data set

There are two methods for bulk-loading technique are top-down method and bottom-up method. As their names imply, bottom-up method builds a tree from leaf-level to root-level by merging, while top-down method prepare a tree from root-level to leaf-level by slitting as shown in the Figure. 5 and Figure.6.

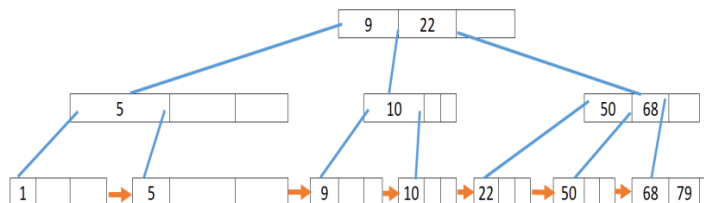


Figure 5: The normal B+ Tree is built in top-down method with sorted data and fanout value is 3, each node will have 3 memory areas. After inserting new data, it can not be inserted to the empty memory areas that passed (the following data will always be large

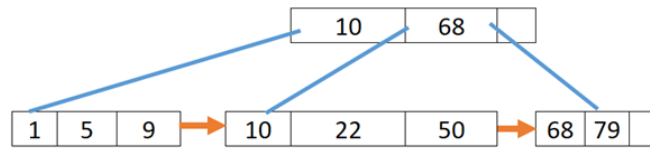


Figure 6: Bulk loading Bottom-up

3. Proposed parallel B+ tree construction schema

As we discussed before, in the proposed schema, our main considerations is enhancing the quality of the B+-tree for a huge volume of available data while reducing the construction time significantly.

Our schema consists of three phases, in which, the second phase is also the most intensive computation will be implemented on Hadoop-MapReduce framework while the others phases are performed outside the cluster due to their computational processing is not intensive and quite simple as shown in the Figure.7.

Three Phases:

- Pre-processing phase, proceed to sort the data if the data set has not been sorted, randomly select a data set from the original dataset and divide the dataset into small parts. Determine the boundaries of the sections, after which we will get a set of boundaries for the original dataset.
- Next phase, from the found boundaries, we will divide the input data into blocks of data in A-Z order. After dividing, we construct the B+ tree from the divided data blocks by bulk loading method and find the root for small B+ tree. After the previous step we can get the small B+ trees and their roots, built from blocks of data bounded by the pre-processing stage.
- Last phase, from the small B+ tree that found roots in the previous phase, we combine all the small B+ tree in to a complete B+ tree. So we have complete building of B+tree with the given dataset.

Note that, because our main target is how to improve quality of the storage for all FPTU students database, so in our data set, every student is represented by each line in form <o.id, o.S> where o.id is the item's identifier and o.S is the student information includes some attributes, such as : first name, last name, student number, as shown in the Figure.8.

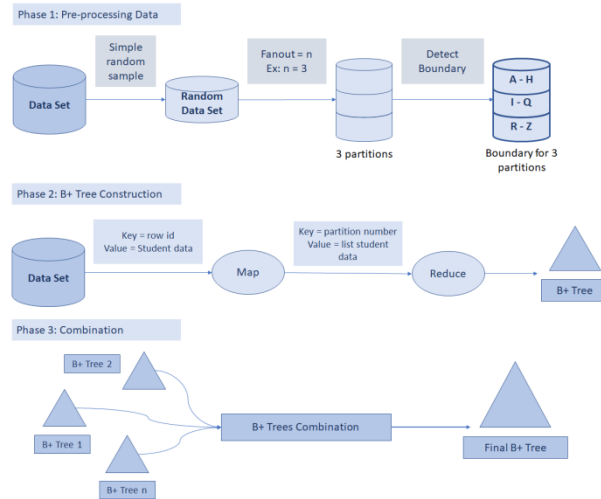


Figure 7: The stages of building a B+ tree

STT	Họ và Tên	MSSV	SĐT	Email
1	Nguyễn Khánh	SE12345	914138737	thuyaiqt13@gmail.com
2	Nguyễn Văn Đông	SE12346	982555942	27hyuugahinato12@gmail.com
3	Nguyễn Lê Thảo Ngân	SE12347	1653522582	thaonganlmit@gmail.com
4	Nguyễn Huy	SE12348	90599787	hien.nthithu@mobifone.vn
5	Hồ Tất Nhật	SE12349	93549885	honhatfiction233@gmail.com
6	Nguyễn Hữu Nghĩa	SB12400	943678212	boyhamchoi242@gmail.com
7	Nguyễn Thị Thảo Huyền	SB12401	1232523173	lecnnguyen123@gmail.com
8	Lê Thường Như	SB12402	947387553	vitdore902@gmail.com
9	Lê Vũ Thực Nhi	SB12403	913156306	thucnhi99@gmail.com
10	Hoàng Trọng Kiên	SB12404	1653437904	minhminh16197@gmail.com
11	Hồ Tiến Đạt	SB12405	947528396	paololuka1998@gmail.com
12	Ngô Xuân Tùng	SE12350	1247259521	nhokkaito@gmail.com
13	Phạm Hoàng Xuân Phúc	SE12351	905922555	PHXPhuc@yahoo.com
14	Nguyễn Thanh Thúy Vi	SE12352	905891374	nguyenthanhthuyvi17599@gmail.com

Figure 8: Student Data Sample

In order to implement the above steps, we will use the given large datasets as Student Data Sample and proceed to sequence the steps as shown below. We would like to present step by step in detail:

3.1. Data Pre-Processing Phase

Main purpose of this phase is the input data is separated into partitions, then detect the boundary between partitions. It is quite difficult to detect boundary. If a system can execute in the huge input data, then the accuracy of boundaries is 100%. In fact, with huge input data size can make any system corrupted. Sampling Technique is choosed to apply to solve that problem. This is a randomly selected method that outputs the most similar description to the input data. With the amount of data collected, we begin to partition this dataset into subset datasets, noting that the number of partitions we divide depends on the number of fanouts. Also, from the result of dividing the random data into each partitions, we define the partition boundaries, and expect that the number on each partitions is same.

3.2. Parallel local B+ tree

In this phase, Framework MapReduce is used to distribute the data to small blocks and build B+-tree from data blocks. In the Map stage, based on the boundaries found on the previous phase, we will map the data from the dataset to the appropriate sections, the re-mark the sections. Then at the stage Reduce, we construct a B+ tree using the bottom-up bulk loading method and determine the root of the newly constructed B+ tree. So after this stage, we will have B+ trees built from partitions and tree roots, for the next step.

With the sorted data set, using the bottom up bulk loading method to create the tree ensures that we get the B+ tree at the lowest possible height, so the performance for the retrieval task is also the highest. And with data-independent partitions, we can let nodes on the system run and create trees simultaneously, so the time to create the tree is also faster.

3.3. Combine every B+ tree to be a complete B+ tree

In this phase, we will combine root in each B+ tree in phase 2 into a complete B+-tree.

4. Experimental result and discussion

4.1 Experimental Environment

We have set up a system include of 3 nodes: a master node to manage tasks and 2 slave nodes to perform tasks and process data.

The using environment includes: Ubuntu OS 16.04, Hadoop 2.8.5, JDK 11.0.1 and Java Programming Language. The hardware details are: 650GB Disk capacity, 12GB RAM and 10 cores for processing. (Figure 9)

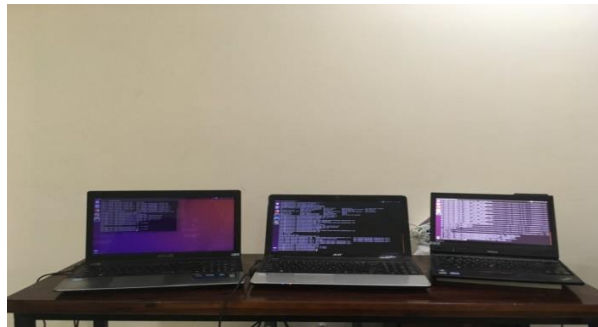


Figure 9: Map-Reduce System

4.2 Data set

The used data set is csv file contain an assumed list of students with attributes are: student code, name and email. In order to evaluate the overall scheme, we experimented on data sets with capacity of 200MB, 500MB, 1GB and 2GB, respectively with the number of students are 6 millions, 13.7 millions, 30.6 millions and 61.3 millions. The constructive B+ Tree will consist of key is student code and value is student data. (Figure 10).

GD16158066	Le Van Ngan	nganlv@fpt.edu.vn
GD16158067	Dao Van Hieu	hieudv@fpt.edu.vn
GD16158070	Ly Van Nguyen	nguyenlv@fpt.edu.vn
GD16158071	Luu Van Anh	anhlv@fpt.edu.vn
GD16158073	Dang Van Ky	kydv@fpt.edu.vn
GD16158076	Ly Van Ngoc	ngoclv@fpt.edu.vn
GD16158083	Tran Van Linh	linhtv@fpt.edu.vn
GD16158087	Cao Van Hieu	hieucv@fpt.edu.vn
GD16158094	Le Van Ngoc	ngoclv@fpt.edu.vn
GD16158096	Ho Van Kiet	kiethv@fpt.edu.vn
GD16158098	Dao Van Dung	dungdv@fpt.edu.vn
GD16158099	Le Van Trung	trunglv@fpt.edu.vn
GD16158100	Thai Van Dung	dungtv@fpt.edu.vn
GD16158105	Dang Van Trung	trungdv@fpt.edu.vn

Figure 10: Sample Data set

4.3 Experiment Result

1. Pre-processing Data Phase

In this phase, we get random 10%, 50% and 100% number of students according to init data sets and process to get boundaries.

2. Second Phase

After pre-processing phase, we build a set of small B+ trees according to data set by installed mapreduce system with data sets of 200MB, 500MB, 1GB and 2GB. The B+ tree will be conducted with fanout of 6, 10, 14 and 18. We will compare B+ tree parallelly construction speed with sequentially speed. In this phase, Reducers steps to build small B+ trees is the most computationally intensive part and also take most of the time.

3. Third Phase

In this phase, we will combine all small B+ trees from the second phase to a completed B+ tree which contains student data.

4.4 Discussion

1. Pre-processing Data

The Sampling technique is used to get exactly boundaries whether data is taken in many different data sizes, and with the less data, the significantly shorter execution time. We noticed that we can save more time if we use the sampling technique to random a small data set and generate boundaries from it. (Figure 11)

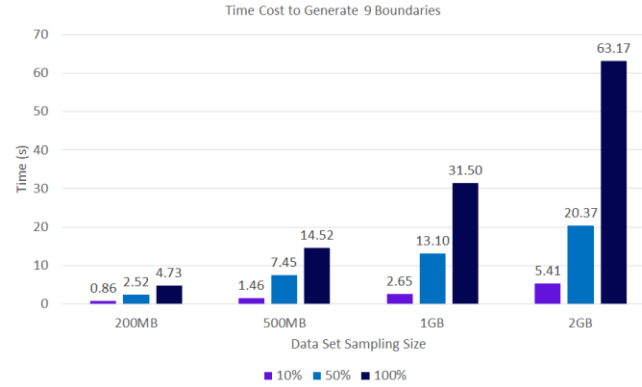


Figure 11: Time cost to generate boundaries in pre-processing data stage

2. B+tree construction for Large Data set

When using sequentially B+ tree construction, if fanout increases, the time to build the tree is reduced. However, when data increases significantly, time cost is also increased. Bulkloading method can reduce the time cost rather than sequentially method, though huge volume data may lead to memory overflow (Figure 12, 13). While constructing B+ tree with Mapreduce framework, which is using bulkloading and parallel construction, the building time has been decreased considerably.

Currently, our mapreduce system still have some issues, so it can only be experimented with fanout 6 and 10. We realize that using mapreduce framework for B+ tree construction helps to reduce time significantly. (Figure 14, 15)

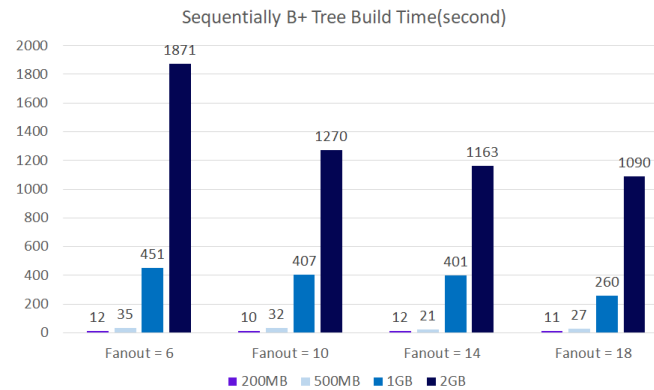


Figure 12: Sequentially B+ Tree Build Time

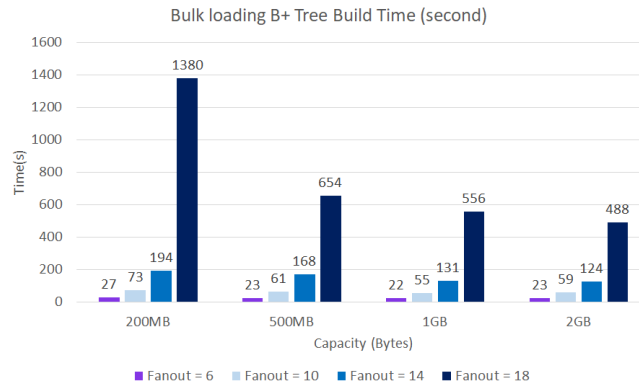


Figure 13: Bulkloading B+ Tree Build Time

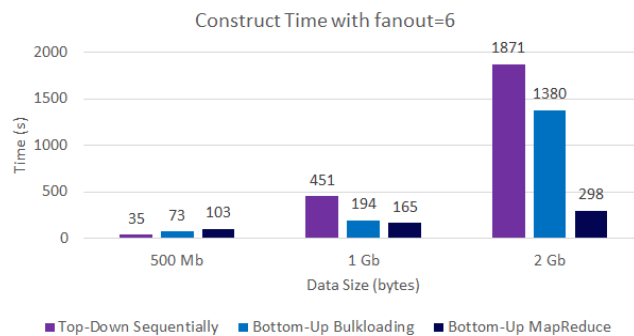


Figure 14: B+ Tree Constructive time with fanout 6

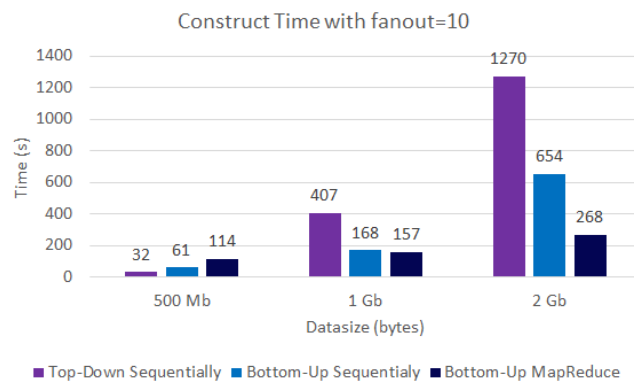


Figure 15: B+ Tree Constructive time with fanout 10

5. Conclusion and future work

Every year, FPT University is developing, students are increasing more and more, and the data of 4 campus need to be synchronized. Therefore, we need an effective solution that manage data for along time necessarily. We believe that using Big Data Technique is one of the best way to store and query data. By the way using Hadoop Map Reduce framework, we saved the time for building B+-tree in order to indexing student and this B+-tree is the best tree. The amounts of FPTU students will change dramatically every year, so if our suggestion was applied, we will build B+-tree again to be served for query operation. Although

MapReduce has helped us solve the problem, it still has many limitations. Thus, our future plan will improve performance with new technique, Spark.

Acknowledgment

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References

- [1] [Comer, Douglas](#) (June 1979), "The Ubiquitous B-Tree", *Computing Surveys*
- [2] [HDFS Data Block](#) – Learn the Internals of Big Data Hadoop
- [3] [Why java.util.Arrays uses Two Sorting Algorithms](#) - The Cafes » Java
- [4] [Stability in sorting algorithms](#) - GeekforGeeks
- [5] Meng, Xiangrui (2013). "[Scalable Simple Random Sampling and Stratified Sampling](#)" (PDF). Proceedings of the 30th International Conference on Machine Learning (ICML-13): 531–539.
- [6] [MapReduce: Simplified Data Processing on Large Clusters](#)
- [7] <https://wiki.apache.org/hadoop/MapReduce>
- [8] <https://wiki.apache.org/hadoop/HadoopMapReduce>
- [9] Huynh Cong Viet Ngu, Department of IT FPT University HCMC Campus, “B+tree construction on Massive data with Hadoop (Cluster Computing – DOI 10.1007_s10586-017-1183-y – recommended from ICISA 2017)”
- [8] <https://wiki.apache.org/hadoop/HadoopMapReduce>

Tính chất quang của tinh thể quang tử kim loại điện môi

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Tóm tắt

Chúng tôi sử dụng phương pháp nhúng bất biến để nghiên cứu tính chất quang của tinh thể quang tử kim loại điện môi tuần hoàn và giả tuần hoàn. Trong trường hợp kim loại nguyên khối độ truyền qua giảm rất nhanh khi tăng bề dày của lớp kim loại chỉ đạt dưới 3% với bề dày của lớp kim loại khoảng 70nm. Trong báo cáo này chúng tôi chia lớp kim loại thành nhiều lớp mỏng hơn xen kẽ giữa chúng là lớp điện môi, kết quả độ truyền qua tăng lên rất nhanh có thể đạt khoảng 85%. Đồng thời chúng tôi cũng quan sát được phân bố điện, từ trường được tăng cường lên rất nhiều lần, chúng tôi hy vọng kết quả này sẽ được ứng dụng trong việc chế tạo các thiết bị quang học như bộ lọc hay cảm biến quang học.

1. Giới thiệu

Ngày nay với sự phát triển mạnh mẽ của máy tính, việc mô phỏng tính chất của các vật liệu trên máy tính đặc biệt quan trọng nó tìm ra các tính chất mới của vật liệu cũng như tìm ra cấu trúc tối ưu cho một tính chất nào đó, nó giúp thực nghiệm trong việc định hướng chế tạo cấu trúc vật liệu một cách chính xác để tìm ra cấu trúc tối ưu cần thiết, loại bỏ các cấu trúc không đạt được độ tối ưu hóa cần thiết, làm giảm thời gian chế tạo cũng như chi phí cho thực nghiệm. Hòa chung với xu hướng phát triển của vật liệu mới cũng như sự phát triển của mô phỏng tính chất vật liệu bằng máy tính, chúng tôi sử dụng phương pháp nhúng bất biến (Invariant Imbedding method) [1-2] để nghiên cứu tính chất quang của các tinh thể và giả tinh thể kim loại điện môi.

Có rất nhiều phương pháp nghiên cứu tính chất quang của tinh thể quang tử kim loại điện môi chẳng hạn có phương pháp sai phân hữu hạn trong miền thời gian (FDTD Finite-difference time-domain method) [3] hoặc phương pháp gần đúng hàm bao (Slowly varying envelope approximation) [4] hoặc phương pháp ma trận chuyển (transfer matrix method) [5]. Mỗi phương pháp trên đều tính gần đúng hoặc có những hạn chế nhất định, chẳng hạn như phương pháp biến phân phần tử hữu hạn FDTD thì chúng ta cần chia thành các lưới, nếu như chia lưới quá lớn thì dẫn đến không chính xác, ngoài ra nếu chia quá nhỏ dẫn đến số lượng tính toán quá lớn dẫn đến sai số tích lũy, thêm nữa cần một điều kiện khớp pha. Còn phương pháp gần đúng hàm bao thì đây là phương pháp gần đúng, nếu như biên độ của hàm sóng biến thiên lớn thì phương pháp này không áp dụng được. Còn phương pháp ma trận chuyển thì không giải được bài toán độ điện thẩm và từ thẩm biến thiên một cách liên tục hoặc thay đổi một cách quá nhanh, chẳng hạn như các bài toán phi tuyến. Những năm gần đây chúng tôi phát triển phương pháp nhúng bất biến, ưu điểm của phương pháp này biến hệ phương trình đạo hàm riêng thành hệ phương trình vi phân đồng nhất, đồng thời đưa việc giải bài toán điều kiện biên sang giải bài toán điều kiện ban đầu. Về mặt tính toán số thì việc giải bài toán với điều kiện ban đầu đơn giản hơn rất nhiều so với việc giải bài toán với điều kiện biên. Đây là phương pháp giải bài toán một cách chính xác trong phạm vi tính toán số, tuy nhiên

phương pháp này chỉ giải bài toán trong phạm vi một chiều. Trong phạm vi tính toán của phần nhánh đề tài này chúng tôi tiến hành nghiên cứu tính chất quang tử tinh thể và giả tinh thể quang tử một chiều kim loại điện môi, nên phương pháp nhúng bất biến rất phù hợp với bài toán.

2. Lý thuyết

Xét quá trình truyền sóng phẳng dọc theo trục oz khi đó phương trình truyền sóng thỏa mãn phương trình

$$\frac{d^2 E(z)}{dz^2} - \frac{d\mu(z)}{dz} \frac{dE(z)}{dz} + (k_0^2 \varepsilon \mu - k_x^2) E(z) = 0 \quad (1)$$

Chúng ta giả định sóng truyền từ môi trường đồng nhất có $z > L$ sang môi trường không đồng nhất và cuối cùng truyền sang môi trường đồng nhất có $z < 0$. Giả sử điện thẩm và từ thẩm là hàm của tọa độ z

$$\varepsilon(z) = \begin{cases} \varepsilon_1 & z > L \\ \varepsilon_R(z) + i\varepsilon_I(z) & 0 \leq z \leq L \\ \varepsilon_2 & z < 0 \end{cases} \quad (2)$$

$$\mu(z) = \begin{cases} \mu_1 & z > L \\ \mu_R(z) + i\mu_I(z) & 0 \leq z \leq L \\ \mu_2 & z < 0 \end{cases} \quad (3)$$

ở đó $\varepsilon_R, \varepsilon_I, \mu_R, \mu_I$ là các hàm bất kỳ phụ thuộc vào tọa độ z . Hệ số điện thẩm và từ thẩm của vùng sóng tới và sóng truyền qua lần lượt là ε_1, μ_1 và ε_2, μ_2 .

Đại lượng chúng ta quan tâm là hệ số phản xạ (r) và truyền qua (t) được định nghĩa thông qua hàm sóng tới và sóng truyền qua:

$$E(x, z) = \begin{cases} \exp(ip(L - z) + iqx) + r(L) \exp(ip(z - L) + iqx), & z > L \\ t(L) \exp(-ip'z + iqx) & z < 0 \end{cases} \quad (4)$$

Sử dụng phương pháp nhúng bất biến cho ta kết quả hệ số phản xạ và truyền qua thỏa mãn hệ phương trình vi phân:

$$\begin{aligned}\frac{dr(L)}{dL} &= 2ip \frac{\mu(L)}{\mu_1} r(L) + \frac{ip}{2} \left\{ \frac{\varepsilon(L)}{\varepsilon_1} \frac{1}{\cos^2 \theta} - \frac{\mu(L)}{\mu_1} - \frac{m_1}{\mu(L)} \tan^2 \theta \right\} [1 + r(L)]^2, \\ \frac{dt(L)}{dL} &= 2ip \frac{\mu(L)}{\mu_1} t(L) + \frac{ip}{2} \left[\frac{\varepsilon(L)}{\varepsilon_1} \frac{1}{\cos^2 \theta} - \frac{\mu(L)}{\mu_1} - \frac{\mu_1}{\mu(L)} \tan^2 \theta \right] [1 + r(L)] t(L).\end{aligned}\quad (5)$$

Để giải hệ phương trình vi phân (5) cần điều kiện ban đầu thu được từ công thức nổi tiếng của Fresnel:

$$\begin{aligned}r(0) &= \frac{\varepsilon_2 \sqrt{\dot{\partial}_1 \mu_1} \cos \theta - \varepsilon_1 \sqrt{\dot{\partial}_2 \mu_2 - \dot{\partial}_1 \mu_1 \sin^2 \theta}}{\varepsilon_2 \sqrt{\dot{\partial}_1 \mu_1} \cos \theta + \varepsilon_1 \sqrt{\dot{\partial}_2 \mu_2 - \dot{\partial}_1 \mu_1 \sin^2 \theta}}, \\ t(0) &= \frac{2\varepsilon_2 \sqrt{\dot{\partial}_1 \mu_1} \cos \theta}{\varepsilon_2 \sqrt{\dot{\partial}_1 \mu_1} \cos \theta + \varepsilon_1 \sqrt{\dot{\partial}_2 \mu_2 - \dot{\partial}_1 \mu_1 \sin^2 \theta}}.\end{aligned}\quad (6)$$

Đại lượng chính mà chúng ta quan tâm là độ phản xạ và truyền qua thu được từ hệ số phản xạ và truyền qua tương ứng:

$$R = |r|^2, \quad T = \frac{\varepsilon_1 \sqrt{\dot{\partial}_2 \mu_2 - \dot{\partial}_1 \mu_1 \sin^2 \theta}}{\varepsilon_2 \sqrt{\dot{\partial}_1 \mu_1} \cos \theta + \varepsilon_1 \sqrt{\dot{\partial}_2 \mu_2 - \dot{\partial}_1 \mu_1 \sin^2 \theta}} |t|^2 \quad (7)$$

Đồng thời phương pháp nhúng bất biến cũng cho phép ta tính được phân bố biên độ của điện trường bên trong hệ thỏa mãn phương trình vi phân:

$$\frac{dE}{dL} = 2ip \frac{\mu(L)}{\mu_1} E + \frac{ip}{2} \left[\frac{\varepsilon(L)}{\varepsilon_1} \frac{1}{\cos^2 \theta} - \frac{\mu(L)}{\mu_1} - \frac{\mu_1}{\mu(L)} \tan^2 \theta \right] [1 + r(L)] E \quad (8)$$

Để giải phương trình (8) cần điều kiện ban đầu thỏa mãn $E(z) = 1 + r(z)$.

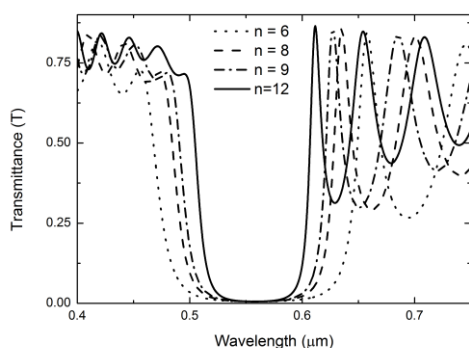
3. Kết quả tính số và thảo luận

Chúng tôi đi tính số với tinh thể quang tử kim loại điện môi với tổng độ dày của lớp kim loại khoảng 70nm [6]. Vật liệu kim loại mà chúng tôi chọn đó là bạc (Ag) có điện thẩm thỏa mãn

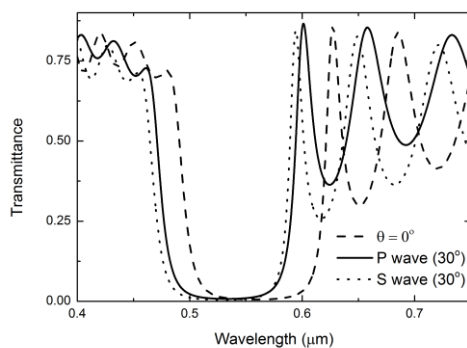
công thức Drude: $\varepsilon = \varepsilon_\infty - \frac{\omega_p^2}{\omega^2 + i\gamma\omega}$ và $\gamma = \alpha + \beta\omega^2$, các thông số chúng tôi lựa chọn

theo [7] $\varepsilon_\infty = 4$, $\omega_p = 1.36 \times 10^{16} s^{-1}$, $\alpha = 2.37 \times 10^{13} s^{-1}$, $\beta = 5.9 \times 10^{-18} s$. Lớp điện môi là TiO_2 có điện thẩm là 2.35.

A. Kết quả của tinh thể quang tử kim loại điện môi tuần hoàn



Hình 2: Phổ truyền qua với bước sóng, độ dày của lớp điện môi là 120nm. Tổng độ dày của lớp kim loại là 72nm,



Hình 3: Phổ truyền qua với phân cực khác nhau với góc tới là 30°. Độ dày của lớp điện môi 120nm. Tổng độ dày của lớp kim loại 72nm.

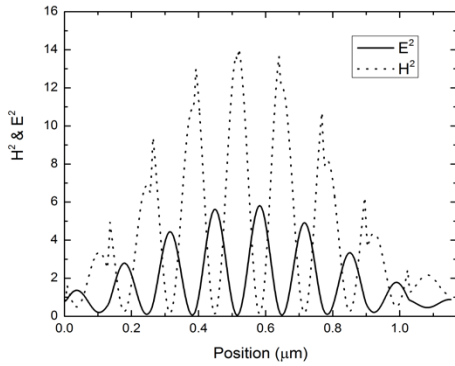
Phổ truyền qua phụ thuộc vào bước sóng với các cấu hình khác nhau được thể hiện trên Hình 2. Trong các trường hợp tổng độ dày của lớp kim loại vào khoảng 70nm và độ truyền qua đạt được khoảng 85% kết quả này cùng phù hợp với kết quả được công bố trong [6] thể hiện ở hình 3. Khi số lớp tuần hoàn tăng lên thì độ truyền qua cao nhất có xu hướng tăng nhưng rất ít. Khi góc tới bằng 0 thì không có sự phân biệt giữa sóng phân cực s và p, tuy nhiên khi góc tới khác 0 thì có sự dịch chuyển phổ về phía bước sóng nhỏ hơn đồng thời có sự phân tách giữa phổ của sóng phân cực s và p, kết quả được thể hiện trên hình 3. Trên hình 3 chúng tôi chọn cấu hình có 9 lớp kim loại điện môi tuần hoàn, ở góc tới bằng 0° và 30°. Khi góc tới khác 0 thì độ truyền qua lớn nhất của sóng p lớn hơn một chút so với độ truyền qua lớn nhất của sóng s.

Tiếp theo chúng tôi nghiên cứu phân bố bình phương biên độ điện, từ trường tại bước sóng mà có độ truyền qua cao nhất trong hình 2 ứng với số lớp tuần hoàn là 9 kết quả thể hiện trên hình 4. Kết quả của bình phương biên độ điện trường phù hợp với kết quả trong [6] ứng với hình 3b, còn bình phương biên độ từ trường thì lớn hơn nhiều so với bình phương biên độ điện trường. Ở các lớp giữa cả điện trường và từ trường được tăng cường rất mạnh, nếu chúng ta quan tâm đến các hiệu ứng phi tuyến của kim loại thì ảnh hưởng của hiệu ứng phi tuyến lên các đại lượng mà chúng ta quan tâm sẽ tăng lên rất mạnh.

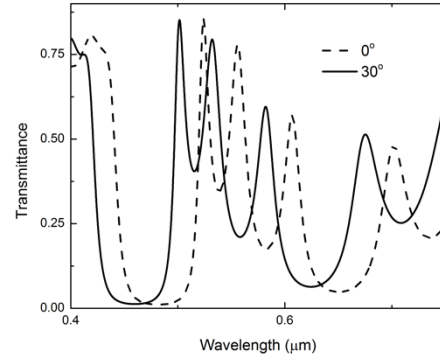
B. Kết quả của tính thể quang tử giả tuần hoàn Thue Morse

Trong phần báo cáo này chúng tôi quan tâm đến tính thể quang tử giả tuần hoàn Thue Morse (TM), lý do chúng tôi chọn tính thể này là số lớp kim loại bằng số lớp điện môi. Tính thể quang tử giả tuần hoàn TM được tạo sinh ra theo quy luật thể hệ sau được xác định từ thể hệ trước, giả sử lớp kim loại được ký hiệu là A còn lớp điện môi được ký hiệu là B. Giả định thể hệ trước là lớp A thì sẽ thay thế thành lớp AB, còn là lớp B thì sẽ thay thế thành BA khi đó ta có quy luật mở rộng sẽ là

$$A \rightarrow AB \rightarrow ABBA \rightarrow ABBABAAB \rightarrow ABBABAABBAABABBA \dots$$

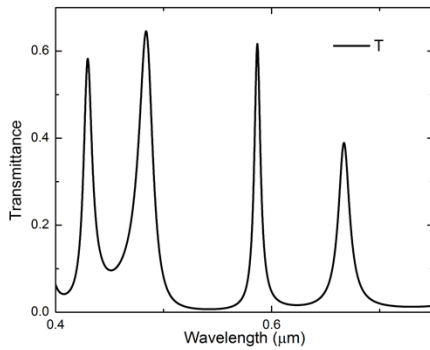


Hình 4: Phân bố bình phương biên độ điện, từ trường trong hệ $\lambda = 627.4\text{nm}$. $d_d = 120\text{nm}$, $d_m = 8\text{nm}$, $n = 9$, $\theta = 0^\circ$.

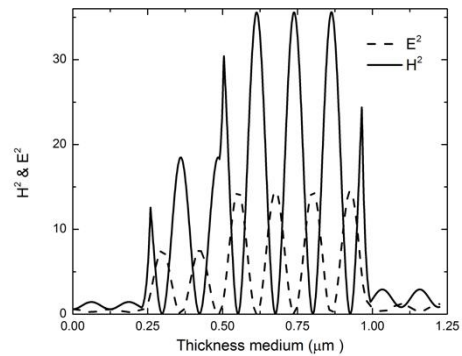


Hình 5: Phổ truyền qua của sóng p phụ thuộc bước sóng, trong cấu trúc TM, $n = 12$, $d_m = 6\text{nm}$, $d_d = 102\text{nm}$.

Trên hình 5 chúng tôi nghiên cứu phổ truyền qua của sóng p với hệ có là 12 lưỡng lớp kim loại điện môi đầu tiên trong cấu trúc TM. Giá trị lớn nhất của độ truyền qua vẫn xảy ra tại bước sóng ứng với cạnh cuối của khe năng lượng. Khe năng lượng dịch chuyển về phía bước sóng nhỏ đồng thời độ rộng của nó giảm và khi góc tới tăng lên.



Hình 6: Phổ truyền qua phụ thuộc vào bước sóng của 5 lưỡng lớp kim loại điện môi đầu tiên trong dây TM, $d_d = 230.4\text{nm}$, $d_m = 14.4\text{nm}$, $\theta = 0$.



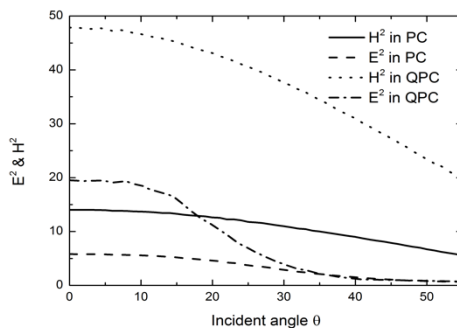
Hình 7: Phân bố bình phương biên độ điện, từ trường trong hệ ứng với cấu hình như hình 6 và bước sóng 586.8nm

Vấn đề chính mà chúng tôi quan tâm là đi tìm cấu trúc tối ưu sao cho phân bố biên độ điện, từ trường trong hệ đạt được giá trị lớn nhất. Bằng cách thay đổi độ dày của lớp điện môi, thay đổi độ dày cũng như số lớp tuần hoàn sao cho tổng độ dày của lớp kim loại là không đổi, số lượng tính toán rất lớn đòi hỏi cần có kỹ thuật tính. Với một chương trình ban đầu tính phổ truyền qua đối với một hệ xác định, và một chương trình xác định phân bố điện, từ trường bên trong hệ tại một bước sóng cũng như góc tới xác định, chúng tôi đã tiến hành viết

script để sinh ra các cấu hình mà ta mong muốn, rồi tính phổ truyền qua ứng với từng cấu hình được sinh ra từ script ở trên. Tiếp theo chúng tôi viết một chương trình khác xử lý các file kết quả vừa sinh ra, xác định bước sóng mà ở đó giá trị truyền qua là lớn nhất ứng với cấu hình đó sau đó tính phân bố biên độ điện, từ trường ứng với bước sóng mà chúng ta vừa xác định, rồi từ đó lọc ra cấu hình tối ưu nhất để có phân bố điện, từ trường bên trong hệ là lớn nhất. Kết quả của việc tính toán trên chúng tôi tìm được một vài cấu hình tối ưu để có phân bố biên độ điện từ trường đạt giá lớn nhất là 5 lưỡng lớp kim loại - điện môi đầu tiên trong tinh thể quang tử giả tuần hoàn TM BAABABBAAB, trong đó A và B đại diện cho lớp kim loại và điện môi. Trước hết chúng tôi nghiên cứu phổ truyền qua ứng với cấu trúc trên kết quả thể hiện trên hình 6.

Trên hình 6 ta thấy độ truyền qua tại bước sóng 586.8nm là không quá cao chỉ đạt được khoảng 60%, tuy nhiên đỉnh này cũng rất là nhọn nên chúng tôi hy vọng kết quả này có thể áp dụng trong các thiết bị lọc ánh sáng hoặc cảm biến quang học. Tiếp theo chúng tôi tiến hành nghiên cứu phân bố điện, từ trường bên trong hệ ứng với đỉnh này kết quả được thể hiện trên hình 7. Trên hình 7 ta thấy giá trị lớn nhất của bình phương biên độ điện, từ trường trong hệ đạt được khoảng 15 và 40, giá trị này lớn hơn nhiều so với kết quả trong trường hợp tinh thể quang tử tuần hoàn. Chúng tôi hy vọng kết quả này sẽ gợi ý cho những nhà nghiên cứu khác khi họ quan tâm đến tính chất phi tuyến của kim loại, cũng như ảnh hưởng của độ phi tuyến lên tính chất quang của hệ.

Cuối cùng chúng tôi đi tìm giá trị lớn nhất của cấu trúc toàn hoàn và giả tuần hoàn khi tổng bề dày của lớp kim loại là 72nm. Đối với cấu trúc tuần hoàn có 9 lưỡng lớp kim loại và điện môi, độ dày của lớp kim loại và điện môi tương ứng là 8nm và 120nm tương ứng, còn đối với cấu trúc giả tuần hoàn bề dày của lớp kim loại và điện môi tương ứng là 14.4nm và 288nm tương ứng, kết quả giá trị lớn nhất của bình phương biên độ điện, từ trường bên trong cấu trúc tuần hoàn và giả tuần hoàn phụ thuộc vào góc tới được thể hiện trên hình 8.



Hình 8: Giá trị lớn nhất của bình phương biên độ điện, từ trường bên trong tinh thể quang tử tuần hoàn và giả tuần hoàn phụ thuộc vào góc tới.

Trên hình 8 chúng tôi thấy giá trị lớn nhất của bình phương biên độ của cả điện trường và từ trường đều rất lớn ở góc tới bằng 0, khi góc tới tăng thì tất cả các giá trị đều giảm. Trong tinh thể quang tử giả tuần hoàn cả điện trường và từ trường được tăng cường rất mạnh lớn hơn rất

nhiều so kết quả trong tinh thể quang tử tuần hoàn. Giá trị lớn nhất của bình phương biên độ điện trường có thể đạt được là khoảng 20, còn giá trị lớn nhất của bình phương biên độ từ trường đạt được gần 50. Chúng tôi hy vọng nếu xét các lớp ở giữa là vật liệu phi tuyến phụ thuộc vào bình phương biên độ của điện trường hoặc từ trường ảnh hưởng của độ phi tuyến sẽ tăng cường rất lớn đối với các cấu hình này.

Kết luận

Áp dụng phương pháp nhúng bất biến chúng tôi nghiên cứu và một số kỹ thuật trong tính số chúng tôi nghiên cứu tính chất quang của tinh thể kim loại điện môi tuần hoàn và giả tuần hoàn. Trong cả hai trường hợp độ truyền qua lớn hơn rất nhiều so với độ truyền qua của kim loại nguyên khối.

Nếu muốn quan tâm độ truyền qua lớn để có thể áp dụng vào các thiết bị quang học như bộ lọc hay sensor thì chúng ta nên dùng cấu trúc tinh thể tuần hoàn.

Nếu chúng ta quan tâm nghiên cứu ảnh hưởng của độ phi tuyến hay là quan tâm đến độ lớn của biên độ điện, từ trường thì chúng ta nên sử dụng tinh thể quang tử giả tuần hoàn.

Tài liệu tham khảo

- [1] “Propagation of electromagnetic waves in stratified media with nonlinearity in both dielectric and magnetic responses” Kim, Kihong, Optics Express 16, 1150 **2008**.
- [2] “Strong influence of nonlinearity and surface plasmon excitations on the lateral shift” Kihong Kim, Optics Express 16 -15506 **2008**
- [3] "Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media". *IEEE Transactions on Antennas and Propagation*. **14** (3): 302–307. [doi](https://doi.org/10.1109/TAP.1966.1138693):10.1109/TAP.1966.1138693
- [4] Arecchi, F. T. & Bonifacio, R. *IEEE J. Quantum Electron.* 1, 169–178 **1965**.
- [5] O. S. Heavens “*Optical Properties of Thin Films*”. Butterworth, London **1955**.
- [6] Gui-qiang Du, Hai-tao Jiang, Zhan-shan Wang and Hong Chen “*Optical nonlinearity enhancement in heterostructures with thick metallic film and truncated photonic crystals*” OPTICS LETTERS **34** 578-580 (2009)
- [7] Markos, P. and C. M. Soukoulis, *Wave Propagation: From Electrons to Photonic Crystals and Left-handed Materials*, Princeton University Press, New Jersey, 2008.

Visual Sitemap Generator & Idea for Processing Data Structure to Test Spelling

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Abstract

- Gathering and storing the sitemap information for websites.
- Test spelling mistakes for website's content and recommend alternative words based on user actions in history.
- Optimize performance by familiar algorithms and data structures.

Keywords

Sitemap, Spelling Test, Breadth – First Search, Trie Tree, Recursion.

I. Introduction

Nowadays, the website design and development is rising rapidly. Businesses use the website as a main channel for providing information, products, and services to partners and potential customers. A good website does not only have a good look but also needs to operate correctly. That's why web development is so important to every company, even brand-new start up. If only concerned with the design of a website and not the functionality – a business won't be as successful at attracting new users to their website because they'll be lacking in the area of user experience.

Even in critical information, spelling and grammar mistakes still exist. It directly influences the enterprise's trademark.

The higher a website's site quantity, the more complicated the test process is. A link is whether correct when redirect to another page? There are duplicated or mistake when taking pages referencing to the same page? Sometime, it makes Web owners to become perplexed and confused in references between pages. These reasons reduce the effectiveness of product sale, business ads.

Therefore, we researched and suggest some below solutions:

- Apply Trie Tree data structure and Recursion algorithm for checking the spelling of website's content. With each spelling mistake, application give 3 recommends based on accuracy and user behavior in recent period time.

- Build a sitemap to control the link structure of website. Then, supply a visual picture for Web owner. They can also immediately know that which pages referencing on the same page. This feature will support web owner ensure their web application is being implemented correctly for the last expected purposes.

1. Sitemap Generators



Figure 1 - Sitemap Generator

A sitemap generator is a specific type of software that can automatically create a list of pages that are contained within a website or online application. Designing a totally new website or redesigning an existing website can be a daunting process, and a sitemap generator can take a significant amount of work off of the shoulders of the webmaster by creating the sitemap in just a few clicks. Sitemap generators can be used right in the browser or some come as programs that are downloaded. Gone are the days of manually creating sitemaps with no other option—though some may still opt to do this. Sitemap generators allow websites of all sizes to quickly and accurately obtain essentially a map of their content and how each piece relates to other pieces so that work can be performed on the website when needed.

WHAT IS A SITEMAP?

A sitemap is a list of pages that are contained in a website that is accessible to website crawlers or users. It can vary in type - sometimes it may be a simple document used as a planning tool for designing the website, or it may be a web page that contains a list of all pages within a website, which is generally organized in a hierarchical way. Sitemaps display the relationship between various pages and content of a website, demonstrating the way that the website is organized, how it can be navigated, and how it is labeled. There are a few different types of sitemaps, and a few different styles of sitemaps. Both of these factors will vary simply based on who or what the sitemap is intended for.

Sitemap generators allow webmasters to easily render sitemaps for their websites, rather than the webmaster crafting them by hand, in a spreadsheet, or by writing a script. Webmasters will use a sitemap generator to quickly create a sitemap for their website that can be uploaded and then registered with the search engines of the internet.

TYPES OF SITEMAPS

Visual sitemaps are used mostly as a planning tool that will help webmasters to organize and sort the content that will be included on the website, and helps to eliminate any pages that

may be unnecessary. When doing this, a visual sitemap allows the webmaster to outline the purpose and goal of the website to be focused and easy to navigate, which will provide a great user experience to the website visitors. Visual sitemaps are ideal for when the webmaster is planning the project, managing it through the process, and maintaining it after it has been completed.



Figure 2 - Visual Sitemap

XML sitemaps are structured in a way that the user does not need to see, but its purpose is to inform the search engines about the pages that are on the website, relates their importance to each other, as well as how often they are updated.

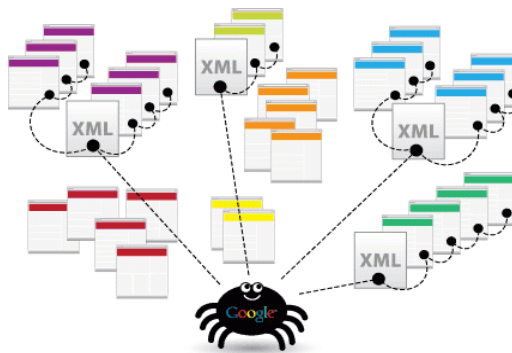


Figure 3 - XML Sitemap

This sitemap will contain URLs to all of the individual pages so that they can be found by web crawlers. This type of sitemap is much more precise than others - syntax must be exact because errors are absolutely not tolerated. An XML sitemap ensures that all nooks and crannies of a website are available to be crawled and indexed, so that they can be found by search engines when relevant search queries are performed.

```

<?xml version="1.0" encoding="utf-8"?>
<urlset xmlns="http://www.sitemaps.org/schemas/sitemap/0.9">
  <url>
    <loc>http://example.com/</loc>
    <lastmod>2012-03-08</lastmod>
    <changefreq>daily</changefreq>
    <priority>0.9</priority>
  </url>
  <url>
    <loc>http://example.com/schedule/</loc>
    <lastmod>2012-01-24</lastmod>
    <changefreq>monthly</changefreq>
    <priority>0.6</priority>
  </url>
  <url>
    <loc>http://example.com/news/</loc>
    <lastmod>2012-01-24</lastmod>
    <changefreq>hourly</changefreq>
    <priority>0.8</priority>
  </url>
</urlset>

```

Figure 43 - XML Sitemap Format

HTML sitemaps are designed with the user in mind, to help them find content on the web page. Because of this, the HTML sitemaps do not need to include every single subpage on the website. An HTML sitemap helps both website visitors and search engine bots to find web pages within a website. It should be noted that this format is not supported by Google's Webmaster Tools, thus it cannot be submitted. This is purely for the user experience, front end portion, and website search.



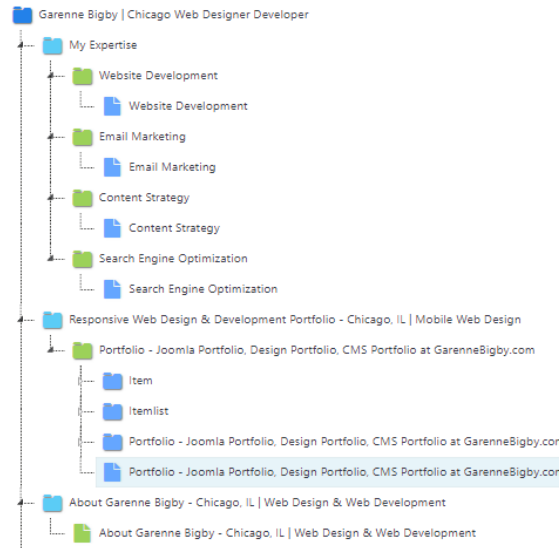


Figure 5 - HTML Sitemap

Visual sitemaps, XML sitemaps, and HTML sitemaps all provide different benefits and make a website great when they are all used together and cohesively.

Sitemap generators allow webmasters to easily render sitemaps for their websites, rather than the webmaster crafting them by hand, in a spreadsheet, or by writing a script. Webmasters will use a sitemap generator to quickly create a sitemap for their website that can be uploaded and then registered with the search engines of the internet.

In this paper's scope, we just mention a way to generate sitemap which represents link structure of the specific website. With the built result, we use it as an input parameter for testing features of the system. Furthermore, we will use this information to display a visual image for supplying a general view to users.

2. Automated misspelling detection and correction



In software, a spell checker is a software feature that checks for misspellings in a text. Features are often in software, such as a word processor, email client, electronic dictionary, or search engine

A basic spell checker carries out the following processes:

- It scans the text and extracts the words contained in it.

- It then compares each word with a known list of correctly spelled words (i.e. a dictionary). This might contain just a list of words, or it might also contain additional information, such as hyphenation points or lexical and grammatical attributes.

An additional step is a language-dependent algorithm for handling morphology. Even for a lightly inflected language like English, the spell-checker will need to consider different forms of the same word, such as plurals, verbal forms, contractions, and possessives. For many other languages, such as those featuring agglutination and more complex declension and conjugation, this part of the process is more complicated. It is unclear whether morphological analysis—allowing for many different forms of a word depending on its grammatical role—provides a significant benefit for English.

As an adjunct to these components, the program's user interface will allow users to approve or reject replacements and modify the program's operation.

Spelling suggestion is a feature of many computer software applications used to suggest plausible replacements for words that are likely to have been misspelled.

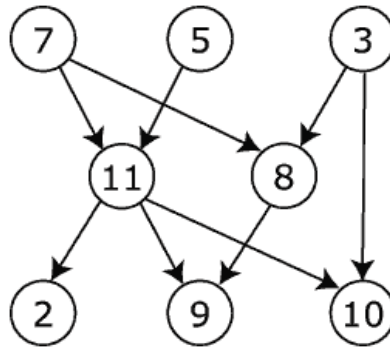
Algorithms for spelling suggestion may incorporate several information resources to determine candidates for misspelled words and the words' likely correct replacements, including the following:

- Frequency of a word's occurrence in reliable data sources
- Search query logs
- List of frequently misspelled words
- Domain specific data resources

In this paper's scope, we introduce a solution: applying a data structure named "Trie Tree" for detecting spelling mistakes. Similar to other ways, it also gives suggestion words. In implement process, to optimize performance, we traverse Trie Tree combine with recursion and mark frequently error weight of each word. The main purpose is study the organization and storing data structure, and the way to apply concept to handle realistic issues.

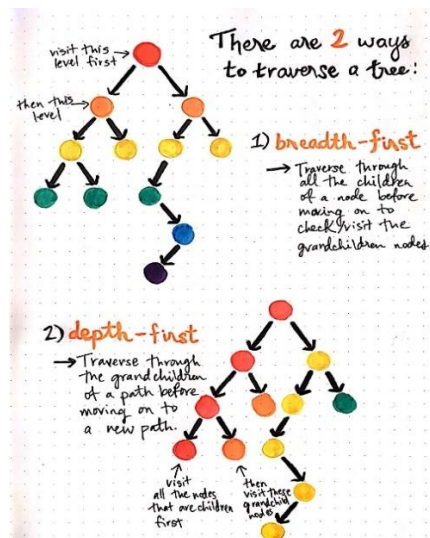
II. Problem and solution plans

1. Display the relationship between various pages of a website, demonstrating the way that the website is organized, how it can be navigated, and how it is labeled. Represent data organization: link structure of website.
➔ Directed Graph



2. Visualize graph by drawing image on canvas for webmaster. Display type of each link: internal or backlink, and its status.

➔ Apply Breadth-First Search for traverse tree.



3. Detect spelling mistakes and recommend relevant words.

➔ Apply Trie Tree data structure.

A **trie** is a tree-like data structure wherein the nodes of the tree store the entire alphabet, and strings/words can be **retrieved** by traversing down a branch path of the tree.

III. Plan implementation

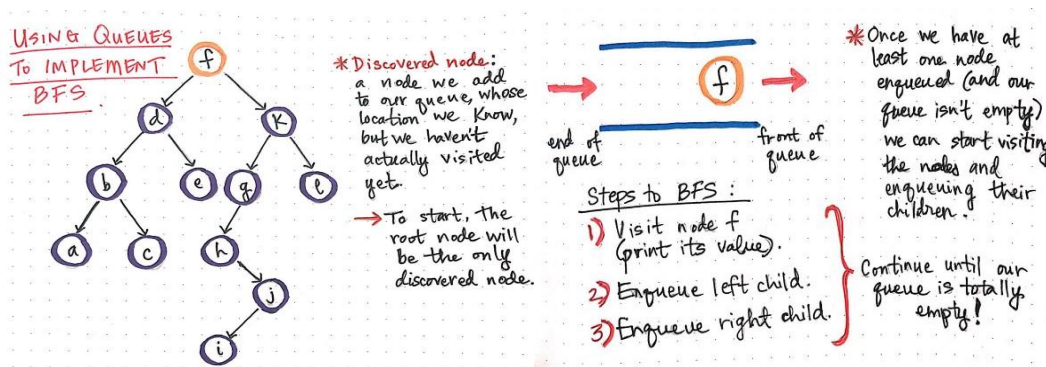
❖ Sitemap Generator

Enqueue each level of a tree sequentially as the root of any subtree is encountered. There are 2 cases in the iterative algorithm:

- **Root case:** The traversal queue is initially empty so the root node must be added before the general case.
- **General case:** Process any items in the queue, while also expanding their children. Stop if the queue is empty. The general case will halt after processing the bottom level as leaf nodes have no children.

Input: the root URL of a website

Output: The sitemap.



Sitemap's structure:

- SiteLink: object with attributes:
 - src: source link
 - des: destination link
 - desType: type of destination link (internal, external)
- HashMap<String, Integer> urlMap: Number URLs into distinct integers, which is also the vertex index on the graph.
- List<List<SiteLink>> graph: adjacency list
- List<List<SiteLink>> invGraph: adjacency list represents graph with all inverse edges from origin graph.
- List<Integer> urlType: get type of link from vertice index.
- List<String> links: inverse mapping with urlMap, allow get url link from vertice index.
- codeGraph: string encoded of graph to create visual image.

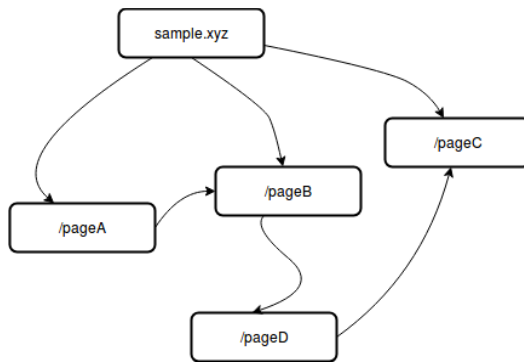


Figure 6 - Directed Graph

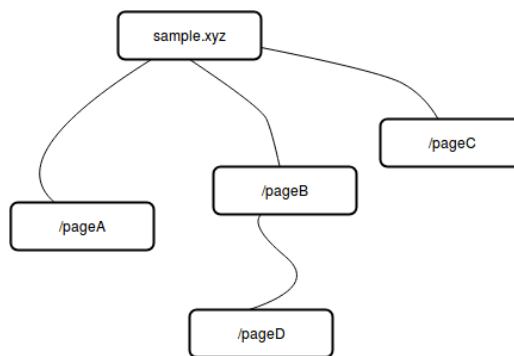


Figure 7 - Site Tree (BFS)

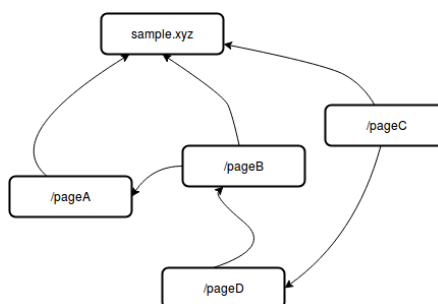


Figure 8 - Inverse Graph

Define some functions

- CreateEdge(u, v): create edge from u to v and add to graph, also create an inverse edge v to u and store to invGraph.

- `getListReferences(url)`: crawl with url and list all others url links in that page. We could also get more information like `urlType`.
- `getUniqueID()`: get new unique integer number.

Pseudo code for BFS

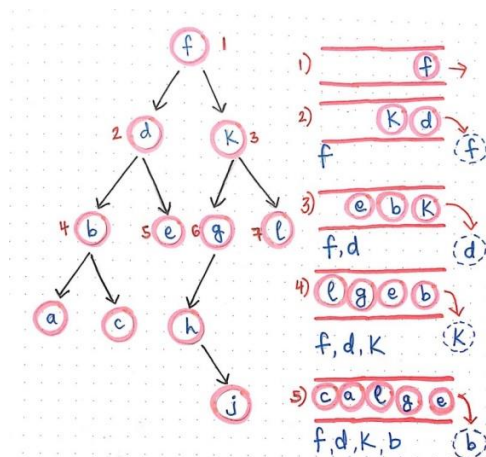
```

1:  function BFS(rootURL)
2:    Queue q  $\rightarrow$  init empty
3:    urlMap.mark(rootURL) = getUniqueID()
4:    while q is not empty
5:      URL = q.pool()
6:      refURLs = getListReferences(URL)
7:      for url in refURLs:
8:        createEdge(URL, urlMap) // create edge of graph
9:        if urlMap.containsKey(url)
10:       urlMap.mark(url) = getUniqueID()
11:       q.add (url)

```

Note:

- The depth of the sitemap-tree is always minimal
- A tree path from one vertex to another is a way to get to the desired link through the link.



But what about space-time complexity?

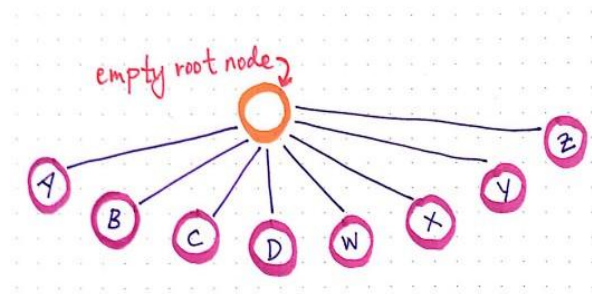
- Visiting a node (reading its data and enqueueing its children) takes constant time. Since we are only visiting each node once, the time it will take us to use a BFS is $O(n)$, where n is the number of nodes.
- The space complexity depends on the size of the queue at its worst, which could be up to $O(n)$ also.

❖ Spelling Test

○ Definition

A **trie** is a tree-like data structure whose nodes store the letters of an alphabet. By structuring the nodes in a particular way, words and strings can be retrieved from the structure by traversing down a branch path of the tree.

We know that tries are often used to represent words in an alphabet. In the illustration shown here, we can start to get a sense of how exactly that representation works.



Each trie has an empty root node, with links (or references) to other nodes—one for each possible alphabetic value.

The shape and the structure of a trie is always a set of linked nodes, connecting back to an empty root node. An important thing to note is that the number of child nodes in a trie depends completely upon the total number of values possible. For example, if we are representing the English alphabet, then the total number of child nodes is directly connected to the total number of letters possible. In the English alphabet, there are 26 letters, so the total number of child nodes will be 26.

○ Structure of Trie Node:

- isLeaf: determine true if the path from root to current node could build a correct word in dictionary.
- eWeight: the frequently of failure when user type wrong.
- refNode: List of reference link to another Trie Node, normally, Trie Node has 26 reference links corresponding to 'a' --> 'z', we can extend the number of reference link if the collection of character has larger.

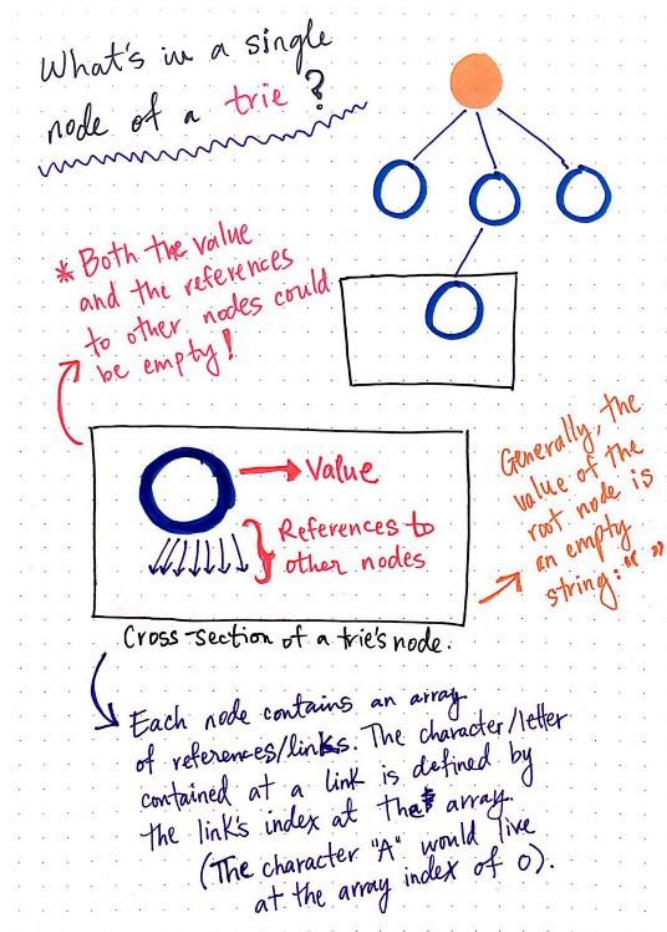
A single node in a trie contains just two things:

1. A value, which might be null
2. An array of references to child nodes, all of which also might be null

Each node in a trie, including the root node itself, has only these two aspects to it. When a trie representing the English language is created, it consists of a single root node, whose value is usually set to an empty string: "".

That root node will also have an array that contains 26 references, all of which will point to null at first. As the trie grows, those pointers start to get filled up with references to other nodes.

The way that those pointers or references are represented is particularly interesting. We know that each node contains an array of references/links to other nodes. What's cool about this is that we can use the array's indexes to find specific references to nodes. For example, our root node will hold an array of indexes 0 through 25, since there are 26 possible slots for the 26 letters of the alphabet. Since the alphabet is in order, we know that the reference to the node that will contain the letter A will live at index 0.



Looking at our trie, we can see that we have an empty root node, as is typical for a trie structure. We also have six different words that we're representing in this trie: Peter, piper, picked, peck, pickled, and peppers.

To make this trie easier to look at, I've only drawn the references that actually have nodes in them; it's important to remember that, even though they're not illustrated here, every single node has 26 references to possible child nodes.

Notice how there are six different "branches" to this trie, one for each word that's being represented. We can also see that some words are sharing parent nodes. For example, all of the branches for the words Peter, peck, and peppers share the nodes for p and for e. Similarly, the path to the word picked and pickled share the nodes p, i, c, and k.

So, what if we wanted to add the word pecked to this list of words represented by this trie? We'd need to do two things in order to make this happen:

First, we'd need to check that the word pecked doesn't already exist in this trie.

Next, if we've traversed down the branch where this word ought to live and the words doesn't exist yet, we'd insert a value into the node's reference where the word should go. In this case, we'd insert e and d at the correct references.

But how do we actually go about checking if the word exists? And how do we insert the letters into their correct places?

- **Idea of inserting method:** go through each character of word, check if has reference link correspond with this character. If not, we make new reference link. If the link has, just follow the path. Finally, mark the current node as a Leaf - that mean path from root to this node form correct word in dictionary.

Pseudo code for Insert word to Trie Tree

```
1: function mapPosition(char letter)
2:     return (letter - 'a')
3:
4: function insertWord(String word)
5:     Node currentNode = root
6:     for each char w of word:
7:         position = mapPosition(w)
8:     if currentNode.getRefNode(position) = null then
9:         currentNode.setRefNode(position, new Node())
10:    currentNode = currentNode.getRefNode(position)
11:    currentNode.isLeaf = True
```

- **Idea id searching on Trie Tree:** The method is quite same the insert method but when we check in some Trie Node if doesn't contain reference link, just return with False result. If could find the path, check if this Trie Node is Leaf.

Pseudo code for Search word in Trie Tree

```
1:  function searchWord(String word)
2:    Node currentNode = root
3:    for each char w of word:
4:      position = mapPosition(w)
5:      if currentNode.getRefNode( position) = null then
6:        return False
7:      currentNode = currentNode.getRefNode(position)
8:    return currentNode.isLeaf
```

❖ Spelling Generator using Recursion

We come up with the smallest case: wrong one letter.

That mean, if the needed check word has wrong one letter (missing, redundant, difference), the system will provide some suggestion words in dictionary.

Normal method is “brute force”, we can generate all cases of a word could be, by adding one letter to word: happ → happ + y, by changing one word: happ → harp, or remove one letter: happ → hap.

We make generator use recursion:

Let function **Generator** (word, position, currentGenWord, changed) is a state when we generate word with:

- word: the word we need to generate to all posible
- position: we stand at word.charAt(position), if position > word.length the method terminate.
- currentGenWord: current word that we are constructing, when postion reach the end of word, then currentGenWord is finished made.

changed: the flag to verify that if currentGenWord is differ one letter with original word.

Transform state:

- **if changed = False:**
 - We couldn't make any change to origin **word**, so just add:
 - currentGenWord → currentGenWord + word.charAt(position)
 - position → position + 1
- **if changed = True:**
 - We could do nothing one word, it's same case above when **changed** is False. The difference that **changed** still get True.
 - We could remove current letter by just increase **position** and go the another state:
 - position → position + 1
 - changed → False

- We could add one letter to current **position** and make no change **position**:
 - `currentGenWord → currentGenWord + (any char from 'a' to 'z')`
 - `changed → False`
- We could change current letter:
 - `currentGenWord → currentGenWord + replaceOther(word.charAt(position))`
 - `changed → False`

Finally, we get the generator for wrong one letter. We could improve the method to flexible extend by changing the flag **changed** from boolean value to int value with mean, the remain of change we could make on origin **word**. Then if we check wrong for two or three letters, just pass the param **changed** = 2 or 3 when call the recursion.

After have generator, we combine with any searching method, we could make a list of suggestion words. Currently, we compare the speed with two searches method:

- Linear Search
- Trie Tree Search

The Trie Tree Search's speed dominate of Linear Search, faster than about 150 times with 10 input words. Because the time to search one word in Trie Tree equal length of input word when we have to iterator all words in dictionary if using Linear Search.

But, we still could improve method better by combine Trie Tree Search on recursion generator: we keep a Trie Node go follow with recursion. We can terminate if it current Trie Node is null.

The recursion method now look like: **Generator** (word, position, currentGenWord, changed, currentTrieNode).

Pseudo code for Generator combine Trie Tree search

- 1: **function** Generator(word, position, currentGenWord, changed, currentTrieNode)
- 2: **if** currentTrieNode = null **return** // terminate condition
- 3: **if** position > word.length **return** // terminate condition
- 4: **for** all of possible states:
Generator (word, new position, new currentGenWord, new changed, new TrieNode)

Note that: new TrieNode could get simple by follow the modify letter: if we add letter 'a', the new TrieNode will equal link from current Trie Node to `refNode.get('a')`.

The method after optimizing is quite fast than normal search. We could see that the method will stop when could not found on tree that prevent to generate all cases that wasted a lot of time.

IV. Experimental results and conclusion

- ❖ Drawing Sitemap on canvas (demo)
- ❖ Test spelling:

Use the dictionary with more than 110,000 words. Make sample input by random select 10,000 words from the dictionary. Each word will be changed to wrong spelling by choosing random apply one of three methods:

- Remove one character in random position
- Insert one character in random position
- Change one character to other letter.

We apply testing sample to three of own methods:

	Trie and Recursion	Trie Tree Search	HashSet Search	Normal Search	
Detection	-	-	-	-	
1 st	171.665	228.58	360.905	70.843.211	
2 nd	282.936	515.356	486.516	213.282.707	
3 rd	227.485	424.986	356.754	217.496.979	
4 th	133.382	322.748	438.503	346.019.168	
5 th	105.295	131.974	225.477	251.235.083	
6 th	87.536	131.619	218.067	295.021.079	
7 th	122.989	151.977	213.425	245.818.985	
8 th	134.28	363.798	305.237	303.394.747	
9 th	102.281	236.726	197.911	252.620.838	
10 th	246.47	437.805	295.182	303.870.749	
Finish	277.041.472	732.268.077	930.599.743	2.568.054.697.004	(nano-sec)
	0.277	0.732	0.93	2568	(seconds)
				42.8	(minutes)

Acknowledgment

We would like to give a special thanks to Mr. Nguyen Huy Hung for his professional guidance and the useful, constructive recommendations throughout the course of this project.

Rererences

- [1] [DFS and BFS Algorithms using Stacks and Queues](#), Professor Lawrence L. Larmore
- [2] [The Breadth-First Search Algorithm](#), Khan Academy
- [3] [Data Structure—Breadth First Traversal](#), TutorialsPoint
- [4] [Binary tree: Level Order Traversal](#), mycodeschool
- [5] [Breadth-First Traversal of a Tree](#), Computer Science Department of Boston University
- [6] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol.
- [7] [Digit-based sorting and data structures](#), Professor Avrim Blum
- [8] [Lecture Notes on Tries](#), Professor Frank Pfenning
- [9] [Algorithms: Tries](#), Robert Sedgewick and Kevin Wayne
- [10] [Tries](#), Brilliant Learning

- [11] [Tries](#), Daniel Ellard
- [12] [Tries](#), Harvard CS50
- [13] [Sitemap](#), Garenne Bigby

Purpose-based Data Shaping

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Abstract

In this paper, we address a specific problem of building the Career Trend Suggestions (CTSA) system. CTSA is a system which provides suggestions and predictions about trends of careers based on data which is collected from many sources, some of them are recruitment websites. Job descriptions or requirements in posts contain information about specific skills that are required, which is needed to be collected for analysis, as well as a lot of unnecessary text. This paper describes our solutions for extracting the information that is only necessary for analysis.

Keywords

Inverted index, Keyword extraction, Elasticsearch, Synonyms, Analyzer, Tokenizer.

I. Introduction

In the CTSA system, we identify the collected raw text content as “document”, and words that need to be extracted from a document as “keywords”. To be more specifically, we consider our solution as a keyword extraction technique.

Extracting keywords from a single document has been studied extensively – using occurrences frequency [1], or more specifically, applying TF-IDF algorithm. Biases are later solved using clustering of terms. TF-IDF is also applied in extracting keywords in multiple documents. If a word appears frequently in a document, it is a keyword; but if a word appears in many documents, it is not.

However, in the CTSA system, keywords are neither supposed to be counted nor selected based on frequencies, but are predefined. Our premise in this paper is the following: giving a collection of words, input any document, the output should be a collection of words, from the original collection, that appear in the input document. We applied a structure called inverted index and the results are very promising.

In Section 2, we formalize the problem and describe our approach to solve it. Section 3 describes the data structures that need to be set up and the algorithm. We analyze our algorithm in Section 4. Experimental results and the software used are described in the concluding Section 5.

II. Problem and solution plan

Keyword extraction in the CTSA system consists of three main specific problems:

1. Keywords are predefined: Instead of counting and using occurrences frequency to identify keywords, keywords in the CTSA system have to be predefined. Due to the system’s business, keywords are terms that relate to specific positions or skills of majors. To be more specifically:

- **Major:** A term that denotes business field, for example: Information Technology (IT), Medical, Economy, etc.
- **Position:** A term that denotes a specific career of a major, for example: in IT major, positions are Developer, Tester, Project Manager, Business Analyst, etc.
- **Skill:** A term that denotes a technique that relates to a specific major, for example: in IT major, skills are Java, Python, JavaScript, SQL, NoSQL, etc.

For analysis purpose, keywords in the CTSA system have to be predefined. Services inside the system which is responsible for collecting the data are required to be capable of extracting those predefined keywords and save them to the system's database for later analysis purpose. Therefore, the solution of keyword extraction should be able to produce the exact predefined keywords from the input document.

To be more specific, let's take a brief assumption.

Example 1: Given two different collections of predefined keywords as follow:

1. IT positions: $P = \{\text{Developer, Tester, Project Manager}\}$
2. IT skills: $S = \{\text{Java, MySQL, MongoDB}\}$

Input a job description, the keyword extraction service of the CTSA system have to be able to identify which position is mentioned, and what skills are needed for that position, which is also mentioned in the job requirement.

2. Keywords may contain many synonyms and forms:

Using the above-mentioned example, for some document, the CTSA system have to face some difficulties in dealing with synonyms and variety of word forms.

- **Synonyms:** Some keywords may come along with synonyms or slangs. With "Developer", some job descriptions may define the term as "Programmer" or even "Dev".
- **Forms:** In some cases, "developer" and "developers" are pretty similar, which requires some effort to stem "developers" to its root form as "developer".

3. Keywords are not always unigrams and have translations in Vietnamese:

To be specific, a unigram is a term that only consists of one word, for example: "Developer", "Tester", or "Java". In the CTSA system, some keywords are word pairs (bigrams) or word triplets (trigrams), or even more. In this paper, we denote these n-grams to be "shingles". Shingles are extremely complicated to be extracted since they contain common text delimiters, such as whitespace (for example: "Project Manager", "Quality Assurance", etc.) or hyphens (for example: "Back-end", "Front-end"). Moreover, since the system is applied in Vietnam's situations, job descriptions are mostly written in Vietnamese and keywords also appear in their translated forms, for example: "developer" in Vietnamese is "lập trình viên", which is a trigram.

Solution: To solve the problem, instead of TF-IDF algorithm, we apply the inverted index structure, which is designed to allow very fast full-text searches. We also apply inverted index on shingles. Fortunately, there is an available open source service called Elasticsearch, which is already implemented the very basic forms and structure for inverted index. Using Elasticsearch is more preferable for us in doing this research since it helps

saving a lot of implementation time. However, the original structure of inverted index cannot completely satisfy our purposes; therefore, we made some minors modifications to the Elasticsearch's inverted index [2] to meet our goal.

III. Plan implementation

Originally, an inverted index consists of a list of all the unique words, in this case, are keywords, that appear in any document; for each word, a list of the documents in which it appears.

Example 2: We have two documents containing the following:

1. This job requires developers with experience in Java, MySQL, and Spring Framework.
2. Java and MongoDB are required for this job. Devs with experience in Spring Framework have lots of advantages.

To create an inverted index, we split the document into separate and unique words. The result looks something like this:

Term	Doc1	Doc2
This	X	
Job	X	
Requires	X	
developers	X	
With	X	X
experience	X	X
In	X	X
Java	X	X
MySQL	X	
And	X	X
Spring	X	X
Framework	X	X
MongoDB		X
Are		X
Required		X
For		X

This		X
Devs		X
Have		X
Lots		X
Of		X
Advantages		X

Table 1

Now, if we want to search for “This Java”, we just need to find the documents in which each term appears:

Term	Doc1	Doc2
This	X	
Java	X	X

Table 2

Both documents match, but the first document has more matches than the second. Applying a naive *similarity algorithm* that just counts the number of matching terms, then we can say that the first document is a better match than the second one.

But there is a problem with the current inverted index: “This” and “this” are denoted as separate terms, while we think of them as the same word and expect both documents to match the query. To solve this, we lowercase all the terms, then find documents that contain terms that are not exactly the same as the original requests, but are similar enough to still be relevant. The index now looks like this:

Term	Doc1	Doc2
This	X	X
Job	X	
Requires	X	
Developer	X	X
With	X	X
Experience	X	X
In	X	X

Java	X	X
Mysql	X	
And	X	X
Spring	X	X
Framework	X	X
Mongodb		X
Are		X
For		X
Have		X
Lots		X
Of		X
Advantages		X

Table 3

Now the original search string for “This Java” will also be lowercased into “this java”, which would match both documents.

However, as mentioned in Section 2, keywords may have synonyms and forms. Let’s take a look at the above example of 2 documents. After getting lowercased, if we search for “Java developers”, the result would be:

Term	Doc1	Doc2
Java	X	X
Developers	X	

Table 4

However, the second document consists of a term “devs”, which is basically the same as “developers”, since “dev” is simply a short-form of “developer”. In addition, “requires” and “required” are pretty similar, since they share the same root word of “require”. Therefore, we do one last step of stemming, or reducing both of them to their root form – “require”. The same case happens for “developers”, we can also stem it to its root form as “developer”. Therefore, we do one more step of indexing these as a single term “developer”. Now, the index looks like this:

Term	Doc1	Doc2
This	X	X
Job	X	
Requires	X	
Developer	X	X
With	X	X
Experience	X	X
In	X	X
Java	X	X
Mysql	X	
And	X	X
Spring	X	X
Framework	X	X
Mongodb		X
Are		X
For		X
Have		X
Lots		X
Of		X
Advantages		X

Table 5

That is how original structure of Elasticsearch's inverted index works. However, as we mentioned above, this does not completely help solving the CTSA system's problems. We put some effort in modifying the structure of Elasticsearch.

1. Search for predefined keywords

This requires two steps:

1.1. Index keywords, not documents:

Originally, Elasticsearch indexes the documents and produces unique terms to apply full-text searches. On the contrary, we make Elasticsearch to index the keywords that is predefined, not the whole document. To be simple, we are trying to reverse the default way that Elasticsearch works on. Moreover, instead of indexing each word independently, we index the whole shingle, then we could retain more of the context in which the words were used. This step is required for putting predefined keywords into our Elasticsearch's database.

```

1 {
2   "settings": {
3     "analysis": {
4       "analyzer": {
5         "ctsa_analyzer_keyword": {
6           "type": "custom",
7           "tokenizer": "keyword",
8           "filter": [
9             "asciifolding",
10            "lowercase"
11          ]
12        }
13      }
14    },
15    "mappings": {
16      "ctsa_keywords": {
17        "properties": {
18          "keyword": {
19            "type": "text",
20            "analyzer": "ctsa_analyzer_keyword"
21          }
22        }
23      }
24    }
25  }
26 }

```

Figure 1

Figure 1 describes the JSON script that is used for configuring the Elasticsearch for accepting and indexing the input of predefined keywords. Keyword Tokenizer at line 7 is a predefined tokenizer of Elasticsearch [4], which helps configuring Elasticsearch for receiving and indexing the keyword as a whole. For example, with original analyzer, if we input the term “Project Manager”, it is inverted indexed to be {“project”, “manager”}. Applying Keyword Tokenizer, our inverted index structure now indexes the term “Project Manager” as “project manager”, since we need to find “project manager” in the job description, not just “project” or “manager”.

1.2. Documents are input: Originally, inverted index accept some words and returns documents that contains those terms. The CTSA system, instead need to input a document and extract keywords from it. With indexed keywords in step 1, applying in Example 1 and 2, we have another example.

Example 3: Assume that the collection of IT skills in Example 1 is pushed to the inverted index database. Input the first sentence of Example 2, result would be:

Term	java	mysql	mongodb
this			
Job			
Require			
Developer			
With			
experience			
In			
Java	X		
Mysql		X	
And			
Spring			
framework			

Table 6

2. Synonyms and Vietnamese translations

Since inverted index can help us solve the problem of plural forms. Vietnamese translations are still need to be handled. In order to do that, we build a simple relational database model that is described in Figure 2.

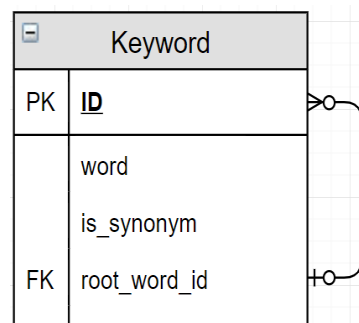


Figure 2

Keywords from the described table are pushed to Elasticsearch for extracting. The collection of extracted keywords is later sent back another service that is responsible for retrieving the root word and removing the synonyms or translations.

3. Search for indexed shingles

Unfortunately, the configuration is not good enough when dealing with indexed shingles. Get back to Example 3, now if we push one shingle keyword “Spring Framework” to Elasticsearch, the result would be:

Term	java	mysql	mongodb	spring framework
This				
Job				
require				
developer				
With				
experience				
In				
Java	X			
Mysql		X		
And				
Spring				
framework				

Table 7

As we can see, even the term “spring framework” do exist in the document, it cannot be extracted since the default configuration of Elasticsearch is to separate input search string into tokens by whitespaces and take a single word as a token [3]. To improve this, we make some more modification to Elasticsearch’s analyzer as the following figure:

```

1  {
2    "settings": {
3      "analysis": {
4        "filter": {
5          "filter_shingle": {
6            "type": "shingle",
7            "max_shingle_size": 5,
8            "min_shingle_size": 2,
9            "output_unigrams": "true"
10         }
11       },
12       "analyzer": {
13         "ctsa_analyzer_shingle": {
14           "type": "custom",
15           "tokenizer": "whitespace",
16           "filter": [
17             "asciifolding",
18             "lowercase",
19             "filter_shingle"
20           ]
21         }
22       }
23     },
24     "mappings": {
25       "ctsa_keywords": {
26         "properties": {
27           "keyword": {
28             "search_analyzer": "ctsa_analyzer_shingle"
29           }
30         }
31       }
32     }
33   }
34 }

```

Figure 3

We define a filter called *filter shingle* from line 5 to 10, which help separated the input search string into tokens by number of words per token. For example: a search string of “Require Java Developer” is transferred into {“require”, “java”, “developer”, “require java”, “java developer”, “require java developer”}, each element of the provided collection will be indexed for a full-text search. Now, applying the new configuration, the Example 3 would return:

Term	java	mysql	mongodb	spring framework
this				
job				
require				
developer				
with				
experience				
In				
java	X			
mysql		X		
and				

Spring				
framework				
...				
mysql and				
and spring				
spring framework				X
...				

Table 8

Now the result is matched with our expectation.

IV. Analysis

Our solution's performance and functionality are tested through extended testing process. The testing result is presented in the next section. As mentioned in Section 1, we need to identify which position and what skills are required in a specific job description.

1. Search for unigram keywords.

Provide Elasticsearch with the following collection of keywords: $K = \{\text{"Java", "MySQL", "Developer", "MongoDB"}\}$.

Input a search string in English, to be specific: "This job requires developers with experience in Java, MySQL, and Spring Framework". The CTSA system should be able to return the array ["developer", "java", "mysql"].

2. Search for n-grams keywords using search string with synonyms and Vietnamese.

Put a 2-word keyword into K, now $K = \{\text{"Java", "MySQL", "Developer", "MongoDB", "Spring Framework"}\}$.

Input a search string in Vietnamese, to be specific: "Tuyển lập trình viên có kinh nghiệm lập trình Java và Spring Framework". The CTSA system is expected to return the array ["developer", "java", "spring framework"].

V. Experimental results and conclusion

Provide Elasticsearch with the following collection of keywords: $K = \{\text{"Java", "MySQL", "Developer", "MongoDB", "Spring Framework"}\}$. We have executed some tests and retrieved some positive results. Here are some examples:

	Hit keywords	Time
This job requires developers with experience in Java, MySQL, and Spring Framework	- developer - spring framework	~12ms
This job requires developers with experience in Java MySQL and Spring	- developer - java	~16ms

Framework	- mysql - spring framework	
Tuyển lập trình viên có kinh nghiệm lập trình Java và Spring Framework	- developer - java - spring framework	~13ms

Table 9

With larger dataset of keywords (above 100 terms) and long documents that consist of from above 50 words (or above 200 characters), elapsed time oscillates above 60ms.

However, experiments point out that with search strings that contains especial characters such as colons, semicolons, hyphens, etc. the extraction cannot work properly. In order to resolve this, we implement a workaround solution to remove all of those characters before sending the string to the Elasticsearch for extraction.

Acknowledgment

We would like to thank to Mr. Kieu Trong Khanh for helping us defining project scope and improving the functionality.

References

- [1] Yutaka Matsuo and Mitsuru Ishizuka, “Keyword Extraction from a Single Document using Word Co-occurrence Statistical Information”, International Journal of Artificial Intelligence Tools, March 2003.
- [2] Inverted Index - Elasticsearch Reference:
<https://www.elastic.co/guide/en/elasticsearch/guide/current/inverted-index.html>
- [3] Analysis and Analyzer – Elasticsearch Reference:
<https://www.elastic.co/guide/en/elasticsearch/guide/current/analysis-intro.html#analysis-intro>
- [4] Keyword Tokenizer – Elasticsearch Reference:
<https://www.elastic.co/guide/en/elasticsearch/reference/current/analysis-keyword-tokenizer.html>

Learning Sparse Representation From Multiple-source Data for Relative Similarity in Music

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Abstract

Relative similarity learning is a branch of machine learning where a model is learned from relative comparison of triplets, i.e. x is more similar to y than to z . This learning paradigm has been used for music optimization and personalization through ranking and searching applications. In this paper we introduce the use of sparse multi-modal restricted Boltzmann machine (mulRBM) in learning features from multiple sources for relative similarity. In the experiments, we evaluate our approach on music similarity where data is composed of audio and text features. The results show that sparse features are better than original features, PCA features and features learned from mul-RBM without sparsity.

CCS Concepts

• **Information systems** → **Database management system engines**

Keywords

Relative similarity, Restricted Boltzmann Machines, Feature Learning.

1. Introduction

Learning similarity metric is a crucial element in many machine learning applications such as clustering, ranking, and recommendation systems. In order to train a similarity metric

SAMPLE: Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on function, a relative measurement in the form of instance x is more similar to instance y than to instance z is easier to obtain than absolute ranking. For example, given a song x , one can point out which song among two others (y, z) is more similar to that song, but it would take tremendous efforts to rank a list of songs on a similarity order just by listening to them. In addition, samples for training a relative similarity model can be obtained from labelled or tagged data in which an instance is more similar to other instances in the same category or tag group than to instances in different categories or groups.

Learning similarity metric from relative comparison has been studied intensively. Schultz and Joachims [1] proposed a method to learn similarity metric with kernel methods which has been used in this paper. In a survey work, Daniel and coauthors explain and compare different approaches which have been employed for music similarity [2]. In [3], the authors show that by taking advantage of unsupervised model for features learning they can improve performance of similarity models. Features learning has been showed effective for signal processing. In [4], a Gaussian restricted Boltzmann machine

(Gaussian RBM) is used to learn movement patterns from videos for activity recognition. With sparsity, RBMs can focus on learning most important patterns which represent the semantic of training data [5], [6].

In this paper, we study the effect of feature representation of data on similarity metric learning. Representation of features is important for learning tasks. It has been shown in many application domains such as vision, audio, and natural language processing that unsupervised models [7], [8], [9], [4] have capability of learning useful features which perform comparable or better than hand-crafted features. We expect that better representation of data, especially data from multiple sources, is able to diminish the ambiguity within similarity relations and therefore improve the metric learning. In music, features of a script can be collected by looking at different aspects and characteristics such as key, mode, loudness, tempo, time signature, danceability, energy, pitch and timbre. This can also include tags from users who have listened to it and annotated it with relevant words that best describe the song/music script. In order to extract effective features from unsupervised models we propose the use of multi-modal restricted Boltzmann machines (mul-RBM). This is an extension of normal restricted Boltzmann machines [10] where inputs are split into different groups for encoding of different types of data. We also apply sparsity constraint to the learning of mul-RBM as this can help filter out noisy patterns. For evaluation of our feature learning model, we develop a general similarity model that can be learned using gradient ascent or soft-margin methods. This model and learning algorithms are used to evaluate the features learned from multi-modal RBMs. The combination between RBMs's features and soft-margin method can be seen as an extension of Schultz and Joachims work [1] in which linear transformation in the distance metric function is replaced by non-linear transformation using mulRBMs.

In the experiment, we evaluate our approach on music similarity where the data is composed of audio features and tagging texts. Here, the audio features are engineered from signals using basic processing techniques. These features are continuous which are much different from tag features which are binary. The tag features consists of text inputs from users/annotators who actually listen to the songs. Due to the nature of the features, we employ a mul-RBM with two groups of visible units, one for continuous inputs and the other for binary input. The energy function of the RBM then would be defined accordingly to represent such nature. Using two similarity models mentioned above, we compare the sparsity features from mul-RBM with original features, PCA features and features learned from mul-RBM without sparsity. The results show that soft-margin model is better than gradient based model. In terms of features, PCA features are slightly better than the original features and comparable to mul-RBM features. Among all types of features in this comparison, sparse features from mul-RBM achieve highest accuracy. The organization of the paper is as follows. In Section II, the relative similarity model is introduced along with two learning approaches. Section III discusses the proposed multi-modal RBM and its sparse constraint. In Section IV, we present the experimental results on music dataset consisting of audio and tags. Section V concludes the paper and discusses directions for future work.

2. Relative similarity modelling

In relative similarity, given a triplet x, y, z a model should be able to decide whether y or z is more similar to x than the other. At first we define a distance vector between two instances x, y as:

$$\text{dist}(x, y) = (x - y) * (x - y) \quad (1)$$

Here $*$ denotes element-wise multiplication operation. Note that the square root of the dot product of a transposed distance vector and an unit vector \mathbf{I} : $\sqrt{\text{dist}(\mathbf{x}, \mathbf{y})^T \mathbf{I}}$, is Euclidean distances between two instance \mathbf{x}, \mathbf{y} . The similarity measurement function is defined as:

$$S(\mathbf{x}, \mathbf{y}) = - \sum_k w_k (\mathbf{x}_k - \mathbf{y}_k)^2 = - \mathbf{W}^T \text{dist}(\mathbf{x}, \mathbf{y}) \quad (2)$$

Where \mathbf{W} is the learnable parameters of the function. The similarity function (2) implies that if $S(\mathbf{x}, \mathbf{y}) > S(\mathbf{x}, \mathbf{z})$ then \mathbf{x} is more similar to \mathbf{y} than to \mathbf{z} . From a training dataset $D = \{\mathbf{x}^{(i)}, \mathbf{y}^{(i)}, \mathbf{z}^{(i)} \mid i = 1, \dots, N\}$, each triplet $\mathbf{x}^{(i)}, \mathbf{y}^{(i)}, \mathbf{z}^{(i)}$ represents a relation that $\mathbf{x}^{(i)}$ is more similar to $\mathbf{y}^{(i)}$ than to $\mathbf{z}^{(i)}$. We denote $d^{(i)} = \text{dist}(\mathbf{x}^{(i)}, \mathbf{z}^{(i)}) - \text{dist}(\mathbf{x}^{(i)}, \mathbf{y}^{(i)})$ as the difference of two distances for $\mathbf{x}^{(i)}, \mathbf{z}^{(i)}$ and $\mathbf{x}^{(i)}, \mathbf{y}^{(i)}$ respectively. Our general model is to learn parameter vector \mathbf{W} to:

$$\text{Maximize} \quad C \sum_i \mathbf{W}^T d^{(i)} - \frac{1}{2} \|\mathbf{W}\|^2 \quad (3)$$

With C is regularization trade-off. In what follows, we present two learning approaches to learn the parameter \mathbf{W} for our model.

2.1 Gradient Ascent

Since the optimization function in (3) is concave, we are able to find the global optimal using gradient ascent. In particular, we step by step update the parameters:

$$w_k = w_k + \eta \left(C \sum_i d_k^{(i)} - w_k \right)$$

2.2 Gradient Ascent

An alternative method to learn the similarity metric model is using soft-margin. At first, the weight vector is constrained to be positive and the model is set to learn a large-margin such that $S(\mathbf{x}, \mathbf{y}) - S(\mathbf{x}, \mathbf{z}) \geq 1$, which make (3) become:

$$\begin{aligned} \text{Maximize} \quad & C \sum_i (\mathbf{W}^T d^{(i)} - 1) - \frac{1}{2} \|\mathbf{W}\|^2 \\ \text{s. t} \quad & w_k \geq 0 \text{ for all } k \end{aligned} \quad (4)$$

By further soften the margin constraint with slack variables ζ as in standard SVM classifier, (4) becomes:

$$\begin{aligned} \text{Maximize} \quad & \frac{1}{2} \|\mathbf{W}\|^2 + C \sum_i \zeta_i \\ \text{s. t.} \quad & w_k \geq 0 \text{ for all } k \\ & \zeta_i \geq 0 \text{ for all } i \\ & \mathbf{W}^T d^{(i)} \geq 1 - \zeta_i \end{aligned} \quad (5)$$

Using dual method to solve the optimization problem we show the algorithm to learn the parameter vector \mathbf{W} below:

Algorithm 1 Learning Soft-margin

- 1: Initialize \mathbf{W}, α
- 2: **Loop**

```

3:      % Until all KTT conditions are met
4:      Update  $w_k = \sum_i \alpha_i s_k^{(i)}$ 
5:      if  $w_k < 0$  then
6:           $w_k = 0$ 
7:      end if
8:      Update:  $\alpha_i = \frac{1 - w^T s^{(i)}}{\|s^{(i)}\|^2} + \alpha_i$ 
9:      if  $\alpha_i < 0$  then
10:           $\alpha_i = 0$ 
11:      end if
12:      if  $\alpha_i > C$  then
13:           $\alpha_i = C$ 
14:      end if
15: end loop

```

3. Sparse multi-modal restricted boltzmann machine

In this section, we study the Multimodal Boltzmann Machine with sparsity constraints.

3.1 Multimodal RMB

An RBM is two-layer symmetric connectionist network in which connections are forbidden among units in the same layer, see Figure 1a. The multi-modal RBM is an RBM with multiple groups of units in visible layer connecting to the same hidden layer. Each group of unit represents observed information from different data sources. For example, Figure 1b shows a bimodal RBM with a group of binary data (i.e text, Boolean) and a group of continuous data (images, audio). Similar to other symmetric connectionist systems, a multimodal RBM is characterized by an energy function as a sum of energy functions for each group. For example, the energy of bimodal RBM in Figure 1b is.

$$\begin{aligned}
 E = & \sum_k \frac{(x_k - \alpha_k)^2}{\sigma_k^2} + \sum_{kj} \frac{1}{\sigma_k^2} x_k w_{kj} h_j + \sum_{ij} y_i u_{ij} h_j \\
 & + \sum_i b_i y_i + \sum_j c_j h_j
 \end{aligned}$$

Where α_k , σ_k^2 are mean and variance; w_{kj} and u_{ij} are the connection weights from continuous layer X and binary layer Y to the hidden layer respectively; b_i and c_j are biases for layer Y and hidden layer respectively. The joint distribution of visible and hidden states is represented as:

$$P(x, y, h) = \frac{1}{Z} \exp(-E(x, y, h)) \quad (7)$$

With $Z = \sum_{x,y,h} \exp(-E(x, y, h))$ is partition function. Given a state of a layer, an unit in another layer is inferred by sampling from the conditional distributions.

$$\begin{aligned}
 P(h_j | x, y) &= \text{sigmoid} \left(\sum_k x_k w_{kj} + \sum_i y_i u_{ij} + c_j \right) \\
 P(x_k | h) &= N \left(\sum_j h_j w_{kj}, \sigma_k^2 \right) \quad (8)
 \end{aligned}$$

$$P(y_i|h) = \text{sigmoid}\left(\sum_j h_j u_{ij} + b_i\right)$$

Normally, a multi-modal RBM can be learned by maximizing the log-likelihood

$$\mathcal{L} = \sum_{x,y \in D} \log P(x,y) \quad (9)$$

However, similar as in RBM, learning multi-modal RBM is difficult since the partition function is intractable. In order to learn the model, we use an approximate method named Contrastive Divergence [11].

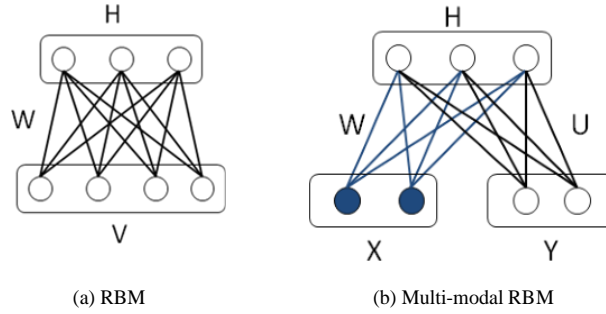


Figure 14. Restricted Boltzmann Machine and its multi-modal variant

3.2 Sparsity Constraint

Sparsity is important in learning important (6) regularities in data while being able to filter out the unnecessary, noisy patterns. Learning sparse features can be done by adding a constraint during the learning process where it allows a small portion of hidden units to be activated given an input sample. We apply sparsity constraint to maximizing a log-likelihood (10) so that only a few units in hidden layer are activated for each input data. Here, we use a constraining regularization proposed by Lee et. al. [5].

$$\mathcal{L} = \sum_{x,y \in D} \log P(x,y) - \rho \sum_j \left\| \gamma - \frac{1}{N} \sum_{x,y \in D} \mathbb{E}[h_j|x,y] \right\|^2 \quad (10)$$

The second term in (10) forces the average expectation of the hidden state to be within a specific range defined by γ . Therefore, if we set the value of γ to be very small then most of the hidden units will have the states close to 0s. In this work we use $\gamma = 0.00001$.

4. Experiments

In this section, we apply our approach to music similarity. Generally, online music data may consist of audio, lyrics, comments from listeners, and tags. We extract the audio and tagging data from TagATune data and learn sparse features with bimodal RBM as discussed in Section III. The features then have been evaluated on the similarity model proposed in Section II using 10-fold cross validation scheme.

4.1 Features

The original features of ~ 1000 music scripts are showed in Figure 2. As we can see, the first 43 features are real-values in cluding the key, mode, loudness, tempo, time signature, danceability, energy which are called global features in music informatics [12], as well as segment-based features describing pitch and timbre extracted as 12-dimensional vectors of mean and standard deviation respectively. The others features are binary which consist of the tags annotated by the TagATune.

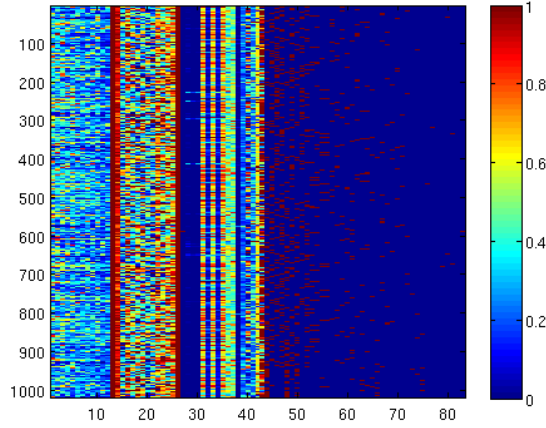


Figure 2. Original features

Such features are encoded in our multi-modal RBM by using X layer for the real-valued part and Y layer for the binary part. As mentioned earlier, we learn a multi-modal RBM using Contrastive Divergence [2] and use the states of the hidden units as new features to train the gradient-based and soft-margin similarity models. We compare the features learned with and without sparsity constraint to see whether sparse features be useful for similarity learning with data from multiple sources. For completeness, we also compare these features with the original features and features extracted by applying principle component analysis.

Principle component analysis can be seen as an effective features extraction method where original features are transformed to what are called principle components [13]. An advantage of PCA is that, the components can be evaluated based on their variance where noisy features, i.e whose values do not change much for samples in different categories, can be removed by only using K highest variant components. In this section, we select the value of K which give the best accuracy.

4.2 Results

Table 1: Experimental results

	<i>No feature learning</i>	<i>PCA</i>	<i>mul-RBM</i>	<i>mul-RBM + Sparsity</i>	<i>Average</i>
Gradient	68.82	69.35	69.02	70.84	69.5075
Soft-margin	70.61	70.78	72.86	74.11	72.09
<i>Average</i>	69.715	70.065	70.94	72.475	

In Table I, we show the accuracy of two models presented in section II, with different features: No feature learning is for original features; PCA: is for PCA features; mul-RBM is for multi-model RBM; and mul-RBM + Sparsity is for multi model RBM with sparsity constraint.

The results show that soft-margin model is better than gradient based model in all types of features. It is not surprised since soft-margin allows flexible comparison for similarity measures. However, as we observe, gradient based model seems more efficient than soft-margin due to its simplicity. In terms of features, the PCA features are slightly better than the original features. This is because by applying PCA transform and removing low variant components we are able to clean the features for better performance. The mul-RBM features are comparable to the PCA features. In particular, when gradient-based model is used, PCA features have higher accuracy, however, when soft-margin model is used the latter outperform the former. Finally, we show that by training multi-modal RBM with sparsity constraint we can achieve the highest results in both models. It seems that by constraining the hidden units to be activated only for important patterns of the data, we can ignore the unimportant information which may damage the quality of the models. Together with the results from PCA, we can see that in this case it is the noise in the data that makes great challenge for learning similarity. In order to have more improvement we need to find a better solution to solve this problem.

5. Conclusion

The paper presented an idea of using multi-modal RBMs for learning features from different data sources. We test the idea on relative similarity task for music scripts from TagATune dataset. Here, we propose two different models for relative similarity learning, namely gradient-based and soft-margin. These models are used to evaluate features learned from RBMs where sparsity constraint can be applied. In the experiments, we evaluate our approaches on music similarity where the data is composed of audio and text features. The results show that features learned from mul-RBM with sparsity achieve better accuracy than original features, PCA features and features learned from mul-RBM without sparsity.

6. References

- [1] Matthew Schultz and Thorsten Joachims. Learning a distance metric from relative comparisons. In Sebastian Thrun, Lawrence Saul, and Bernhard Scholkopf, editors, "Advances in Neural Information Processing Systems 16. MIT Press, Cambridge, MA, 2004.
- [2] Daniel Wolff and Tillman Weyde. Learning music similarity from relative user ratings. *Inf. Retr.*, 17(2):109–136, April 2014.
- [3] Son N. Tran, Daniel Wolff, Weyde Tillman, and Artur dAvila Garcez. Feature preprocessing with restricted boltzmann machine for music similarity learning. In *In Audio Engineering Society 53rd conference on Semantic Audio*, 2014.
- [4] Emmanouil Benetos Son N. Tran and Artur dAvila Garcez. Learning motion-difference features using gaussian restricted boltzmann machines for efficient human action recognition. In *In International Joint Conference in Neural Network*, 2014.
- [5] Honglak Lee, Chaitanya Ekanadham, and Andrew Y. Ng. Sparse deep belief net model for visual area v2. In J. C. Platt, D. Koller, Y. Singer, and S. T. Roweis, editors, *Advances in Neural Information Processing Systems 20*, pages 873–880. Curran Associates, Inc., 2008.

- [6] Honglak Lee, Peter T. Pham, Yan Largman, and Andrew Y. Ng. Unsupervised feature learning for audio classification using convolutional deep belief networks. In NIPS, pages 1096–1104, 2009.
- [7] Hazrat Ali, Son N. Tran, Emanouil Benetos, and Artur d’Avila Garcez. Speaker recognition with hybrid features from a deep belief networks. Neural Computing and Applications, 2016.
- [8] Honglak Lee, Roger Grosse, Rajesh Ranganath, and Andrew Y. Ng. Convolutional deep belief networks for scalable unsupervised learning of hierarchical representations. In Proceedings of the 26th Annual International Conference on Machine Learning, ICML ’09, page 609616, New York, NY, USA, 2009. ACM.
- [9] Abdel-rahman Mohamed, George E. Dahl, and Geoffrey E. Hinton. Acoustic modeling using deep belief networks. IEEE Transactions on Audio, Speech & Language Processing, 20(1):14–22, 2012.
- [10] Paul Smolensky. Information processing in dynamical systems: Foundations of harmony theory. In Rumelhart, D. E. and McClelland, J. L., editors, Parallel Distributed Processing: Volume 1: Foundations, pages 194–281. MIT Press, Cambridge, 1986.
- [11] Geoffrey E. Hinton. Training products of experts by minimizing contrastive divergence. Neural Comput., 14(8):1771–1800, August 2002.
- [12] Sebastian Stober and Andreas Nurnberger. An experimental comparison of similarity adaptation approaches. In Proc. of AMR11, 2011.
- [13] I.T. Jolliffe. Principal Component Analysis. Springer Verlag, 1986.

Applying the GPGPU-Quicksort for Improving the Sorting Performance in a large collection of documents

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Abstract

In most of current techniques and applications, data sorting is kernel algorithm of preprocess and it effects to performance of other task. Improving performance of sorting algorithm is scientist's desired problem. And in current data explosion century, amount of data become billions records and sorting them is waste so much time and memory when we applied popular algorithms like Quicksort, K-way External Merge Sort. With the growth of coprocessors in GPUs, applying parallel programming to sorting by CUDA will improve performance and execute time better than same cost CPU. In this paper, we applied GPU-Quicksort to sort data in huge file for improve performance for preprocess task and manipulation task in system storage large data.

1. Introduction

When sorting algorithm is kernel, support for other algorithm and a wide range of applications, not only in science but also in industry. Improving sorting is desire of scientists and it impact to performance competition of current applications. And in data explosion century, with millions records processing everyday, sorting data is not only a desire but also a requirement for most of applications.

In a long time, Quicksort is one of the fastest and most popular algorithms in computer science. With divide-and-conquer method, Quicksort presented first time by C.A.R Hoare in Communications of the ACM 1961[1], is applied, modified and developed until now. But working with large data, both sequence and parallel Quicksort implementations on CPUs cores show the limit on memory and wasting time execution.

With evolution of computer hardware and appearance of supercomputers [2], parallel processing is improved. Although supercomputers can improve performance large data processing, it is very expensive. Seizing this opportunity and with the growth of coprocessors in GPUs, the manufacturers developed libraries for computing on GPUs like OpenGL [3]. If comparing to supercomputers, GPUs are cheaper and more conform to parallel programming for sorting task based on divide-and-conquer method. Previous work on general purpose computing on GPUs have used the OpenGL interface, but since it was primarily designed for performing graphics operations it gives a poor abstraction to the programmer who wishes to use it for non-graphics related tasks. So, NVIDIA developed CUDA language programming based on C language, a programming platform for doing general purpose computation on their GPUs [4].

Based on CUDA, algorithms are developing in parallelism programming and applied on GPUs popularly, and sorting algorithms are not exceptional. And in these algorithms, GPU-Quicksort [5] is investigated with more performance for large data than sequential sorting implementation on CPU like K-way External Merge Sort [6]. GPU-Quicksort utilized the advantages of GPUs: fast computing, multiprocessing in multi core and strong synchronization threads. This algorithm is also modified for conforming to using limited memory in GPUs in reading/writing large data. In current techniques and applications, data storage and data manipulation depend on how billions records be sorted on disk. In this paper, we applied GPU-Quicksort to sorting data in huge file for speeding up

preprocess task of other algorithm and improving performance of system storage. Our purpose is using a high performance sorting based on strong coprocessors GPUs and fastest huge file processing.

2. Related Works

2.1 PGPU-CUDA Computing Model

2.1.1 Parallel Computing: In multicore revolution, Central Processing Units has more than 1 core which read and run program instructions independently [7]. With multicores, Parallel computing [8] is the simultaneous use of multiple compute resources to solve a computational problem which is broken into discrete parts that can be solved concurrently.

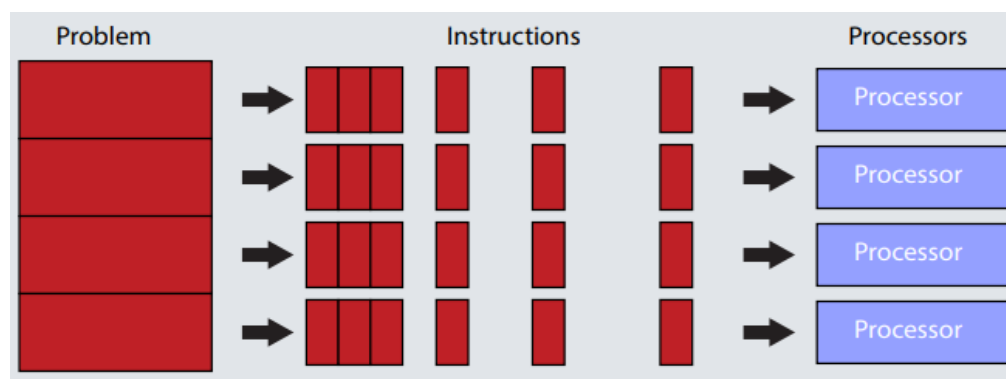


Figure 2.1: Parallel Computing

2.1.2 GPGPU-CUDA Model:

Because CPU core is designed for very complex control logic, seeking to optimize the execution of sequential programs, GPU core, relatively light-weight, is optimized for data-parallel tasks with simpler control logic, focusing on the throughput of parallel programs. In CUDA programming, we call CPU as Host and GPU as Device.

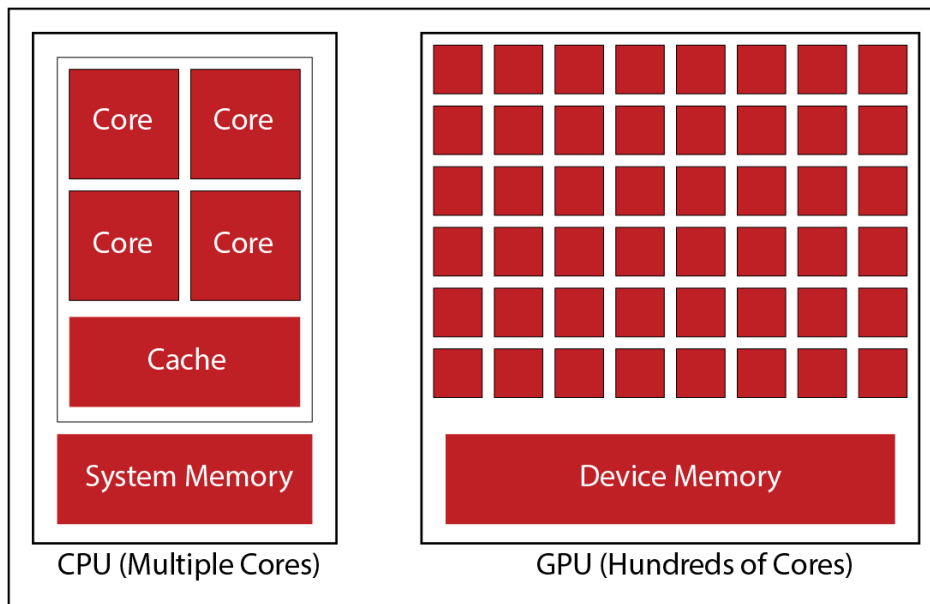


Figure 2.2: CPU and GPU architecture

When develop programs on GPU, we see from software point of view that all threads on GPU run in parallel. But from hardware point of view, there are multiprocessor in GPU, each multiprocessor has threads and threads are divided into thread blocks.

Memory:

- **Global memory:** Host communicates with Device and reverse, we use global memory as intermediate memory. Each thread and thread block can calculate on global memory and return result to Host by global memory.
- **Shared Memory:** If global memory is large and on-board memory, each thread block have its own shared memory, which is smaller and on-chip memory support higher bandwidth.
- **Local Memory:** Lower level memory is local memory, a private memory of each thread.

That is motivation for GPU-Quicksort researcher. GPU-Quicksort is implemented by CUDA and utilized GPUs hardware for speeding up. Because CUDA based on C, data processing on disk and data manipulation are high performance with libraries like cuFFT and linear algebra.

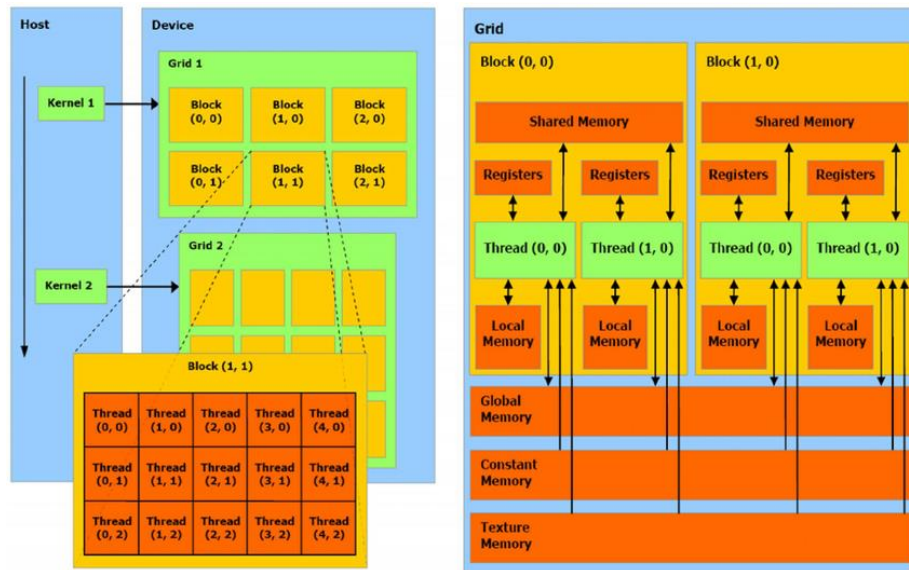


Figure 2.3: CUDA Architecture

2.2 Sorting Technique for large Data Collection

Researching and improving sorting algorithms have a long history and still be developed. Quicksort is one of popular sorting algorithms in a wide range of applications. But when implement with large data, records do not fit to memory and the more conform algorithm in this position is K-way External Merge Sort.

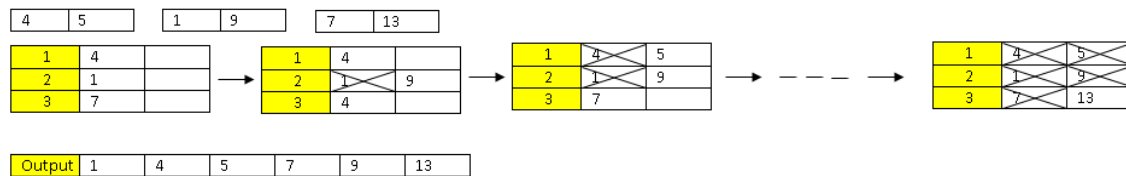
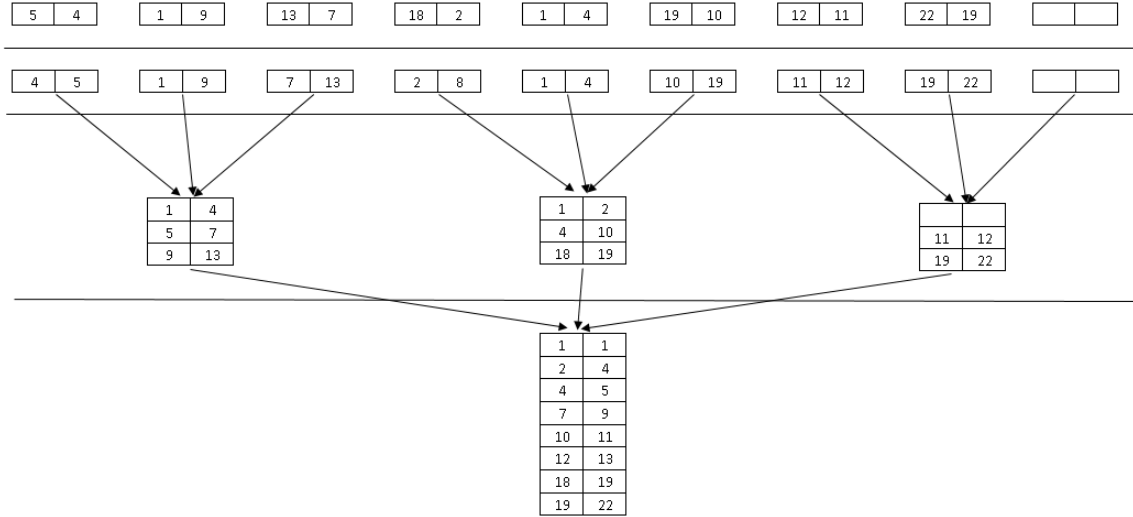


Figure 2.4: Example Merge Pages of K-way External Merge Sort: L = 2, N = 16 and K = 3



**Figure 2.5: Example of K-way External Merge Sort: $L = 2$,
 $N = 16$ and $K = 3$**

K-way External Merge Sort: we define N pages are data collections with each page size is L records located on disk. For each page, we use default merge sort to have an ordered record in page. After that, we use K buffers input and 1 buffer output for merging pages together. Each input buffer read one page sequentially. Each buffer read one record per time, compare records read from every input buffers and get the smallest record to write to output buffer. Input buffer have the smallest record will read next record. Repeat comparison step until end of all pages. If buffer output can not add more record, write it to disk and flush buffer. Repeat read step with new output page written on disk until having only 1 output pages. Cost of this algorithm is:

$$O(L*N * [1 + \log_K(N/K)])$$

But applications of this algorithm still have more limits about time execution of CPUs cores. Although current CPUs not only improved clock speed per core but also use more cores for improving processing, it have some problems about size of transistors, heat and price.

Based on GPU-Quicksort, in next section we will present model we apply for huge file and we will compare performance of this algorithm to other algorithms.

3. Applying QUICKSort-GPU Based for large data collection

3.1 Origin Quicksort:

Origin Quicksort algorithm sort a collection of data by choosing a pivot in collection, find all of records lower than pivot to move to left and find all of records higher than pivot to move to right. Then repeat this processing with sub collections until entire collection is sorted. With every sub collection iteration, we choice new pivot value and result as two sub collections are created which can be sorted independently.

With sub collections be able to be sorted independently, we can apply parallelism to sort these sub collections. Furthermore, reading/writing records in sub collection and comparison record with pivot also can be work simultaneously. When applying to large data, we can use advantages of GPU like assigning thread blocks to sub collections and

threads in block for reading/writing records for improving performance. But when amount of records in sub collections become small, using blocks will waste environment.

3.2 Quicksort-GPU based Algorithm:

3.2.1 Reading Data:

```

1 No.,Title,Authors,Created At,Conference,Publisher,Keywords
2 1,FPGA design & implementation of a very-low-latency video-see-through (VLLV) head-mount display (HMD) system for
  mixed reality (MR) applications,[Tao Ai],December 2016,VRCAI '16: Proceedings of the 15th ACM SIGGRAPH Conference on
  Virtual-Reality Continuum and Its Applications in Industry - Volume 1,ACM,"[FPGA, augmented reality, head-mount
  display, mixed reality, video see-through, virtual reality]"
3 2,Using structural patches tiling to guide human head-shoulder segmentation,"[Pengyang Bu, Nan Wang, Haizhou
  Ai]",October 2012,MM '12: Proceedings of the 20th ACM international conference on Multimedia,ACM,"[head-shoulder
  segmentation, markovian sliding window, patch-based classification]"
4 3,User simulation as testing for spoken dialog systems,"[Hua Ai, Fuliang Weng]",June 2008,SIGdial '08: Proceedings of
  the 9th SIGdial Workshop on Discourse and Dialogue,Association for Computational Linguistics,[ ]
5 4,A Probabilistic Dynamic Contour Model for Accurate and Robust Lip Tracking,"[Qiang Wang, Haizhou Ai, Guangyou
  Xu]",October 2002,ICMI '02: Proceedings of the 4th IEEE International Conference on Multimodal Interfaces,IEEE
  Computer Society,[ ]
6 5,Video parsing based on head tracking and face recognition,"[Pengxu Li, Haizhou Ai, Yuan Li, Chang Huang]",July
  2007,CIVR '07: Proceedings of the 6th ACM international conference on Image and video retrieval,ACM,"[face
  recognition, face vision, video parsing, video content retrieval]"
7 6,Can big data improve public policy analysis?,"[Jing Shi, Xiaoyan Ai, Ziyi Cao]",June 2017,dg.o '17: Proceedings of
  the 18th Annual International Conference on Digital Government Research,ACM,"[Public policy, big data, data privacy,
  policy analysis]"
8 7,Virtual Screening for COX-2 Inhibitors with Random Forest Algorithm and Feature Selection,"[Shangjie Ai, Yong Bai,
  Xiande Liu]",December 2017,ICBRA 2017: Proceedings of the International Conference on Bioinformatics Research and
  Applications 2017,ACM,"[Random forest, Drug discovery, COX-2 inhibitor, Machine learning, QSAR, Virtual screening]"

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Figure 3.1: Data format in file CSV

In this paper, we use huge file in CSV format as input data for sorting. And when we want to check research paper greater or lower than pivot, we use their names for comparison.

The first step is we had to read data into main memory of host. We read collection of data and put it to an array in main memory.

GPU-Quicksort based on Quicksort for processing and divide-and-conquer method for sorting on GPUs. We avoid wasting environment problem by divide processing to two phase. We have first phase when amount of lines in file large enough for assign thread blocks to the sections and second phase with assign one thread blocks for all sections.

3.2.2 First Phase:

This phase is used for collections and sub collections which have large data size executed by lots of thread blocks. We had data collection in main memory and in this phase, we use thread blocks for calculating on their shared memory and synchronization between blocks.

Picking pivot: we pick randomize research paper for pivot to comparison.

We logically divide collections with S lines into m equally sized sections where m is a number of thread block we used (**Figure 3.2**). Each thread block is assigned into each K lines section of file (**Figure 3.3**) with $K = S / m$. We use shared memory of each thread block as temporary data because calculating on shared memory faster than global memory. We transfer each part of data collection in main memory to each correspondent thread block.



Figure 3.2: The file to be sorted is divided into m equally K records sections

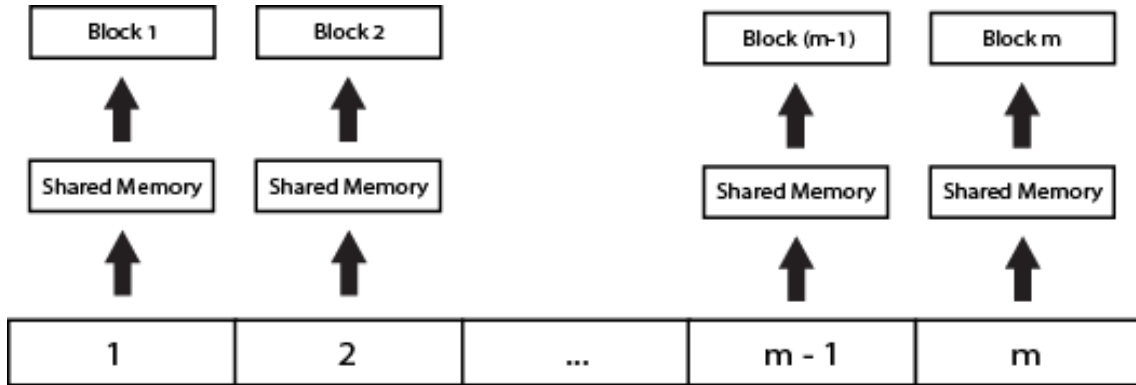


Figure 3.3: Thread blocks are assigned to collection

By parallel computing independently of thread blocks, each block put threads to read the records and with thread's local memory, each thread store 2 array in local memory: buffer lower than pivot and buffer higher than pivot(**Figure 3.4**).



Figure 3.4: Threads in thread block read data in sections

Auxiliary Array: Because we used shared memory for store data, that is too expensive thread synchronization for moving research paper to the left or right in same large array. For that reason, we have a better solution for reading and writing to increase performance, we use an auxiliary array. We write all research papers lower than pivot to the left and all research papers greater than pivot to the right of auxiliary array.

Writing data: When thread blocks execute writing data to auxiliary array in parallel, we want to prevent each thread writing overlap to auxiliary array. So we must find a right data writing place for each thread. Solving this problem, we use cumulative sum with two step:

1. Each thread find amount of research papers lower and amount of research papers greater than pivot. With these two numbers, each thread assign space of memory in auxiliary array and know where to write research papers.

2. Iterating array again and move research papers to correspondent position.

Finally, we put last research paper pivot to the gap between the left and right sub collections and return auxiliary array on device to host.

If sub collection smaller than shared memory size of block, we put it to later list to execute in second phase. Otherwise, repeat first phase.

3.2.3 Second phase

This phase is used for collections and sub collections which have data size fit to shared memory of thread block. Instead of using multi blocks, we use one block for saving environment and unnecessary synchronization between thread anymore.

In this phase, we execute on entire device until entire sub collection is sorted. This means when we have two left and right sub collection results, we continue sort sub collection results. Repeat sort sub collections until entire sub collection is sorted.

4. Conclusion & Future work

In this paper, we applied GPU-Quicksort, a parallel Quicksort algorithm on graphic processors to take advantages of GPUs by solving synchronization threads problem. In experiment we compare GPU-Quicksort for large document with conformable algorithm for large data K-way External Merge Sort. We hope that GPU-Quicksort performed better than these algorithms and this application will help to improve performance of preprocess task or data manipulation task.

With the growth of computer hardware, we focus not only a huge file but also a lot of file. So with this result, we want to enlarge a scope of input from a huge file to lots of huge file in same disk or in multi nodes cluster.

5. Acknowledgements

We would like to thank Huynh Cong Viet Ngu for his valuable support during the writing of this paper. We also would like to thank reviewers helped us improving the presentation of this paper.

6. References

1. Hoare, C. A. R. 1961. Algorithm 64: Quicksort. Communications of the ACM 4, 7, 321.
2. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing) 1st Edition.
3. Khronos, OpenGL (Open Computing Language). <https://www.opengl.org/>

4. NVIDIA, CUDA, <https://docs.nvidia.com/cuda/>.
5. Daniel Cederman, Philippas Tsigas from Chalmers University of Technology, “GPU-Quicksort: A Practical Quicksort Algorithm for Graphics Processors” In: Journal of Experimental Algorithmics (JEA): Volume 14, 2009.
6. Raghu Ramakrishnan, Johannes Gehrke, “Chapter 13 : External Sort in Database Management Systems 3rd Edition”, pp. 421-428
7. Peter Kipfer, Rüdiger Westermann, Chapter 46: Improved GPU Sorting in GPUGem2.
8. Blaise Barney, Lawrence Livermore National Laboratory, Parallel Computing https://computing.llnl.gov/tutorials/parallel_comp/#WhatIs
9. John Cheng, Max Grossman, Ty McKercher, “Professional CUDA C Programming”, pp. 2-8

So sánh các phần mềm tách từ tiếng Việt

On comparing Vietnamese word segmentation softwares

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Tóm tắt

Bài viết này nghiên cứu các phần mềm xử lý tiếng Việt trong việc thực hiện tác vụ tách từ. Việc xác định đâu là một từ giúp máy tính rút trích các đơn vị đặc trưng có ý nghĩa đối với văn bản. Đây là tác vụ tiền xử lý quan trọng, đảm bảo thông tin đặc trưng được rút trích, tránh nhiễu, giảm chiều không gian dữ liệu, làm tăng độ chính xác và giảm thời gian thực thi của các thuật toán xử lý ngôn ngữ tự nhiên. Từ đó hiểu các bộ công cụ để áp dụng cho việc phân tích, xử lý dữ liệu phục vụ cho các ứng dụng như nhận diện giọng nói, tự động sửa lỗi chính tả và ngữ pháp, tóm tắt văn bản. Nghiên cứu được thực hiện bằng cách áp dụng các phần mềm phân tích từ tiếng Việt lên các tập dữ liệu có kích thước khác nhau. Sau đó, ghi nhận tốc độ thực thi và độ chính xác. Kết quả của nghiên cứu cho thấy thuật toán kết hợp giữa từ điển và n-gram mang lại độ chính xác cao với thời gian thực thi ngắn.

Từ khoá

Xử lý ngôn ngữ tự nhiên; cấu trúc; tách từ; tiếng Việt; phần mềm tách từ tiếng Việt.

I. Đặt vấn đề

Xử lý ngôn ngữ tự nhiên là một lĩnh vực quan trọng trong nghiên cứu máy học, trí tuệ nhân tạo, kỹ thuật thông tin liên quan đến sự tương tác giữa máy tính và ngôn ngữ con người[1]. Bài toán tách từ là một phần trong xử lý ngôn ngữ tự nhiên. Tách từ là tác vụ xác định ranh giới các từ trong văn bản, đảo bảo tính nguyên tử trong ý nghĩa. Việc xác định được đâu là một từ giúp máy tính rút trích được các đơn vị đặc trưng có ý nghĩa đối với văn bản. Đây là tác vụ tiền xử lý quan trọng, đảm bảo thông tin đặc trưng được rút trích, tránh nhiễu, giảm chiều không gian dữ liệu, từ đó làm tăng độ chính xác và giảm thời gian thực thi của các thuật toán xử lý ngôn ngữ tự nhiên.

Đối với các ngôn ngữ đa âm đơn nghĩa như tiếng Anh, Pháp việc phân tách từ một câu khá là đơn giản vì mỗi từ được cách nhau tự nhiên bởi ký tự khoảng trắng. Tuy nhiên, đối với các ngôn ngữ tượng âm và tượng hình thuộc vùng Á châu như tiếng Việt, tiếng Trung thì tác vụ tách từ lại không đơn giản. Khoảng trắng trong các ngôn ngữ này vừa dùng để tách từ, vừa dùng để tách tiếng. Trong các loại ngôn ngữ đơn âm tiết như tiếng Việt, một từ có thể được cấu tạo bởi nhiều tiếng. Từ xác định theo tiếng có một ý nghĩa và từ xác định theo tổ hợp các tiếng lại có ý nghĩa hoàn toàn khác. Vì vậy điểm khó khăn trong việc tách từ tiếng Việt là xem một tổ hợp các tiếng là một từ ghép hay nhiều từ đơn lẻ. Nếu tìm hiểu ý nghĩa của một câu tiếng Việt bằng cách dịch nghĩa từng từ trong câu thì sẽ không chính xác. Ví dụ, đối với từ “xanh ngắt” nếu ta dịch riêng từ “xanh” và từ “ngắt” thì ý nghĩa của từ sẽ hoàn toàn khác so với từ gốc.

Để xử lý vấn đề trên thì việc sử dụng các công cụ xử lý ngôn ngữ tự nhiên nói chung hoặc sử dụng các công cụ tách từ trong tiếng Việt nói riêng một cách hiệu quả là rất cần thiết. Các công cụ tách từ mã nguồn mở được sử dụng trong nghiên cứu là VnTokenizer với thuật toán sử dụng từ điển kết hợp với n-gram, DongDu với phương pháp Pointwise, JvnSegmenter với việc sử dụng kết hợp trường điều kiện ngẫu nhiên (Conditional Random Fields - CRFs) và máy vector hỗ trợ (Support Vector Machines - SVMs) và UETSegmenter sử dụng thuật toán so khớp từ dài nhất kết hợp với hồi quy logistic.

Trong quá trình thực hiện tách từ, kho ngữ liệu là quan trọng nhất. Trên thế giới hiện nay có nhiều kho ngữ liệu khác nhau, tồn tại dưới nhiều dạng khác nhau, cấu trúc và định dạng của kho ngữ liệu rất đa dạng, phải kể đến các kho ngữ liệu của Anh là ICE[2], kho ngữ liệu của Hoa Kỳ là ANC[3],... Ở Việt Nam, kho ngữ liệu cũng được quan tâm và xây dựng như: kho ngữ liệu Sketch của tác giả Phan Thị Hà (94 triệu từ) [4]; VietTreebank của Nguyễn Phương Thái và các cộng sự [5], Kho ngữ liệu dự án VLSP của Lê Thanh Hương[6]. Cả hai kho ngữ liệu VietTree-bank và kho ngữ liệu dự án VLSP đều thuộc dự án KC01/01 của tác giả Hồ Tú Bảo[7].

Để đảm bảo tính độc lập của dữ liệu, nghiên cứu thực hiện xây dựng bộ dữ liệu khoảng 10000 câu và được chia làm 5 tập dữ liệu với kích thước câu khác nhau. Nghiên cứu thực hiện kiểm tra độ chính xác và tốc độ thực thi, từ đó đưa ra những đánh giá về kết quả thực hiện tách từ trong xử lý ngôn ngữ tự nhiên tiếng Việt đối với các phần mềm nghiên cứu được đề cập.

II. Phần mềm nghiên cứu

1) Phần mềm VnTokenizer

Phần mềm VnTokenizer [8] được training với kho giữ liệu Vietlex với 40,181 từ được tạo nên từ 7,729 âm tiết khác nhau.

VnTokenizer sử dụng bộ quy tắc phân đoạn được quy định tại bộ chuẩn ISO/TC37/SC4[9] để xác định tính chính xác của công cụ tách từ. Các tiêu chí đó là: từ ghép, từ láy, từ ngữ gồm nhiều từ, tên riêng, các mẫu tự thường gặp.

Dữ liệu khi đưa vào chương trình, sẽ được phân tích bằng cách tìm các danh từ riêng, thời gian, ngày tháng, tên viết tắt, thư điện tử. Sau đó, sẽ được phân tích bằng cách tìm các từ ghép, từ láy hoặc từ ghép gồm nhiều từ đơn thông qua thuật toán tham ăn, nếu một nhóm từ thỏa mãn một mô hình có trong mẫu huấn luyện thì nhóm từ đó sẽ được gom lại thành một cụm. Để tăng độ chính xác, thì khi tìm ra được một cụm từ phù hợp với mẫu đã huấn luyện, thì những từ này sẽ được lưu lại và sau đó chọn lại từ phù hợp nhất.

Thuật toán biểu diễn các chuỗi đầu vào như một đồ thị có hướng tuyến tính $G = (V, E)$ với $V = \{v_0, v_1, \dots, v_n, v_{n+1}\}$ biểu diễn vị trí của từng âm tiết trong câu. Sẽ có một cặp (v_i, v_j) sao cho các âm tiết liên tiếp được đánh dấu từ $s_{i+1}, s_{i+2}, \dots, s_j$ tạo nên một từ, khi $i < j$. Ta gọi hàm $\text{accept}(A, s)$ – hàm này có chức năng lấy ra những cụm từ thoả mãn điều kiện. Tuy vậy vẫn có khả năng thuật toán chọn những cụm từ không rõ nghĩa, ví dụ khi trong câu tồn tại các cụm từ đều có khả năng kết hợp với nhau.

Thuật toán tạo một đồ thị được trình bày như sau:

```

V ← ∅;
for i = 0 to n + 1 do
    V ← V ∪ {vi};

```

```

end for
for i = 0 to n do
    for j = i to n do
        if (accept(A, si ... sj)) then
            E ← E ∪ {(vi, vj+1)};
        end if
    end for
end for
return G = (V, E);

```

Để giải quyết, các cụm từ không rõ nghĩa. Thuật toán n-gram, dùng để tính xác suất xuất hiện của một cụm từ trong ngôn ngữ, được áp dụng trong công cụ để xác định xem từ đang được xét có phù hợp hay không, dựa vào tần suất xuất hiện của nó.

$$P(s) = \prod_{i=1}^m P(w_i | w_{1:i-1}) \approx \prod_{i=1}^m P(w_i | w_{i-n+1}^{i-1}) \quad (1)$$

Trong công thức (1) ta có s là chuỗi đầu vào với $s = w_1, w_2, \dots, w_m$. Các w_i^j biểu thị các từ $w_i \dots w_j$. Giá trị n thường là 2 hoặc 3 tương đương với mô hình bi-gram hoặc tri-gram [10]. Sau khi xác suất xuất hiện của một từ được tính, thì công cụ sẽ dựa vào xác suất đó để chọn từ phù hợp để nhóm lại.

2) Phần mềm JvnSegmenter

Phần mềm JvnSegmenter sử dụng dữ liệu huấn luyện có 2000 tên người, 707 địa danh cũng với 7800 câu thuộc các chủ đề xã hội khác nhau[11]. Khác với các công cụ trước, phần mềm này thực hiện gán nhãn các âm tiết thành các nhóm BW (Beginning of word), IW (Inside of word) và O (Others).

Phần mềm JvnSegmenter sử dụng mô hình chuỗi tuyến tính Conditional Random Fields (CRFs)[12] được dùng để dự đoán nhãn dựa trên chuỗi đầu vào. Sau khi được huấn luyện với kho ngữ liệu gồm các cụm từ tiếng Việt đã được tách. Thuật toán sẽ hoạt động bằng cách làm tăng tối đa sự tương đồng của dữ liệu kiểm tra hoặc đầu vào so khớp với mô hình đã được huấn luyện từ trước và đặt nhãn các từ trong từng chuỗi trong dữ liệu.

Với $o = (o_1, o_2, \dots, o_T)$ là chuỗi dữ liệu quan sát được và S là tập hợp các máy trạng thái hữu hạn, mỗi trạng thái liên kết với nhãn $l \in L$. Gọi $s(s_1, s_2, \dots, s_T)$ là một chuỗi trạng thái, để xác định mối liên hệ của chuỗi dữ liệu quan sát với chuỗi trạng thái cho một chuỗi quan sát sử dụng thuật toán CRFs[13] để xác định dựa trên xác suất.

$$p_\theta(s|o) = \frac{1}{Z(o)} \exp \left[\sum_{t=1}^T \sum_k \lambda_k f_k(s_{t-1}, s_t, o, t) \right] \quad (2)$$

Trong công thức (2) ta có:

$$Z(o) = \sum_{s'} \exp \left(\sum_{t=1}^T \sum_k \lambda_k f_k(s'_{t-1}, s'_t, o, t) \right) \quad (3)$$

Công thức (3) là hệ số chuẩn hoá trên tất cả các chuỗi có thể nhận diện. Tương ứng với mỗi đặc trưng f_k có trọng số là λ_k , đây là mục đích chính của CRFs. Đặc trưng f_k được xem xét ở đặc trưng trạng thái (4) và đặc trưng chuyển tiếp (5).

$$f_k^{(per-state)}(s_t, o, t) = \delta(s_t, l) x_k(o, t) \quad (4)$$

$$f_k^{(transition)}(s_{t-1}, s_t, t) = \delta(s_{t-1}, l') \delta(s_t, l) \quad (5)$$

Bên cạnh đó, thuật toán máy vector hỗ trợ (SVMs) được dùng để phân loại các âm tiết và phân loại nhãn vào một trong ba nhóm BW, IW hoặc O. Sau khi phân loại các từ thì công cụ sẽ nhóm các âm tiết thuộc BW và IW kế tiếp nhau thành một từ hoàn chỉnh.

Công cụ bước đầu sẽ duyệt qua các từ xem có thuộc vào tập tên người, địa danh, chữ viết tắt để xác định đó là một cụm từ. Sau đó áp dụng thuật toán mô hình CRFs cùng với SVMs để chọn các cụm từ có khả năng và đem so sánh với dữ liệu có trong từ điển.

3) Phần mềm UETSegmenter

Phần mềm UETSegmenter sử dụng hướng tách từ bằng cách đánh giá khoảng trắng ở giữa các từ là dùng để tách âm tiết hay dùng để tách từ. Với cách tiếp cận này, ta có thể thay đổi loại (tách âm tiết hay tách từ) của khoảng trắng mà không làm ảnh hưởng đến những khoảng trắng kế nó [14].

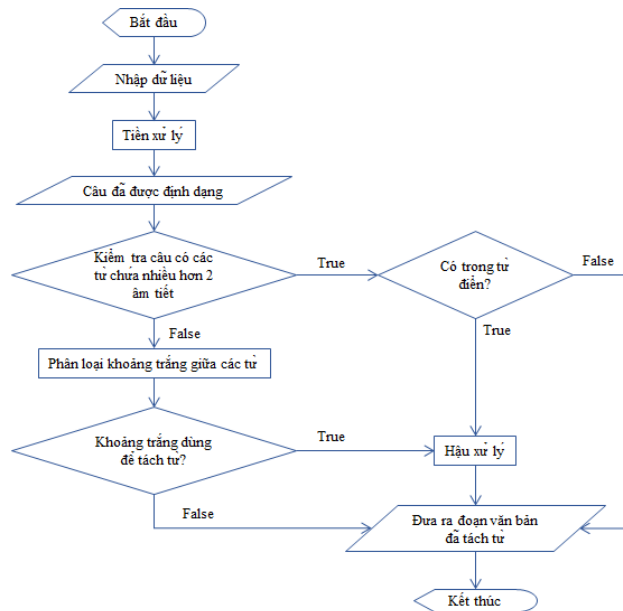
Vì hầu hết các từ trong tiếng Việt đều gồm một hoặc hai âm tiết (71%), nên đối với các từ nhiều hơn hai âm tiết ta có thể lưu chúng vào trong từ điển. Ta có thể áp dụng thuật toán so khớp từ dài nhất để tìm ra các cụm từ có nhiều âm tiết và so sánh chúng với từ có trong từ điển. Vì vậy ta chỉ cần xử lý các từ có hai âm tiết và các danh từ riêng.

Để giải quyết các từ có hai âm tiết hoặc các danh từ riêng, ta sử dụng thuật toán hồi quy logistic để phân loại các khoảng trắng. Sau khi phân loại được đâu là khoảng trắng để tách từ và đâu là khoảng trắng tách âm tiết, công cụ thay thế các khoảng trắng đó bằng dấu gạch dưới ‘_’. Để tăng thêm độ chính xác, ta lại so sánh những từ ghép gồm ba âm tiết do thuật toán hồi quy logistic đưa ra, và xét trong từ điển. Nếu không có trong từ điển, ta lại tiếp tục tách ra và gọi thuật toán hồi quy để đưa ra các kết quả có khả năng khác. Tóm tắt hoạt động của phần mềm UETSegmenter dựa trên thuật toán hồi quy logistic được mô tả trong (Hình 1).

Hồi quy logistic dùng để phân loại khoảng trắng trong dữ liệu văn bản. Ta có tập huấn luyện $D = \{(X, Y)\}$ với X là vector đặc trưng, Y là các nhãn tương ứng với cái loại khoảng trắng. Ta gọi nhãn 1 biểu thị cho khoảng trắng tách âm tiết của một từ, và nhãn 0 biểu thị cho khoảng trắng tách các từ. Xác suất nhãn 1,0 được tính bằng công thức (3,4).

$$P(Y = 1|X) = \frac{1}{1 + \exp(w_0 + \sum_{i=1}^n w_i X_i)} \quad (3)$$

$$P(Y = 0|X) = 1 - P(Y = 1|X) \quad (4)$$



Hình 1. Nguyên lý hoạt động của UETSegmenter

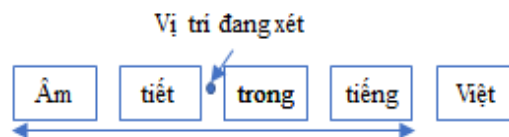
4) Phần mềm DongDu

Kết quả tách từ có sử dụng các phương pháp như mô hình Markov ẩn[15], CRFs đều cho kết quả thực nghiệm với độ chính xác không cao vì cần lượng từ điển lớn và đối với từ mới thì không nhận diện được, do đó một từ sai sẽ kéo theo các từ khác sai khi tách từ.

Để khắc phục sự hạn chế, phần mềm DongDu được xây dựng dựa trên phương pháp Pointwise [16]. Một lượng từ vựng vừa phải và có khả năng xác định từ mới không có trong từ điển bằng sự hỗ trợ của công cụ máy véc tơ hỗ trợ (SVMs), cách này giúp tập trung vào từng nhân độc lập và giảm kích thước dữ liệu của mô hình.

Ba đặc trưng cơ bản của phương pháp Pointwise được sử dụng trong phần mềm DongDu là: n-gram âm tiết, n-gram chủng loại âm tiết, đặc trưng từ điển. Cụ thể gồm:

- N-gram âm tiết: Theo thực tế thì từ ghép trong tiếng việt có 70% từ gồm hai âm tiết và 14% từ gồm ba âm tiết. Vì vậy khi đánh giá từ đang được chọn có phải là từ ghép ta có thể kiểm tra ba hoặc hai từ xung quanh của từ đang xét (Hình 2).
- N-gram chủng loại âm tiết, bao gồm:
 - Âm tiết viết hoa: Những âm tiết bắt đầu bằng chữ hoa.
 - Âm tiết viết thường: Những âm tiết chỉ gồm những chữ cái thường.
 - Số: Là các chữ số.
 - Loại khác: Kí hiệu, tiếng nước ngoài, và không thuộc vào ba loại trên.



Hình 2. Ví dụ về n-gram âm tiết

- Đặc trưng từ điển: Là những từ tồn tại trong từ điển. Đối với hai phương pháp trên sẽ

thực hiện gom các từ trong phạm vi một hoặc hai từ xung quanh vị trí đang xét, và xem cụm từ vừa ghép đó có phải là từ ghép có trong từ điển hay không. Do đó, trong đặc trưng từ điển chỉ cần xét từ đó có trong từ điển hay không.

III. Xây dựng tập dữ liệu

Tập dữ liệu nghiên cứu được xây dựng dựa trên việc sưu tầm các mẫu tin tức trên Báo VnExpress với 10000 câu, được chia ra làm 5 tập dữ liệu với số lượng câu được mô tả trong *Bảng 1*.

Tập dữ liệu	1	2	3	4	5
Số câu	2.000	4.000	6.000	8.000	10.000

Bảng 1: Thống kê tập dữ liệu kiểm tra

IV. Kết quả

Nghiên cứu sử dụng những phần mềm đã được giới thiệu trong phần II để kiểm tra tập dữ liệu đã được xây dựng ở phần III, kết quả được thể hiện ở *Bảng 2* như sau:

Phần mềm	Tổng số từ tách được	Độ chính xác	Thời gian xử lý (giây)
Tập dữ liệu 1			
VnTokenizer	24592	98.30%	0.49
JvnSegmenter	23110	93.73%	15.41
Dongdu	21714	90.80%	1.46
UTESegmenter	24230	99.91%	28.05
Tập dữ liệu 2			
VnTokenizer	54517	98.70%	1.11
JvnSegmenter	50776	93.57%	62.04
Dongdu	48123	89.70%	3.27
UTESegmenter	54012	99.91%	29.00
Tập dữ liệu 3			
VnTokenizer	84775	98.70%	1.72
JvnSegmenter	79204	93.80%	141.00
Dongdu	75959	88.80%	5.09
UTESegmenter	84038	99.93%	31.11

Tập dữ liệu 4			
VnTokenizer	110169	97.90%	2.22
JvnSegmenter	103021	94.51%	248.11
Dongdu	99450	89.23%	7.38
UTESegmenter	109306	99.50%	35.06
Tập dữ liệu 5			
VnTokenizer	143933	97.95%	2.85
JvnSegmenter	134886	94.52%	458.10
Dongdu	128946	89.19%	9.53
UTESegmenter	142737	99.50%	37.46

Bảng 2: Kết quả thực nghiệm trên tập dữ liệu được xây dựng

Qua quá trình thực nghiệm, nghiên cứu thấy rằng VnTokenizer có tốc độ xử lý cao nhất khi thực hiện lần lượt tăng số lượng câu kiểm tra. Với việc lọc ra những danh từ riêng, thư điện tử, ngày tháng làm cho đoạn văn bản xử lý ngắn đi hơn rất nhiều. Cùng với đó, việc kết hợp kho từ điển và thuật toán xây dựng đồ thị để chọn ra các từ ghép có khả năng tách làm giảm đi thời gian xử lý so với việc tìm các từ xung quanh và so sánh với từ điển như công cụ DongDu hoặc phải tăng độ dài của từ đang xét một cách lần lượt rồi so với dữ liệu trong từ điển với thuật toán CRFs được sử dụng trong công cụ JVnSegmenter.

Xét về độ chính xác, công cụ UTESegmenter cho ra kết quả với độ chính xác cao nhất nhưng tốc độ xử lý dữ liệu thì chưa thật sự hiệu quả. Công cụ đã liệt kê ra hết tất cả cả cụm từ từ ba âm tiết trở lên, nên việc nhận diện các từ ghép từ ba âm trở lên là rất chính xác. Ngoài ra với việc phân loại khoảng trắng sẽ giúp cho việc xác định từ ghép trở nên đơn giản hơn thay vì việc xác định lượng lớn các từ khác nhau và phân loại từ đó thuộc từ ghép. Tuy vậy việc lưu lượng lớn các từ có lớn hơn hai âm tiết và việc dùng hồi quy logistic dẫn đến kho từ điển và dữ liệu huấn luyện cho model lớn gây ra việc tốn nhiều thời gian cho việc tải chương trình lên bộ nhớ máy tính.

V. Kết Luận

Sau khi thực nghiệm các phần mềm trên với các tập dữ liệu văn bản được thu thập, dễ dàng nhận thấy công cụ VnTokenizer đạt được tốc độ xử lý nhanh, do đó sẽ phù hợp với việc xây dựng các ứng dụng trên website bị giới hạn về thời gian đáp ứng. Tuy nhiên, đề cần độ chính xác, và có những yêu cầu không quá khắc khe về thời gian có thể sử dụng phần mềm UTESegmenter. Bên cạnh đó, nghiên cứu cũng góp phần tạo ra dữ liệu chuẩn để phục vụ cho các nghiên cứu về sau cũng như áp dụng vào các công trình trí tuệ nhân tạo có sử dụng tiếng Việt.

Tài liệu tham khảo

- [1] Aravind K. Joshi, Natural Language Processing, Science 13, Vol. 253, Issue 5025, 1991, pp. 1242-1249, DOI: 10.1126/science.253.5025.1242.
- [2] Kho Ngữ liệu quốc tế Anh Quốc, <http://ice-corpora.net/ice>
- [3] Kho Ngữ liệu quốc gia Hoa Kỳ, <http://www.anc.org>
- [4] Phan Thị Hà, Nguyễn Thị Minh Huyền, Lê Hồng Phương, Adam Kilgarrieff, Siva Reddy, “Nghiên cứu từ vựng tiếng Việt với hệ thống Sketch Engine”, Tạp chí Tin học Và Điều khiển học, Số 3(27), 2011, tr. 206 - 217.
- [5] Nguyễn Phương Thái và các cộng sự, Báo cáo kết quả sản phẩm SP 7.3– Kho ngữ liệu tiếng Việt có chú giải, KC01/01, Dự án VLSP, 2009.
- [6] Lê Thanh Hương, Báo cáo kết quả sản phẩm SP 8.5 – Nghiên cứu xây dựng công cụ phân tích câu Việt, KC01/01, Dự án VLSP, 2009.
- [7] Hồ Tú Bảo, Về xử lý tiếng Việt trong công nghệ thông tin, Viện Khoa học và Công nghệ Tiên tiến Nhật Bản. VLSP - KC01/06-10, 2012.
- [8] H. P. Lê, T. M. H. Nguyen, A. Roussanaly and T. V. Ho, International Conference on Language and Automata Theory and Applications, LATA 2008: Language and Automata Theory and Applications, Tarragona, Spain, 2008, pp. 240-249, ISBN: 978-3540882817.
- [9] ISO/TC 37/SC 4 AWI N309, Language Resource Management - Word Segmentation of Written Texts for Mono-lingual and Multi-lingual Information Processing - Part I: General Principles and Methods. Technical Report, ISO, 2006.
- [10] SvenMartin, Jör Liermann, HermannNey, Algorithms for bigram and trigram word clustering, Speech Communication, Volume 24, Issue 1, 1998, pp.19-37, ISSN: 0167-6393.
- [11] Nguyen, C.-T., Nguyen, T.-K., Phan, X.-H., Nguyen, L.-M., and Ha, Q.-T., Vietnamese Word Segmentation with CRFs and SVMs: An Investigation, In Proceedings of the 20th Pacific Asia Conference on Language, Information and Computation, Publisher: Tsinghua University Press, China, 2006, pp. 215–222.
- [12] John Lafferty, Conditional random fields: Probabilistic models for segmenting and labeling sequence data. ICML 2001 In Proceedings of International Conference on Machine Learning. Publisher: ACM New York, 2001, pp. 282-289.
- [13] Lafferty, J., Mccallum, A., Pereira, F.: Conditional Random Fields: probabilistic models for segmenting and labeling sequence data. The 18th International Conference on Machine Learning, Massachusetts, USA, 2001, pp.282—290, ISBN:1-55860-778-1
- [14] Nguyen, T.-P. and Le, A.-C., A Hybrid Approach to Vietnamese Word Segmentation, In Proceedings of the 2016 IEEE RIVF International Conference on Computing and Communication Technologies: Research, Innovation, and Vision for the Future, 2016, pp.114–119.
- [15] L. R. Bahl, P. F. Brown, P. V. de Souza, and R. L. Mercer, Maximum mutual information estimation of hidden markov model parameters for speech recognition, in Proc.

International Conference on Acoustics, Speech and Signal Processing, Tokyo, April 1986, pp. 49–52.

- [16] Tuan Anh Luu, Kazuhide Yamamoto, A Pointwise Approach for Vietnamese Diacritics Restoration, IALP 2012 International Conference on Asian Language Processing, Vietnam, Publisher: IEEE Computer Society Washington, 2012, ISBN: 978-0-7695-4886-9.

So sánh các phần mềm gán nhãn từ loại tiếng Việt

On comparing Vietnamese part-of-speech tagging softwares

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Tóm tắt

Gán nhãn từ loại tiếng Việt là bài toán toán phổ biến trong xử lý ngôn ngữ tự nhiên tiếng Việt. Tuy nhiên, hiện nay chưa có một nghiên cứu thực hiện việc so sánh giữa các công cụ về độ chính xác, tốc độ xử lý và tính ổn định. Do đó, nghiên cứu thực hiện so sánh các phần mềm mã nguồn mở là VnTagger, RDRPOSTagger, JVNTextPro, VNCORENLP,... Thông qua việc tìm hiểu phần mềm tách từ về thuật toán được sử dụng trong phần mềm, độ chính xác,... Nghiên cứu cho thấy được cái nhìn tổng quan về các phần mềm. Bên cạnh đó, nghiên cứu sử dụng bộ dữ liệu của mỗi công cụ để thực hiện thực nghiệm được chia ra làm nhiều bộ dữ liệu khác nhau với số lượng câu khác nhau, thực nghiệm kiểm tra với các phần mềm tách từ được nghiên cứu để đo thời gian thực hiện và độ chính xác của phần mềm. Dựa trên kết quả đo được về thời gian, nghiên cứu đưa ra những nhận định, bình luận về kết quả có được để đưa ra những nhận định.

Từ khóa

Xử lý tiếng Việt; gán nhãn từ loại; tiếng Việt; xử lý ngôn ngữ tự nhiên; gán nhãn từ loại tiếng Việt.

I. Đặt vấn đề

Tiếng Việt (tiếng Việt Nam) là ngôn ngữ của dân tộc Việt Nam, được sử dụng rộng rãi tại Việt Nam, là một ngôn ngữ chính thức của người dân Việt Nam. Đối với các dân tộc thiểu số ở Việt Nam, tiếng Việt được coi là ngôn ngữ thứ hai đi cùng với ngôn ngữ dân tộc chính. Tiếng Việt được xem là một ngôn ngữ khó. Trên các bảng xếp hạng về độ khó của ngôn ngữ của Học viện Dịch vụ Ngoại giao trực thuộc Bộ Ngoại giao Mỹ (SLS) đã xếp tiếng Việt vào nhóm III (Hard languages), nhóm dành cho những ngôn ngữ khó, có sự khác biệt về ngôn ngữ, văn hóa ngôn ngữ đáng kể so với tiếng Anh và tốn thời gian khoảng 44 tuần học [1].

Trong ngành khoa học máy tính, xử lý ngôn ngữ tự nhiên hay Natural language processing (NLP) được xem là một nhánh của nó. Xử lý ngôn ngữ tự nhiên nghiên cứu về cách thức xử lý ngôn ngữ giữa máy tính và ngôn ngữ con người, những bài toán của ngành xử lý ngôn ngữ tự nhiên là xử lý những vấn đề về cách áp dụng công nghệ, máy tính trong việc xử lý ngôn ngữ thuần túy của con người [2]. Xử lý ngôn ngữ tự nhiên là một bước đệm để giúp con người trong việc xử lý những công việc có liên quan đến ngôn ngữ, trí tuệ nhân tạo như: Phân tích dữ liệu văn bản, dịch thuật, robot nhận diện lệnh của con người... Và gán nhãn từ loại tiếng Việt là một minh chứng cho ngành xử lý ngôn ngữ tự nhiên. Do đó, việc xử lý ngôn ngữ tự nhiên trong thời đại công nghệ 4.0 hiện nay là một việc hết sức cần thiết. Tuy nhiên, tiếng Việt đã được xem là một ngôn ngữ khó, điều đó dẫn đến việc phân tích từ loại trong tiếng Việt không phải dễ dàng. Vì tiếng Việt được tạo nên từ rất nhiều từ, mỗi từ có thể thuộc một hoặc nhiều loại từ khác nhau, tùy vào tình huống cụ thể trong câu mà từ được xếp

từ loại khác nhau [3]. Trong ví dụ (1) từ “bánh” được xem như là một danh từ, trong khi ví dụ (2) từ bánh được xem như một từ chỉ loại.

Ví dụ:

(1) Chúng tôi có ***bánh*** để ăn.

(2) ***Bánh*** xèo được xem làm món ăn đặc trưng của người miền Tây.

Do đó, câu trong tiếng Việt được tạo nên bởi các từ và các từ này thuộc nhiều loại từ khác nhau, các loại từ và được ký hiệu như danh từ riêng là Np (Proper noun) , danh từ phân loại (Classifier noun),... được mô tả trong Bảng 1.

Ký hiệu	Tiếng Anh	Tiếng Việt
Np	Proper noun	Danh từ riêng
Nc	Classifier noun	Danh từ phân loại
Nu	Unit noun	Danh từ đơn vị
N	Common noun	Danh từ chung
V	Verb	Động từ
A	Adjective	Tính từ
P	Pronoun	Đại từ
R	Adverb	Trạng từ
L	Determiner	
M	Numeral	Chữ số
E	Preposition	
C	Subordinating conjunction	Liên từ phụ thuộc
CC	Coordinating conjunction	Liên từ kết hợp
I	Interjection	Thán từ
T	Auxiliary, modal words	Từ phụ trợ
Y	Abbreviation	Viết tắt
Z	Bound morphemes	
X	Unknown	Từ không xác định

Bảng 1. Ký hiệu từ loại trong các phần mềm gán nhãn từ loại.

Trong việc gán nhãn tiếng Việt, đã có một số phần mềm được tạo ra có thể kể đến các phần mềm mã nguồn mở như VnTagger của tác giả Lê Hồng Phương[4], phần mềm RDRPOSTagger của tác giả Nguyễn Quốc Đạt [5], phần mềm JvnTextPro [6], phần mềm VNCORENLP của tác giả Vũ Thanh [7].

Đã có nghiên cứu của tác giả Nguyễn Tuấn Phong [8] đã thực hiện thử nghiệm các phần mềm gán nhãn JVnTagger, vnTagger, RDRPOSTagger và phần mềm ClearNL do tác giả xây dựng trên bộ dữ liệu do tác giả xây dựng. Tuy nhiên, nghiên cứu được trình bày trong bài báo này thực hiện so sánh 4 công cụ phần mềm gán nhãn từ loại tiếng Việt mã nguồn mở đang được sử dụng là nhãn JVnTagger, VnTagger, RDRPOSTagger và VNCORENLP dựa trên 4 bộ dữ liệu với số lượng câu khác nhau với các loại khác nhau để thực hiện đánh giá về thời gian, độ chính xác.

II. Kết quả nghiên cứu

A. Phần mềm VnTagger

Phần mềm VnTagger [4] là một phần mềm thuộc đề tài cấp nhà nước [9] được huấn luyện trên bộ ngữ liệu tiếng Việt (VietTreebank)[10]. Bộ dữ liệu VietTreebank gồm có 10,165 câu được phân đoạn thủ công, gán thẻ và phân tích cú pháp, được thu thập từ các văn bản thô được thu thập từ mạng xã hội, chuyên mục chính trị của báo Tuổi Trẻ. Độ dài tối thiểu là 2 từ và tối đa là 105 từ cho mỗi câu huấn luyện và thử nghiệm.

Ban đầu, phần mềm VnTagger sử dụng mô hình Markov với điều kiện đối chiếu để dự đoán từ loại của một từ w_i trong một câu gồm các từ $w_1 w_2 \dots w_n$ với thể $t_1 t_2 \dots t_n$ là $\{t_{i-1} t_{i-2} w_i w_{i+1}\}$. Mô hình cơ bản này được gọi là Mô hình 0 (Bảng 2). Mô hình này có độ chính xác đến 90.23%. Để cải thiện kết quả dự đoán về từ không xác định, âm tiết trong cấu tạo của từ và dự đoán được các từ dài chưa biết,.. Để giải quyết vấn đề, lần lượt các mô hình 1a (Bảng 3), 1b (Bảng 4), 1c (Bảng 5) được đề xuất và mang lại kết quả đáng kể (Bảng 5).

No.	Template
1.	$w_i = X, t_i = T$
2.	$w_{i-1} = X, t_i = T$
3.	$w_{i+1} = X, t_i = T$
4.	$t_{i-1} = T_1, t_i = T$
5.	$t_{i-1} = T_1, t_{i-2} = T_2, t_i = T$

Bảng 2: Mô hình cơ sở ban đầu (sử dụng mô hình Markov)

No.	Template
1.	w_i chứa số, $t_i = T$
2.	w_i chứa ký tự viết hoa, $t_i = T$
3.	w_i chứa tất cả chữ viết hoa, $t_i = T$
4.	w_i chứa dấu gạch ngang, $t_i = T$

Bảng 3: Các chức năng được sử dụng cho các từ hiếm (Mô hình 1a)

No.	Template
1.	$\sigma(1, w_i) = X, t_i = T$
2.	$\sigma(m, w_i) = X, t_i = T$
3.	$\sigma(1, w_i) = X_1, \sigma(2, w_i) = X_2, t_i = T$
4.	$\sigma(m, w_i) = X_1, \sigma(m - 1, w_i) = X_2, t_i = T$
5.	Number of syllables of w_i

Bảng 4: Tính năng cho âm tiết của một từ. $\sigma(j, w_i)$ là một hàm trả về âm tiết thứ j của một từ có m-âm tiết (Mô hình 1b)

Model	Độ chính xác	Độ chính xác đối với từ không xác định.
Model 0	90.23%	47.08%
Model 1a	92.64%	68.92%
Model 1b	92.85%	73.23%
Model 1c	92.92%	76.92%

Bảng 5: Độ chính xác và độ chính xác đối với từ không xác định của 4 mô hình

Cuối cùng, Mô hình độ hỗn loạn cực đại [11] là nền tảng cốt lõi trong việc phân tích và xử lý gán nhãn từ loại. Đây là mô hình đơn giản để ước lượng xác suất của một lớp xuất hiện cùng

với một số ngữ cảnh khác nhau. Tư tưởng cơ bản của phương pháp này là tìm ra một mô hình có phân phối xác suất thoả mãn mọi điều kiện ràng buộc quan sát có được từ dữ liệu mà không cần thêm giả thuyết nào khác.

Định dạng dữ liệu đầu vào của VnTagger được cung cấp ở dạng thông thường và theo cấu trúc XML với các tệp văn bản có định dạng là .txt, .doc,.... Do đó, kết quả sau khi gán nhãn cũng được định dạng như vậy.

Độ chính xác theo được kiểm tra chéo 10 lần trên kho dữ liệu VietTreebank (với 10.165 câu đã qua xử lý) có độ cao nhất đo là 93.40% và đối với các từ không xác định là 80.69%.

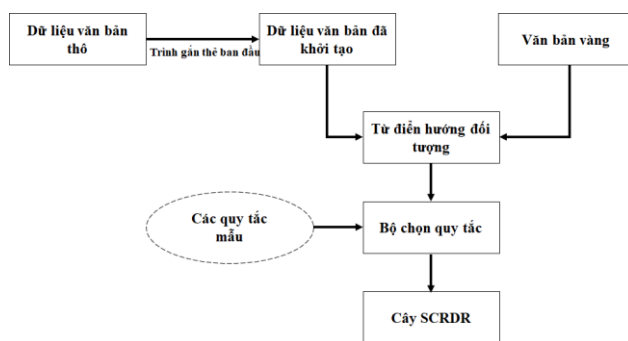
B. Phần mềm RDRPOSTagger

Phần mềm RDRPOSTagger [5] phần mềm gán nhãn từ loại với kho từ huấn luyện gồm khoảng 5000 từ huấn luyện. RDRPOSTagger xây dựng các quy tắc gắn thẻ dưới dạng cây nhị phân bằng phương pháp tiếp cận dựa trên lỗi.

Phương pháp được sử dụng trong RDRPOSTagger là phương pháp SCRDR[12] là một phương pháp tiếp cận dạng cây nhị phân với 2 loại cạnh khác nhau, liên kết với mỗi nút trong cây là một quy tắc, quy tắc này có dạng: nếu α thì β trong đó α được gọi là điều kiện và β được gọi là kết luận. Một nút mới bao gồm một quy tắc mới (tức là một quy tắc ngoại lệ mới) được thêm vào một cây SCRDR khi mà quá trình đánh giá trả về kết luận là sai. Nút mới được gắn vào nút cuối cùng trong đường dẫn của trường hợp đã cho cùng với liên kết ngoại trừ nếu nút được kích hoạt. Ngoài ra, nó được gắn với liên kết if-not. Luật của cây SCRDR được khởi tạo bằng cách xây dựng quy tắc mặt định và tất cả quy tắc ngoại lệ dưới dạng mẫu [if currentTag = "TAG" then tag = "TAG"] ở lớp thứ nhất của cấu trúc ngoại lệ.

Phần mềm RDRPOSTagger bao gồm 2 quá trình:

- SCRDR-learner sử dụng phương thức khai thác thất bại để tự động xây dựng cây SCRDR của quy tắc chuyển đổi (Hình 1).



Hình 1. Mô tả quá trình SCRDR-learner

- Trình gắn thẻ SCRDR thực hiện gắn thẻ trên một văn bản thô nguyên bản, trong đó mỗi dòng là một chuỗi các từ được phân cách bằng ký tự khoảng trắng. Thành phần ghi nhãn văn bản bằng cách sử dụng trình gắn thẻ ban đầu. Nó sẽ đi theo chiều từ trái sang phải để tạo ra một đối tượng tương ứng cho mỗi từ được gắn thẻ ban đầu. Đối tượng sau đó được phân loại theo mô hình cây SCRDR đã được huấn luyện trước đó để tạo ra kết luận cho loại thẻ tương ứng của từ.

Có 27 mẫu quy tắc được áp dụng cho bộ Chọn quy tắc để chọn các quy tắc phù hợp nhất để xây dựng cây SCRDR.

```
#12: if next1stTag == "object.next1stTag" then tag
      = "correctTag"
#14: if prev1stTag == "object.prev1stTag" then tag
      = "correctTag"
```

Hình 2: Ví dụ về các mẫu quy tắc trong cây SCRDR

Định dạng dữ liệu đầu vào của RDRPOSTagger và đầu ra tương tự như VnTagger. Tuy nhiên, RDRPOSTagger được xử lý tách toàn bộ các từ đơn và từ ghép. Tập đầu ra chri bao gồm các từ đơn lẻ đi sau là mã nhận diện loại từ tương ứng.

C. Phần mềm JvnTextPro

JvnTextPro [6] là công cụ gắn nhãn từ loại tiếng Việt được xây dựng như phần mềm VnTagger là dựa trên mô hình CRFs [13] và Mô hình độ hỗn loạn cực đại (MaxEnt) [14] với các mẫu ngữ cảnh cho việc lựa chọn đặc trưng được mô tả trong Bảng 6. JVNTextPro được huấn luyện với bộ dữ liệu huấn luyện gồm 10000 và 20000 câu từ kho dữ liệu văn bản VietTreeBank.

Loại	Ngữ cảnh	Giải thích
Mẫu ngữ cảnh cho cả Maxent và CRFs		
Mẫu ngữ cảnh cơ bản (loại 1)	w:-2; w:-1; w:0; w:1; w:2	w:i cho biết từ tại vị trí thứ i trong chuỗi đầu vào (nằm trong cửa sổ trượt với kích cỡ 5)
	w:0:1; w:1:2; w:-1:1	w:i:j kết hợp từ thứ i và từ thứ j trong chuỗi đầu vào
	is_all_capitalized, is_initial_capitalized, is_number, contain_numbers	Kiểm tra một số thuộc tính của từ hiện tại như: từ có phải là toàn chữ viết hoa hay có kí tự
Mẫu cho đặc trưng cạnh của CRFs		
$t_{-1} \ t_2$	Nhãn của từ trước đó và nhãn của từ hiện tại. Đặc trưng này được trích chọn trực tiếp từ dữ liệu bởi FlexCrfs	

Bảng 6: Mẫu ngữ cảnh trong việc lựa chọn đặc trưng của JvnTextpro

Định dạng đầu vào của phần mềm JvnTextPro cũng như 2 công cụ trước đó và cấu trúc đầu ra tương tự. Tuy nhiên, bảng mã nhận diện đối với dấu câu là Mrk khác với 2 phần mềm trước. JvnTextPro không tách nhỏ toàn bộ từ mà có thể nhận biết và xử lý được các từ đơn và từ ghép, việc này tránh mất nghĩa của từ cũng như sai lệch về cấu trúc từ đơn, từ ghép. Độ chính xác được báo cáo khi kiểm tra độ chính xác của phần mềm JvnTextPro là 90.40% đối với mô hình CRFs và 91.03% với mô hình MaxEnt là kết quả đo với thang đo F của JvnTextPro được báo cáo. Kết quả báo cáo tỉ lệ được thực hiện bằng cách xử dụng kỹ thuật kiểm tra chéo 5 lần trên kho dữ liệu tiếng Việt với hơn 10.000 câu đã qua xử lý.

D. Phần mềm VnCoreNLP

Phần mềm VnCoreNLP [7] là một phần mềm bao gồm phân đoạn từ, gán thẻ từ loại, NER và phân tích phụ thuộc.

Phần mềm VnCoreNLP sử dụng mô hình MarMoT MarMoT [15] và mô hình VnCoreNLP.

- Mô hình MarMoT là một trình gán thẻ hiện đại được phát triển bởi Thomas Müller. Nó được xây dựng dựa trên mô hình CRF và có cải tiến là the pruned CRF (PCRF) [16]. PCRF là mô hình dùng cho các thẻ rất lớn, dựa trên việc giả mã và đào tạo, sau đó là cập nhật. Đối với kích thước thẻ có kích thước vừa phải, mô hình sẽ tăng tốc đáng kể so với mô hình CRF tiêu chuẩn và độ chính xác không giảm đáng kể.

- VnMarMoT là một mô hình được đào tạo sẵn cho việc gán thẻ Part-of-Speech (POS) của Việt Nam dựa trên nền tảng cũng như các tính chất của mô hình gốc MarMoT.

Các thành phần trong phần mềm VnCoreNLP gồm:

- wseg (word segment): Đây là bước đầu tiên quan trọng trong xử lý ngôn ngữ. VnCoreNLP có một mô hình học tập dựa trên quy tắc chuyển đổi cho phân đoạn từ tiếng Việt, có được độ chính xác và tốc độ phân đoạn tốt hơn so với tất cả các phân đoạn từ trước đó.

- pos: Để gán nhãn các từ với thẻ POS nhận diện của chúng.
- ner: Để nhận ra các thực thể được đặt tên, VnCoreNLP áp dụng một mô hình cảm ứng tính năng động tự động để tối ưu hóa các kết hợp tính năng.
- parse: Để thực hiện phân tích cú pháp phụ thuộc, chúng tôi áp dụng phiên bản tham lam của mô hình phân tích dựa trên chuyển đổi với phân nhánh lựa chọn.

VnCoreNLP có khả năng xử lý từ ghép, từ đôi một cách khá tốt. Các từ đôi, từ ghép được xử lý trực tiếp thay vì tách nhỏ ra thành các từ đơn, nên độ chính xác được gia tăng kể cả khi gặp trường hợp từ không xác định.

Định dạng dữ liệu đầu vào của VnCoreNLP tương tự như các công cụ gán nhãn. Tuy nhiên, khác biệt nằm ở kết quả đầu ra của VnCoreNLP, với định dạng gồm 6 cột biểu thị các chỉ mục bao gồm từ, biểu mẫu từ, thẻ POS, nhãn NER, chỉ mục đầu của từ hiện tại và loại quan hệ phụ thuộc (Hình 3).

1	về	E	–	–	–
2	phía	N	–	–	–
3	kẻ	N	–	–	–
4	–	M	–	–	–
5	thù	N	–	–	–
6	của	E	–	–	–
7	dân	N	–	–	–
8	–	CH	–	–	–
9	tộc	N	–	–	–
10	ta	P	–	–	–
11	,	CH	–	–	–
12	nền	N	–	–	–
13	đô	N	–	–	–
14	–	M	–	–	–
15	hộ	N	–	–	–
16	của	E	–	–	–
17	phong	N	–	–	–
18	–	CH	–	–	–
19	kiến	N	–	–	–
20	Trung	Np	–	–	–

Hình 3. Định dạng dữ liệu đầu ra đối với VnCoreNLP

Công cụ gắn nhãn từ loại VnCoreNLP được báo cáo có độ chính xác cao nhất cho đến nay ở mức 95,88% với tốc độ gắn thẻ nhanh ở 25.000 từ mỗi giây.

III. Xây dựng tập dữ liệu

Dựa trên tập dữ liệu VietTreeBank của dự án VLSP [9], nghiên cứu xây dựng 4 bộ dữ liệu khác nhau, với các đặc điểm lần lượt là:

- Bộ dữ liệu 1: Gồm các câu văn bản đơn thuần, không bao gồm số, ký tự đặc biệt, ngày tháng năm. Được lọc ra và tổng hợp lại thành một tệp bao gồm 100 câu. Đánh giá mức độ khó về cấu trúc là dễ.

- Bộ dữ liệu 2: Gồm các câu văn bản bao gồm phần lớn là số, ký tự đặc biệt, từ chỉ thời gian và ngày tháng. Được trích lọc ra và tổng hợp lại thành một tệp bao gồm 500 câu. Đánh giá mức độ khó về cấu trúc, phức tạp trong khâu xử lý nhận diện ngày tháng, ký tự đặc biệt, ký tự nối chữ. Ví dụ : 123, 235, ; /.'"; 01/01/2000

- Bộ dữ liệu 3: Gồm các câu văn bản được lấy ngẫu nhiên trong kho dữ liệu Vietnamese Treebank bao gồm từ, ký tự đặc biệt, số và từ đôi, từ ghép.. Được trích lọc ra và tổng hợp thành tệp bao gồm 2000 câu. Đánh giá mức độ khó về cấu trúc là ngẫu nhiên.

- Bộ dữ liệu 4: Gồm các câu văn bản được lấy ngẫu nhiên trong kho dữ liệu Vietnamese Treebank bao gồm từ, ký tự đặc biệt, số và từ đôi, từ ghép.. Được trích lọc và tổng hợp thành tệp bao gồm 4000 câu. Đánh giá mức độ khó về cấu trúc là ngẫu nhiên, xử lý dữ liệu lớn.

IV. Kết quả

Nghiên cứu thực hiện kiểm tra, đánh giá độ chính xác và thời gian thực hiện gán nhãn từ loại trên các phần mềm được nghiên cứu. Tuy nhiên, do RDRPOSTagger sẽ gán mã CH cho các ký tự đặc biệt nên xử lý chuyển đổi thay thế mã CH thành mã ký tự tương ứng. Sau khi xử lý tệp dữ liệu đầu ra sau xử lý, để có được kết quả so sánh, dùng phương thức kiểm tra bằng cách kiểm tra đối chiếu tệp đầu ra của từng công cụ với tệp kết quả, xét mức độ chính xác bằng cách tính phần trăm tỷ lệ tương thích với tệp kết quả. Đối với mỗi từ được gán nhãn và tương thích với xử lý trong tệp kết quả thì được coi là một xử lý đúng. Đối với mỗi từ khác kết quả so với tệp kết quả thì coi là một xử lý, đồng thời đối với các công cụ phân tách từ đôi, từ ghép ra thành các từ đơn lẻ thì cũng coi là một xử lý sai.

Kết quả thực nghiệm được thể hiện trong bảng:

Công cụ	Độ chính xác (%)	Thời gian xử lý (giây)
Bộ dữ liệu 1 (100 câu)		
JVnTextPro	97,78%	5,30
VnCoreNLP	84,90%	10,720
RDRPOSTagger	96,02%	1,340
vnTagger	86,73%	7,37
Bộ dữ liệu 2 (500 câu)		
JVnTextPro	80,08%	6,440
VnCoreNLP	84,46%	16,231
RDRPOSTagger	88,41%	2,775
vnTagger	77,92%	21,620

Bộ dữ liệu 3 (2.000 câu)		
JVnTextPro	94,66%	24,121
VnCoreNLP	78,01%	35,216
RDRPOSTagger	96,84%	9,570
vnTagger	77,06%	67,023
Bộ dữ liệu 4 (4.000 câu)		
JVnTextPro	97,84%	60,210
VnCoreNLP	82,73%	52,135
RDRPOSTagger	95,98%	28,560
vnTagger	86,15%	84,660

Đối với công cụ VnCoreNLP và vnTagger có độ chính xác thấp khi sử dụng các bộ test có các từ ghép, từ đôi vì tính chất của 2 công cụ này sẽ tách nhỏ các từ ra để gắn nhãn thay vì gắn nhãn trực tiếp từ ghép, từ đôi tương ứng nên khi so về độ chính xác với văn bản gốc, các từ đơn, từ ghép sẽ bị chia nhỏ thành các từ đơn tương ứng với các mã nhận diện có thể khác nhau nên gây ra sai lệch về bản chất cũng như về ngữ nghĩa của từ. Công cụ JvnTextPro và RDRPOSTagger có độ chính xác luôn ở mức ổn định vì 2 công cụ này có khả năng xử lý từ khá ổn định đặc biệt về phần xử lý từ đôi, từ ghép. Khi có từ đôi, từ ghép 2 công cụ nêu trên sẽ trực tiếp gắn nhãn cho các từ đó thay vì sẽ tách nhỏ ra làm mất đi ngữ nghĩa cũng như bản chất của từ đó nên độ chính xác được tăng khá đáng kể so với 2 công cụ là VnCoreNLP và vnTagger.

Nguyên nhân việc kiểm thử có độ sai lệch về độ chính xác đến từ một số nguyên nhân sau:

- Đối với bộ dữ liệu 1: Bộ kiểm thử bao gồm văn bản đơn thuần không bao gồm số, ký tự đặc biệt, ký tự nổi các công cụ hoạt động tốt. JvnTextPro và RDRPOSTagger xử lý kết quả với tỷ lệ cao.
- Đối với bộ dữ liệu 2: Bộ kiểm thử bao gồm văn bản bao gồm phần lớn là số, ký tự đặc biệt, ký tự nổi, định dạng ngày tháng các công cụ xử lý với tỷ lệ kém hơn. Lý giải nguyên nhân này, sau khi đọc và kiểm tra tệp đầu ra. Đánh giá chung các công cụ thực hiện xử lý không tốt đối với các định dạng ngày tháng, ngày tháng được các công cụ tách riêng biệt thành các phần VD: 20/10/2018 thành 20/M /// 10/M 2018/M riêng biệt. Tuy nhiên RDRPOSTagger vẫn có tính ổn định nhất trong việc xử lý ngày tháng, số, ký tự đặc biệt, ký tự nổi.
- Đối với bộ dữ liệu 3: Trong việc xử lý một dữ liệu văn bản ngẫu nhiên, các công cụ xử lý tốt, tuy nhiên độ chính xác và ổn định vẫn thuộc về JvnTextPro và RDRPOSTagger. Tuy nhiên do lý giải ở phần trên, trong việc xử lý từ đôi, từ ghép, tên riêng, tên địa danh không tốt nên công cụ VnTextPro và VnCoreNLP có tỷ lệ chính xác thấp còn đối với JvnTextPro và RDRPOSTagger có khả năng xử lý từ đôi, từ ghép, tên riêng, tên địa danh tốt

nên tỉ lệ chính xác ở mức cao.

- Đối với bộ dữ liệu 4: Dữ liệu kiểm thử lớn hơn công cụ JvnTextPro và RDRPOSTagger vẫn giữ tỷ lệ xử lý tốt.

V. Kết luận

Sau khi thực hiện các công việc và xử lý, so sánh các số liệu. Kết luận công cụ thực hiện việc gắn nhãn từ loại tiếng Việt với tỉ lệ chính xác cao nhất là RDRPOSTagger và JvnTextPro thông qua các bài kiểm tra về độ chính xác

Đối với công cụ có hiệu suất xử lý chính xác cao và tốc độ xử lý nhanh, ta kết luận công cụ RDRPOSTagger có tốc độ và độ chính xác cao nhất trong các công cụ ta nghiên cứu.

Tài liệu tham khảo

- [14] FSI's Experience with Language Learning:
https://www.state.gov/m/fsi/sls/c/78549.htm?fbclid=IwAR1BGAG4fHmB-r_HjBQugQb0OxMUaDZ8lUKJJhv8wfxYCbvtGh8_aUy5OI, accessed 30/10/2018
- [15] Aravind K. Joshi, "Natural Language Processing", *Science* 13, Vol. 253, Issue 5025, 1991, pp. 1242-1249, DOI: 10.1126/science.253.5025.1242.
- [16] Diệp Quang Ban, Ngữ pháp tiếng Việt, Nhà xuất bản Giáo dục Việt Nam, Hà Nội, 2009, số trang 391.
- [17] Le-Hong, P., T M H. Nguyen, M. Rossignol, and A. Roussanaly, "An empirical study of maximum entropy approach for part-of-speech tagging of Vietnamese texts", *Actes du Traitement Automatique des Langues Naturelles (TALN-2010)*, Montreal, Canada, 2010.
- [18] Dat Quoc Nguyen, Dai Quoc Nguyen, Dang Duc Pham and Son Bao Pham. RDRPOSTagger: A Ripple Down Rules-based Part-Of-Speech Tagger. In *Proceedings of the Demonstrations at the 14th Conference of the European Chapter of the Association for Computational Linguistics*, pp. 17-20, 2014.
- [19] Cam-Tu Nguyen, Xuan-Hieu Phan and Thu-Trang Nguyen, "JVnTextPro: A Java-based Vietnamese Text Processing Tool", <http://jvntextpro.sourceforge.net/>, 2010.
- [20] Thanh Vu, Dat Quoc Nguyen, Dai Quoc Nguyen, Mark Dras and Mark Johnson, (2018). VnCoreNLP: A Vietnamese Natural Language Processing Toolkit, 56-60. 10.18653/v1/N18-5012.
- [21] Nguyen Tuan Phong, Truong Quoc Tuan, Nguyen Xuan Nam, Le Anh Cuong, An Experimental Investigation of Part-Of-Speech Taggers for Vietnamese, *VNU Journal of Science: Comp. Science & Com. Eng.*, Vol. 32, No. 3 (2016), p.11–25.
- [22] Hồ Tú Bảo, Về xử lý tiếng Việt trong công nghệ thông tin, Viện Khoa học và Công nghệ Tiên tiến Nhật Bản. VLSP - KC01/06-10, 2012.
- [23] NGUYEN P. T., XUAN L. V., NGUYEN T. M. H., NGUYEN V. H. & LE-HONG P. (2009). Building a large syntactically-annotated corpus of Vietnamese. *Proceedings of the Third Linguistic Annotation Workshop, ACL-IJCNLP 2009*, Singapore, pages 182–185.

- [24] Kamal Nigam, John Lafferty, Andrew Mccallum, Using Maximum Entropy for Text Classification, In IJCAI-99 Workshop on Machine Learning for Information Filtering (1999), pp. 61-67.
- [25] Debbie Richards. 2009. Two decades of ripple downrules research. Knowledge Engineering Review,24(2):159–184.
- [26] John Lafferty and Andrew McCallum and Fernando Pereira, Conditional Random Fields: Probabilistic Models for Segmenting and Labeling Sequence Data, "Proceedings of the International Conference on Machine Learning (ICML-2001)",2001, Pages 282-289.
- [27] Kamal Nigam, John Lafferty, Andrew Mccallum. In IJCAI-99 Workshop on Machine Learning for Information Filtering (1999), pp. 61-67.
- [28] Kamal Nigam, John Lafferty, Andrew Mccallum. In IJCAI-99 Workshop on Machine Learning for Information Filtering (1999), pp. 61-67.
- [29] Thomas Mueller, Helmut Schmid, and Hinrich Schutze. 2013. Efficient Higher-Order CRFs for " Morphological Tagging. In Proceedings of EMNLP. pages 322–332.

Social Sciences Papers

Rượu trong văn hóa tiếp khách

So sánh giữa Nhật Bản và Việt Nam

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Tóm tắt

Trong quá trình đi làm, chúng tôi nhận thấy rằng rượu là thức uống được sử dụng thường xuyên trong khi tiếp khách. Trong bài báo này, chúng tôi sẽ đưa ra những điểm giống và khác nhau về việc sử dụng rượu trong khi tiếp khách ở hai nước Việt Nam và Nhật Bản.

Từ khóa

Rượu Nhật Bản, rượu Việt Nam, văn hóa tiếp khách.

1. Giới thiệu

- Về rượu và văn hóa rượu:

Rượu là gì? Rượu chính là một loại đồ uống được chế biến bằng cách cho một số loại hoa quả hoặc ngũ cốc lên men, do đó rượu là một chất có tác dụng kích thích mạnh mẽ đến tinh thần, tình cảm con người. Uống rượu là một nét đẹp văn hóa của người Việt đã có từ xa xưa. Người ta nói miếng trầu là đầu câu chuyện, càng đối với những “đệ tử Lưu Linh” thì chén rượu là khởi đầu của mỗi cuộc vui. Nguyễn Trãi cũng có câu thơ rất hay về những thú vui tao nhã của các nhà Nho xưa:

“Đua chi chén rượu câu thơ

Thuốc lành ngon nhạt, nước cờ thấp cao”

(Nguyễn Trãi, Gia Huân ca)

Từ xưa đến nay, rượu vốn là một trong những thức uống phổ biến và được yêu thích của con người. Rượu - thức uống không chỉ xuất hiện trên các bàn tiệc, bàn nhậu mà còn xuất hiện trong những hộp quà cao cấp, hay thậm chí trở thành một món đồ trang trí trong gia đình. Việc sử dụng rượu trong đời sống thường nhật đã trở thành một thói quen không thể thiếu trong các nền văn hóa các quốc gia trên thế giới. Mỗi một quốc gia trên thế giới này đều có ít nhất một loại rượu đặc trưng cho đất nước mình, ví dụ như Trung Quốc có bạch tửu, ở Hàn có Soju, Ý có rượu wine... Mức độ phổ biến của việc sử dụng rượu cũng được thể hiện thông qua bản khảo sát 100 người mà chúng tôi đã thực hiện về việc sử dụng rượu trong công việc với hơn 90% người đã từng sử dụng rượu nếp Việt và khoảng 71% người đã từng sử dụng rượu sake.

- Lí do nghiên cứu:

Trong quá trình đi làm tại công ty, doanh nghiệp, chúng tôi nhận thấy rằng sử dụng rượu là một phần không thể thiếu không chỉ ở các bàn nhậu mà còn ở những buổi đi đón tiếp khách hàng, đi gặp đối tác. Bản thân là một người học ngành ngôn ngữ Nhật và có tìm hiểu về văn

hóa Nhật Bản, chúng tôi nhận thấy có sự tồn tại những nét tương đồng giữa văn hóa Việt Nam và Nhật Bản. Chính vì vậy, chúng tôi quyết định đi sâu vào tìm hiểu về văn hóa sử dụng rượu trong công việc của cả hai đất nước để từ đó dẫn ra những nét chung và riêng của rượu sake Nhật Bản và rượu nếp Việt Nam.

- Phạm vi nghiên cứu:

Theo kết quả điều tra về việc uống rượu của Central Rearch Services Inc [1]: Cứ ba người Nhật thì lại có một người uống rượu Sake. Đối với người Nhật, Sake là loại rượu phù hợp với những dịp truyền thống và dành cho những người thật sự yêu cũng như sành sỏi về rượu. Sake không chỉ dành cho đàn ông mà ngay cả phụ nữ cũng có thể uống được: số phần trăm phụ nữ Nhật uống rượu lên đến 72,9%, trong đó có cả người uống để thưởng thức hay để thay đổi tâm trạng. Khi so sánh với tầng lớp trung - cao tuổi, thanh niên Nhật có xu hướng ra ngoài uống nhiều hơn với tần suất 5.5 lần/ tháng. Trước đây, nhiều người cho rằng sake chỉ dùng để uống trước khi ăn nhưng bây giờ số người dùng sake trong bữa ăn đang tăng lên rất nhanh: từ 21,1 % lên 68,5%.

Từ đó ta có thể thấy, rượu Sake là một trong những nét đặc trưng không thể thiếu trong văn hóa ẩm thực của người Nhật. Trên thực tế, chúng ta có thể thấy nó len lỏi khắp mọi ngóc ngách Nhật Bản từ bàn ăn của các bà nội trợ cho đến các luận văn của các nhà nghiên cứu. Tuy nhiên, trong luận văn này, chúng tôi không thể đề cập hết được toàn bộ những kiến thức về rượu, vì vậy chúng tôi xin tập trung đi sâu nghiên cứu về rượu trong văn hóa tiếp khách.

Nhân tiện, nói về việc sử dụng rượu Sake của nhóm đối tượng cụ thể – những người đã bắt đầu đi làm (trên 22 tuổi), chúng tôi cũng muốn nghiên cứu thêm và đưa ra so sánh sự giống và khác nhau về nhiều mặt của hai loại quốc túy: Sake của Nhật Bản và rượu Nếp của Việt Nam.

- Các nghiên cứu trước:

Nghiên cứu của anh Sintaro Nagatomi - Giám đốc điều hành Công ty Cổ phần Insideout tại Nagoya, Nhật Bản website tham chiếu <https://www.ichinenfudou.com/>

+ Quy trình sản xuất rượu Sake trong nhà máy

+ Lịch sử ra đời, ý nghĩa, sự khác biệt giữa các loại rượu Sake

+ Cách thưởng thức rượu Sake

- Phương pháp nghiên cứu:

Từ các tài liệu được đưa lên trong nghiên cứu trước, chúng tôi đưa ra tóm tắt vấn đề về rượu. Và chúng tôi đã nghiên cứu cách sử dụng rượu trong văn hóa tiếp khách. Ngoài ra, chúng tôi thu thập nguồn từ các tài liệu khác cùng với bản khảo sát và những chuyến đi thực tế, từ đó đưa ra được một vài kết luận về sự giống và khác nhau trong cách sử dụng rượu của người Việt Nam và Nhật Bản trong công việc.

2. Phân tích

Chương 1. Tổng quan về rượu

1. Tổng quan về rượu Việt Nam

1.1. Lịch sử phát triển rượu Việt Nam

Việt Nam nằm trong khu vực Đông Nam Á, khí hậu nhiệt đới gió mùa nóng, ẩm tạo mưa nhiều, địa hình có nhiều sông ngòi dày đặc là điều kiện thích hợp phát triển nghề nông nghiệp trồng lúa nước, người Việt đã biết thuần dưỡng cây lúa nước cách đây 3000 đến 4000 năm nên rượu Việt truyền thống gần như đều được làm ra từ ngũ cốc: lúa, ngô, sắn. Trong thực tế có nhiều loại rượu khác nhau như rượu mùi được ướp hương thơm của hoa sen, hoa chanh... hay rượu thuốc là loại rượu được ngâm trong các loài thảo dược hoặc động vật nhưng quan trọng nhất vẫn là rượu trắng hay còn gọi là rượu đế được chưng cất từ gạo hoặc nếp. Dù gia đình có giàu nghèo như thế nào đi chăng nữa thì ngày giỗ ông bà vẫn nhất thiết phải có rượu trắng.

Trước khi người Pháp đến Việt Nam trong cuộc xâm lăng và đô hộ các thuộc địa, ngành sản xuất rượu thủ công Việt Nam đã có lịch sử rất lâu đời vì người Việt nói chung rất phổ biến tập quán uống rượu, đặc biệt trong các ngày lễ tết vốn vô từ bắt thành lễ.

Năm 1858, khi những người Pháp đầu tiên đến Việt Nam, vẫn chưa có sản xuất rượu ở quy mô công nghiệp. Chính phủ bảo hộ khuyến khích người Việt nấu rượu, uống rượu để thu thuế, cấp đăng kí sản xuất rượu, tuy nhiên vẫn không có các biện pháp thu thuế triệt để. Hiện tượng trốn thuế, khai man thuế tràn lan không thể kiểm soát được. Kể từ khi sản xuất rượu công nghiệp ra đời, chính quyền bảo hộ ra sắc lệnh cấm dân tự nấu rượu, ngừng cấp giấy phép đăng kí kinh doanh nấu rượu cho các hộ gia đình đã từng sản xuất kinh doanh bằng nghề nấu rượu, chỉ duy trì một số làng nghề tập trung để dễ thu thuế. Việc cấm dân nấu rượu ngày càng được kiểm soát chặt chẽ đi đôi với đẩy mạnh sản xuất rượu công nghiệp, một số tổ chức thanh tra riêng do người Pháp trực tiếp chỉ huy đã được thành lập chuyên đi bắt phạt những hộ gia đình nấu rượu không phép, những đối tượng mà dân Việt thường gọi là “Tây đoan” hay “Tàu cáo” (một dạng thanh tra thuế).

Một mặt chính phủ bảo hộ đưa ra chính sách ngăn cấm các làng nghề, ngăn cản người dân tự nấu rượu, mặt khác lại bắt người dân phải tiêu thụ theo định mức các loại rượu do nhà máy rượu của Chính Quốc hăng độc quyền sản xuất kinh doanh trên toàn cõi Đông Dương loại rượu tương đối nhạt được nấu bằng gạo và ngô. Chính phủ bảo hộ tính số người cho mỗi tỉnh, mỗi làng mà chia rượu giao cho quan lại đưa dân nhận lãnh rượu. Đồng thời giao kế hoạch tiêu thụ rượu đến các cấp chính quyền huyện, tổng, xã, đề ra các biện pháp cụ thể như ma chay, cưới xin, lễ hội đình đám bắt buộc phải mua rượu đủ theo quy định.

Tuy vậy, rượu Ty vẫn không đủ đáp ứng nhu cầu của người dân và cũng vì muốn dùng thứ rượu dân tộc có nồng độ cao, cay và thơm hơn, khắp nơi người ta vẫn lén lút nấu rượu bằng gạo nếp rồi đem nấu trong những lùm tranh, lùm đề ở xa nhà, hoặc khi thấy Tây đoan, Tàu cáo đến bắt, nghe động thì bê tất cả nồi rượu, bình rượu chạy vội nấu dưới đồng cỏ hoang dại mọc toàn cây đề, một loài cây giống cỏ năn, cỏ lác, cỏ tranh, hay lau sậy mọc cao vút đầu. Tên gọi rượu đế trong Nam xuất xứ từ đó. Loại rượu này cũng còn được gọi là rượu lậu do quy trình nấu rượu và tiêu thụ rượu hầu hết đều là lậu. Rượu lậu được chuyên chở bằng mọi cách, thậm chí bằng cả áo quan, hay bằng bất cứ phương tiện nào có thể tránh con mắt soi mói dò xét của những vị chức sắc truy thu thuế và tình trạng buôn rượu lậu, nấu rượu lậu, tiêu thụ rượu lậu trở nên phổ biến.

Cũng vì “rượu ta nấu nó cho rượu lậu, muối ta làm nó bảo muối gian” (trích lời Phan Bội Châu), nên tại miền Bắc Việt Nam người dân đã tự đặt tên cho loại rượu mình nấu là rượu ngang vì rượu nấu và tiêu thụ theo kiểu đi ngang về tắt; rượu cuốc lủi vì vừa bán vừa lủi như con chim cuốc; hoặc để so sánh với rượu “quốc gia” khi các cụ nhà nho xưa nhại tiếng ngoại

bang gọi rượu quê của người Việt là rượu quốc hồn quốc túy. Tiếng là quốc hồn quốc túy mà phải nấu chui nấu lủi, uống chui uống lủi thì gọi là rượu quốc lủi.

1.2 Cách nấu rượu trắng Việt Nam:

1.2.1 Sơ lược về nguyên liệu chính:

Nguyên liệu để làm rượu trắng rất đơn giản. Gồm nguyên liệu chính là các loại ngũ cốc có hàm lượng tinh bột cao, thông dụng như: gạo tẻ, gạo nếp, gạo lứt, gạo nương lúa mạch... Ở một số vùng miền lại có những nguyên liệu đặc trưng như mầm thóc, ngô, hạt mít, hạt dẻ... nhưng nói chung các loại gạo nếp cho thành phẩm rượu được ưa chuộng nhất ở khắp các vùng miền do gạo rất thơm và rượu có độ ngọt nhất định. Các loại gạo nếp như nếp cái hoa vàng, nếp bông chat, nếp ruồi, nếp mỡ, nếp thơm, nếp ngự... được sử dụng nấu rượu cho thấy sự đa dạng và đôi khi cũng là sự kén chọn hết sức cầu kỳ của các nghệ nhân làm rượu. Rượu nấu bằng các loại gạo tẻ thường mang tính phổ thông, vùng miền nào cũng có thể sản xuất và tiêu thụ được, tuy có một số loại gạo tẻ ngon được lựa chọn nấu rượu như gạo cứt, gạo co, gạo trì, gạo ba trắng, gạo tứ quý, gạo bắng thơm... vẫn cho những chén rượu quý ngọt ngào hương vị.

Ngoài ra nguyên liệu để nấu rượu còn có men rượu. Men rượu được chế biến từ nhiều loại thảo dược (thuốc Bắc, thuốc Nam) như cam thảo, quế chi, gừng, hồi, bạch chỉ, v.v,... theo những bí quyết, công thức riêng của từng gia đình. Những công thức này cùng với kỹ thuật ủ nhiều khi không truyền cho người ngoài nhằm giữ bí quyết rượu của nghệ nhân độc nhất vô nhị. Sau đó người ta nhào trộn hỗn hợp với bột gạo và ủ cho bột hơi nở ra sau đó vo, nắm từng viên quả nhỏ để lên khay trấu cho khỏi dính. Cuối cùng là đem mang phơi thật khô và cất dùng dần.

1.2.2. Quy trình sản xuất rượu trắng

Như đã nói ở phần trước thì rượu Việt Nam có rất nhiều loại với các phương pháp có sự khác biệt rõ ràng. Đi từ các nguồn nguyên liệu khác nhau sẽ cho ra các sản phẩm khác nhau. Do đó, trong phần này, chúng tôi chỉ xin trình bày những phương pháp sản xuất rượu truyền thống từ gạo nếp và gạo tẻ.

- Quy trình:

Chuẩn bị nguyên liệu (gạo, nước...) => Nấu chín => Ủ nguội => Trộn men => Lên men => Chưng cất => Rượu

- Bước 1: Nấu chín

Gạo được ngâm nhằm rửa sạch chất bẩn bám bên ngoài hạt, đồng thời làm cho hạt gạo mềm, trương nở giúp dễ dàng cho quá trình nấu. Sau khi để ráo, gạo được cho vào nồi, thêm nước và nấu chín. Lượng nước cho vào được tính toán sao cho cơm sau khi nấu không quá nhão cũng không bị sống. Tỷ lệ gạo nước khoảng 1:1 tùy theo thể tích. Mục đích của việc làm chín hạt gạo nhằm hồ hóa tinh bột gạo, giúp cho vi sinh vật dễ sử dụng tinh bột này để lên men rượu.

- Bước 2: Làm nguội + Trộn men

Cơm sau khi nấu chín được trải đều trên một bề mặt phẳng để làm nguội xuống nhiệt độ thích hợp cho việc trộn bánh men rượu. Nhiệt độ cơm cao sẽ làm bánh men rất khó hoạt động. Bánh men rượu được trộn vào bằng cách bóp nhỏ, rắc đều lên bề mặt lớp cơm theo tỷ lệ

thích hợp tùy theo hướng dẫn trên từng loại men. Sau đó cho tất cả vào khạp lớn, đậy nắp để bắt đầu quá trình lên men rượu.

- Bước 3: Lên men

Lên men rượu là một quá trình lên men yếm khí (không có mặt của oxy), diễn ra rất phức tạp, bao gồm các quá trình sinh hóa học và các quá trình vi sinh vật. Quá trình lên men diễn ra ở nhiệt độ thường, trong thời gian này có ba quá trình diễn ra song song nhưng với mức độ khác nhau. Trước tiên là quá trình tăng sinh khối nấm men. Quá trình đường hóa có sự phân cắt tinh bột thành đường nhờ men amylase và glucoamylase trong nấm mốc. Đường vừa tạo ra trở thành thức ăn để nấm men thực hiện quá trình lên men rượu. Quá trình lên men rượu diễn ra nấm men sử dụng đường để tạo thành rượu etylic và CO₂. CO₂ sinh ra trong quá trình lên men sẽ tạo thành bọt khí bám vào bề mặt nấm men và làm các tế bào nấm men nổi lên trên, khi lên đến bề mặt, bọt khí vỡ ra và tế bào nấm men lại chìm xuống tạo ra sự đảo trộn giúp quá trình lên men được tốt hơn. Sau hai ngày đầu lên men, có thể bổ sung nước vào khối lên men với tỉ lệ nước: cơm khoảng 3:1, sau đó đậy nắp và tiếp tục lên men trong khoảng ba ngày nữa.

- Bước cuối cùng: Chưng cất

Quá trình chưng cất rượu nhằm tách rượu và nước do chúng có nhiệt độ sôi khác nhau. Ở áp suất thường, rượu sôi và bốc hơi ở 78 độ C, còn nước là 100 độ C. Khi chưng cất, rượu được tách ra khỏi nước nhờ bay hơi dễ hơn nước. Quá trình chưng cất được tiến hành bằng cách đun sôi hỗn hợp lên men, hơi bay lên được dẫn qua ống dẫn và được làm lạnh bằng cách cho qua bồn nước để ngưng tụ rượu. Dung dịch rượu thu được trong suốt, có mùi thơm đặc trưng và nồng độ rượu sẽ giảm dần theo thời gian chưng cất. Tùy theo yêu cầu của khách hàng mà ta có thể tiến hành pha trộn các loại rượu thu được ở các khoảng thời gian chưng cất khác nhau để tạo ra rượu có nồng độ cao thấp khác nhau. [2]

1.3. Cách thưởng thức rượu

Rượu để được đánh giá là ngon nhất khi có độ tinh khiết cao, trong vắt, sủi tăm, uống có mùi vị thơm, ngọt, cay, có độ cồn tương đối cao (từ 39 đến hơn 45 độ) nhưng êm dịu và không gây đau đầu.

Theo truyền thống dân gian ngày xưa rượu có thể được cho vào chai nút lá chuối hoặc cho vào quả bầu nậm. Một số nơi câu kỳ sau khi chưng cất xong còn đem rượu hạ thổ (chôn xuống đất) một thời gian để làm cho rượu "chín", uống vào có độ êm và thơm dịu.

Ngoài ra, có thể uống lạnh bằng cách cho thêm đá viên, làm giảm vị cay, vị nóng, vị tê của rượu.

Rượu để thường được sử dụng rộng rãi nhất là uống trực tiếp, dùng ngâm các loại rượu thuốc và ngoài ra có thể làm gia vị cho một số thực phẩm cần chút rượu để ướp, tẩy.

2. Tổng quan về rượu sake Nhật Bản

2.1. Lịch sử phát triển rượu sake

Có thể nói nguồn gốc của Rượu Sake không được rõ ràng. Tài liệu sớm nhất đề cập đến việc ở Nhật Bản có rượu là “Đông Di Truyện” của Trung Quốc viết vào thời Tam quốc. Trong tài liệu này kể rằng người Nhật ham rượu, có phong tục uống rượu rồi nhảy múa ca hát. Tuy nhiên, cụ thể rượu này làm từ nguyên liệu gì thì không thấy nói tới. Phương pháp nấu rượu

cũng không nói rõ. Sake được nhắc tới vài lần trong tác phẩm “Kojike”, cuốn sách sử đầu tiên của Nhật, biên soạn năm 712 sau công nguyên.

Rượu đầu tiên được đề cập trong tài liệu của Nhật Bản là Kuchikami no sake và Kabi no sake. "Ghi chép về Phong thổ xứ Oosumi" (năm 713 hoặc muộn hơn) nhắc tới việc dân làng có phong tục dùng gạo và nước ủ hơn một đêm cho đến khi thấy có mùi rượu thì đem ra uống. Dân làng gọi thứ đó là Kuchikami no sake. Phương pháp này thường được sử dụng bởi người thổ dân châu Mỹ và được ghi nhận vào thế kỉ XIV TCN chưa kể đến rượu làm từ hạt kê của người Trung Quốc cũng được làm ra từ phương pháp tương tự.

Trải qua các thời kì với nhiều loại rượu được tạo ra, vào thời kì Asuka, Sake đã được tạo ra từ gạo, nước và mốc Koji, và trở thành loại rượu nổi trội trong xã hội Nhật. Trong một thời gian dài việc sản xuất Sake chịu sự quản lý độc quyền của chính quyền, nhưng đến thế kỉ thứ X, các đền thờ Shinto và chùa bắt đầu sản xuất rượu, và họ trở thành nơi sản xuất rượu chính trong 500 năm tiếp theo. Theo “Nhật kí Tamon”, được viết bởi những người đứng đầu đền Tamon từ năm 1478 đến năm 1618, trong đó ghi chép rất nhiều bước của quá trình chế rượu trong đền. Nhật kí mô tả rằng quá trình tiệt trùng và quy trình thêm các chất phụ gia vào trong quá trình lên men chính trong ba bước. Nó đã được chứng minh sự đúng đắn của nó trong ngày nay.

Trong thời kì phục hồi chế độ Meiji, luật đã quy định rằng cho phép bất kì cá nhân nào có tiền và biết sản xuất có thể xây dựng nhà xưởng và kinh doanh rượu Sake. Khoảng 30000 cơ sở sản xuất rượu được dựng lên trên cả nước Nhật trong vòng một năm. Mặc dù thế, như những năm trước đó, chính quyền định thuế rất nặng cho ngành sản xuất rượu sake và làm giảm đi số lượng các cơ sở sản xuất còn 8000 cơ sở. Phần lớn các nhà sản xuất Sake phát triển và tồn tại trong thời kì này đều trở thành địa chủ giàu có. Họ phát triển trồng trọt chủ yếu là lúa vào các mùa vụ để có thể tạo ra gạo có chất lượng cao hơn và cuối mùa họ thu hoạch lúa rồi chuyển đến các cơ sở sản xuất. Thành công nhất của các gia đình sản xuất này là vẫn hoạt động cho tới ngày nay.

Trong thế kỉ XX, kĩ thuật sản xuất Sake Nhật Bản có những bước tiến nhảy vọt. Năm 1904, chính quyền Nhật đã mở viện nguyên cứu các phương pháp sản xuất Sake, trong năm 1907 rất nhiều cuộc thi về Sake được tổ chức. Vi khuẩn lên men Bacteria thực sự đã được chọn lựa cho quá trình lên men và các tank bằng thép tráng men được chuyển đến. Chính phủ đã bắt đầu kêu gọi sử dụng tank lên men vì chúng dễ làm sạch, độ bền lâu dài, và không ảnh hưởng tới vi khuẩn lên men; các thùng chứa làm bằng gỗ không vệ sinh bởi vì tiềm tàng vi khuẩn sống trong gỗ, đồng thời một số lượng Sake bị bay hơi đi (bình thường chỉ khoảng 3%). Đây chính là sự kết thúc thời kì thùng gỗ đựng Sake và việc sử dụng thùng gỗ trong các nhà máy đã bị loại bỏ.

Trong chiến tranh Nga-Nhật 1904-1905, chính phủ đã cấm các gia đình sản xuất Sake. Đó cũng chính là sự kết thúc của việc sản xuất Sake theo quy mô gia đình, và tàn dư của luật này vẫn còn tác động cho đến tận ngày nay, khiến cho việc bán rượu hiện nay chỉ chiếm 2% thu nhập thuế của chính phủ.

Chiến tranh thế giới thứ II xảy ra, chính phủ kiểm soát gạo cho việc chế rượu đã dẫn đến việc thiếu gạo khiến cho ngành công nghệ sản xuất Sake đã bị giáng một cú nặng nề. Khoảng thế kỉ XVII, người ta đã phát hiện ra rằng có thể thêm một lượng nhỏ cồn vào rượu Sake trước khi chiết tách; điều này dẫn đến việc trong chiến tranh, người ta bắt đầu thêm một lượng nhỏ cồn nguyên chất & đường gluco và tăng dần lên sau đó. 75% rượu Sake của ngày nay được

sản xuất bằng kỹ thuật này – có thể coi đây là sự ảnh hưởng còn sót lại từ chiến tranh. Cũng có một vài nhà máy sản xuất Sake mà không dùng gạo do vậy mặt bằng chung chất lượng của Sake trong thời gian này đã giảm đi tương đối nhiều. Hậu chiến tranh, các nhà máy rượu bắt đầu phục hồi và chất lượng của Sake dần dần đi lên. Mặc dù vậy, những đồ uống mới khác như bia, rượu cũng đã dần dần trở nên phổ biến ở Nhật. Điều đó dẫn đến việc lượng Sake tiêu thụ tiếp tục giảm xuống, trong khi với chất lượng Sake ngày càng được nâng lên.

Ngày nay, Rượu Sake đã trở thành một loại đồ uống phổ biến trên thế giới với rất nhiều nhà máy sản xuất đặt ở Trung Quốc, Nam Á, Nam Mỹ, Bắc Mỹ và Úc. [3]

2.2. Cách nấu rượu Nhật Bản

Rượu sake được sản xuất và lên men trong một quá trình hết sức nghiêm ngặt, từ khâu chọn lựa giống gạo đến khâu ủ rượu cũng phải mất từ 6 đến 12 tuần. Ngoài ra nguyên liệu làm rượu sake được chọn lựa kỹ lưỡng để đảm bảo độ thơm ngon của rượu. Dưới đây là các quy trình sản xuất rượu sake tại Nhật Bản

- Bước 1: Xay xát gạo (Seimai)

Gạo được xay cho đến khi chỉ còn lại phần tinh bột. Quá trình này mất khoảng 2-3 ngày. Trong hạt gạo thô có chứa rất nhiều protein, chất béo và các tạp chất khác làm giảm mùi thơm và màu sắc rượu. Để tránh được điều đó, gạo thô được xát đi từ 30% lên đến 65%. Tỷ lệ xay xát lúa gạo được gọi là SEIMAIBUAI - một trong những thông số tỉ lệ rất quan trọng để đánh giá độ ngon của bốn loại rượu chính như Honjozo, Junmai, Ginjo và Daiginjo.

- Bước 2: Rửa, ngâm và nấu gạo thành cơm

Quy trình này mất khoảng 1 ngày để đảm bảo nguyên liệu lên men rượu.

- Bước 3: Lên men rượu (Koji)

Đây là quy trình quan trọng nhất. Đầu tiên là rắc nấm Koji lên cơm và để trong 35 - 48 giờ. Tinh bột bị phân hủy và biến thành đường. Kiểm soát nhiệt độ cũng là công đoạn vô cùng quan trọng nằm trong quy trình lên men bởi đây là công đoạn quyết định để đạt được hương vị của Sake. Công đoạn này được thực hiện trong một căn phòng đặc biệt gọi là Koji Muro được duy trì ở nhiệt độ cao và độ ẩm. Tình trạng của nấm men và nhiệt độ luôn được xem xét và điều chỉnh 3-4 giờ một lần liên tục trong suốt cả quá trình.

- Bước 4: Công đoạn Moto

Trộn Koji, nấm men, cơm và nước. Tại quy trình này đường sẽ biến thành rượu nhờ men và thời gian lên men thêm. (2-4 tuần / nhanh 14 ngày / Yamahai + Kimoto 28 ngày)

- Bước 5: Công đoạn Moromi (hay còn được gọi là Momori)

Moto sẽ được chuyển đến các thùng lớn hơn. Tại đây gạo, Koji và nước sẽ được thêm vào, thường là được thêm vào ba lần. Từ thời điểm này, hỗn hợp trên được gọi là Momori. Ba lần thêm gạo, nước, Koji được tiến hành trong 4 ngày. Một lần thêm gạo, nước, Koji được thực hiện vào ngày đầu tiên; một lần vào ngày thứ 3 và một lần vào ngày thứ 4. Mặt khác, lần thứ hai lượng gạo, nước và koji được thêm vào thì gấp đôi lần thứ nhất, và lần thứ ba thì gấp đôi lần thứ hai, tuy nhiên có sự khác nhau về công thức nấu rượu.

Sau khi, tất cả gạo, nước và Koji được thêm vào, Momori được ủ để lên men từ 18-32 ngày. Thời điểm dừng quá trình lên men là một quyết định quan trọng bởi vì lên men quá lâu sẽ

dẫn đến mùi lạ trong Sake. Koji chuyển hoá từ từ tinh bột thành đường nên tế bào nấm men không bị ức chế bởi sự có mặt của quá nhiều đường và có thể liên tục sản xuất rượu và CO₂. Điều này cung cấp cho Sake một hàm lượng rượu lên tới 20%, không có một dạng lên men đồ uống nào khác trên thế giới có thể tạo ra hàm lượng rượu tự nhiên cao hơn.

- Bước 6: Ép rượu

Sau khi kết thúc quá trình lên men, Momori được ép thông qua một mạng lưới, mạng lưới này sẽ tách rời rượu Sake mới hình thành khỏi phần chất rắn còn lại của gạo, phần chất rắn này được gọi là Kasu. Có nhiều phương pháp để ép Momori. Phương pháp truyền thống ngày nay vẫn còn được sử dụng khá thường xuyên là đặt momori vào những túi cotton dài một mét và đặt những túi cotton này vào trong một cái hộp lớn (Fune) và thường được làm bằng gỗ. Sau đó nắp được quay xuống từ phía trên vào trong hộp, ép Sake ra ngoài thông qua một cái lỗ ở phía dưới. Quá trình ép bằng fune này thường được chia làm ba giai đoạn. Đầu tiên, khoảng 1/3 lượng Sake chảy ra mà không có lực ép nào tác động lên những túi cotton chứa Momori, được gọi là Arabashiri. Tiếp theo, nắp được quay xuống vào trong hộp và lượng Sake chảy ra được gọi là Nakadare hay Nakagumi và thường được đánh giá cao nhất. Cuối cùng, những túi cotton được chuyển tiếp và được sắp đặt lại bên trong hộp để ép thêm một lần nữa. Lượng Sake chảy ra trong lần ép cuối cùng này được gọi là Seme.

Tuy nhiên, hầu hết Sake hiện nay được ép bởi máy ép có hình dáng giống một cái đàn xếp. Năng suất hoạt động của dạng máy này thường vượt trội nhiều hơn năng suất của phương pháp Fune, tuy vậy phương pháp Fune được cho rằng tạo ra Sake có chất lượng tốt hơn. Momori được bơm trực tiếp vào, và những cái túi hình cầu bằng cao su phình ra để ép Sake ra ngoài.

Một phương pháp ép khác là Shizuku, hay còn gọi là phương pháp chảy nhỏ giọt. Những túi cotton được bỏ đầy Momori sau đó được treo lơ lửng để cho Sake tự chảy ra. Phương pháp này thường tạo ra Sake thanh nhã và hoàn hảo hơn.

- Bước 7: Lọc

Sau khi ép, Sake được ủ khoảng 10 ngày để cho các phản ứng hoá học hoàn thành và cặn lắng. Sau đó Sake được đem lọc. Quá trình lọc giúp loại bỏ những thành phần mùi không mong muốn và màu hổ phách tự nhiên của Sake cũng có thể được loại bỏ để rượu Sake được trong suốt. Tiếp theo Sake được đem đi thanh trùng. Quá trình thanh trùng được hoàn thành bởi việc đun nóng Sake tới khoảng 65 độ C, bằng cách đưa Sake qua một ống kim loại uốn khúc đặt trong một thùng nước nóng. Sake chai có thể được ngâm trong nước nóng trong khoảng thời gian nhất định hay Sake được đun nóng khi nó được bơm vào trong chai trên dây chuyền. Nếu Sake không được thanh trùng, không được giữ lạnh, Sake có thể bị Hiochi, đó là trạng thái Sake bị vẩn đục và sủi bọt. Thông thường, quá trình thanh trùng được thực hiện hai lần, một lần trước khi xếp vào kho và một lần trước khi được mang đi tiêu thụ.

Khi đóng chai, nước thường được thêm vào để giảm lượng rượu tự nhiên trong Sake từ 20% xuống khoảng 16%.

- Bước 8: Ủ rượu

Trong quá trình sản xuất rượu, hầu hết rượu mới được tiệt trùng một lần (công đoạn này được gọi là Hiire) để diệt vi khuẩn, nấm men và các yếu tố không cần thiết và sau đó được thả vào bể ủ.

Qua 8 quy trình sản xuất, nhà sản xuất sẽ hoàn tất việc còn lại đó là nếm thử và đóng chai.

2.3. Cách thưởng thức rượu sake

Sake thường được uống trong khi thư giãn như ngắm trăng, ngắm hoa Anh Đào... Có rất nhiều loại Sake nên dẫn đến việc có rất nhiều cách thưởng thức rượu. Rượu sake có thể được uống ấm, nóng hay dùng ở nhiệt độ phòng, Rượu có thể được hâm nóng bằng các loại máy chuyên dụng như trong các nhà hàng Nhật Bản, hâm bằng lò vi sóng hoặc ngâm trong nồi nước nóng, với các loại sake uống lạnh thì được phục vụ như vang trắng.

Cách đầu tiên là hâm nóng rượu. Đây là phương pháp uống sake truyền thống, thông thường nhiệt độ lí tưởng để thưởng thức là từ 43-45 độ C. Ở nhiệt độ cao những chai sake được ngâm ủ lâu với nồng độ acid cao có vị thơm ngon hơn. Còn sake có phức hợp, hương thơm tinh tế thì nên uống ở nhiệt độ từ 35-40 độ C.

Cách thứ hai là làm lạnh rượu. Rượu sake có hương hoa quả đậm đà như ginjo-shu và sake chưa được tiệt trùng (nama) sẽ ngon hơn khi thưởng thức ở nhiệt độ lạnh khoảng 10 độ vì nếu ở nhiệt độ lạnh quá sẽ làm nhạt rượu. Tuy nhiên, các loại sake thông thường thì chỉ cần cho vào tủ lạnh là đạt yêu cầu. Đây là cách uống đơn giản nhất mà vẫn giữ được hương vị ngon của rượu. Đối với sake ướp lạnh ta dùng ly thủy tinh như uống rượu vang.

Cách thứ ba là uống rượu cùng với đá lạnh. Uống rượu với đá lạnh là cách uống mà rượu đã được làm lạnh sẵn cùng với một viên đá to trong loại ly dành riêng cho cách uống này, cần chú ý đến việc chỉ rót khoảng 50-60ml để vừa đủ uống trước khi đá tan. Đây là cách uống thích hợp với Genshu (rượu nguyên chất), rượu gạo hoặc rượu chưa qua giai đoạn làm nóng (seishu).

Cuối cùng là uống rượu ở nhiệt độ thường. Khi uống rượu ở nhiệt độ phòng người Nhật gọi là Hiya. Tuy nhiên dạng nhiệt độ phòng không mang ý nghĩa của nhiệt độ phòng bất kỳ do mùa hè nóng thì cần làm mát rượu, mùa đông lạnh sẽ phải làm ấm rượu lại, nói chung nhiệt độ trung bình ở dạng này là vào khoảng 15-29 độ C. Nhiệt độ này thường được những người sành rượu ưa thích do có thể cảm nhận được đúng nhất hương vị của rượu.

Tại Nhật Bản, người ta đựng rượu sake vào những chai to khoảng 1800ml vì vậy thông thường người ta sẽ rót qua các bình sứ dung tích khoảng 180ml hoặc 300ml để ngâm nóng hoặc lạnh, sau đó mới rót vào các chén nhỏ bằng gốm hay sứ để uống sake, còn đối với sake ướp lạnh thì nên dùng ly thủy tinh như uống rượu vang.

Rượu Sake thường được đựng trong cốc Choko, Choko làm bằng gốm thì gọi là Tokkuri. Cốc Sakazuki cũng được sử dụng và thường là trong đám cưới hoặc trong các nghi lễ. Gần đây, cốc thủy tinh có chân cũng được sử dụng cho các dịp khen thưởng, lễ kết giao...

Một cốc cổ truyền khác là Masu - cốc hình vuông được làm bằng gỗ sugi hoặc hinoki, nó nguyên là vật dụng để đo lường gạo.

Để thưởng thức sake sao cho đúng kiểu, chúng ta cần phải sử dụng cả ba giác quan là: thị giác, khứu giác và vị giác.

- Về mặt thị giác: Trước hết ta rót rượu ra tách khoảng 80%. Sau đó kiểm tra các vết vẩn đục và màu sắc, Sake thường trong suốt, hoặc có màu vàng nhạt trong khi nếu để quá lâu Sake chuyển màu đậm.

- Về mặt khứu giác: Mùi hương là một trong những yếu tố quan trọng của rượu sake. Trước tiên, ta đưa tách rượu lên gần mũi để thưởng thức hương thơm thoang thoảng. Người thưởng thức sake chuyên nghiệp có thể dùng hàng trăm từ để diễn tả mùi hương của rượu sake.

- Về mặt vị giác: Trước tiên, ta nhấp môi một chút. Sau khi chắc chắn rằng bạn đã cảm giác được vị, chậm chậm hít thở hương thơm đặc trưng của sake qua mũi. Mùi hương của rượu sake trong miệng sẽ tràn qua cả khoang mũi, tạo cảm giác mạnh cho cả vị giác và khứu giác. Tiếp đến, ta thưởng thức vị ngọt, vị chua, xen lẫn chút cay, đắng, the the mà rượu sake mang lại. Cuối cùng, chúng ta tận hưởng hương vị sake còn lại trong vòm miệng của mình. [4] [5]

Chương 2. Về sử dụng rượu trong văn hóa tiếp khách

Người xưa có câu “Chén rượu là đầu câu chuyện”, việc sử dụng rượu trong việc tiếp khách đã trở thành một phần không thể thiếu trong xã hội của Nhật Bản và Việt Nam. Theo bản điều tra 100 người Việt và 50 người Nhật đang đi làm mà chúng tôi đã tiến hành vừa qua có hơn 90% số người tham gia khảo sát đồng ý với việc sử dụng rượu trong khi đi tiếp đối tác, khách hàng. Vậy người Nhật Bản và người Việt Nam sử dụng rượu trong tiếp khách như thế nào? Chúng tôi xin được phép trình bày ở phần dưới đây.

2.1 Sử dụng rượu trong văn hóa tiếp khách ở Nhật Bản

Khi rót sake, người rót rượu cầm bình rượu (tokkuri) bằng cả hai tay với lòng bàn tay úp xuống, ta có thể quấn thêm một chiếc khăn quanh tokkuri để rượu không bị rót xuống. Khi rót rượu ta rót vào từng cốc một và lưu ý không tự rót vào cốc của mình. Khi rót rượu chúng ta cũng có thể cầm chai rượu bằng một tay nhưng tay kia phải chạm hờ vào tay đang rót. Trong trường hợp người rót có địa vị cao hơn người được rót thì người rót chỉ cần cầm một tay để rót.

Với trường hợp được đối phương rót rượu cho mình, khi đang được phục vụ, hãy nâng ly của bạn lên để tỏ ý lịch sự. Một tay của bạn cầm ly rượu và đặt cả tay cầm ly lên lòng bàn tay còn lại.

Tiếp theo, hãy nói "kampai" và chạm ly với mọi người khi chúng ta tiếp khách tại nhà hàng Nhật Bản. Ta cần phải lưu ý thêm rằng khi uống rượu với một người có địa vị cao hơn thì cốc của mình phải thấp hơn cốc của đối phương khi chạm cốc. [6]

2.2. Sử dụng rượu trong văn hóa tiếp khách ở Việt Nam

Do không thể tìm thấy được những tài liệu liên quan đến cách thưởng thức rượu ở Việt Nam nên chúng tôi đã tiến hành phỏng vấn 50 người đang làm việc tại Việt Nam về các lễ nghi tiếp rượu cho khách và rút ra được những quy tắc cần phải có khi đi tiếp rượu. Sau đây là một vài quy tắc thưởng thức rượu và tiếp rượu thường thấy trên bàn tiệc của người Việt Nam.

- Quy tắc 1: Trên bàn rượu phải biết mình là ai

Đầu tiên chúng ta phải biết buổi hôm nay mình đi với ai và ăn uống với những đối tượng nào và số lượng là bao nhiêu để từ đó xác định được mình sẽ uống theo kiểu nào.

2.2.1. Khi đi tiếp khách cùng với sếp

Trước hết khi vào bàn ta cần bao quát toàn bộ, rót nước, rót rượu (nên ngồi bên cạnh cấp trên của mình) và nhờ người ngồi đối diện bàn rót hộ bên kia. Tùy vào các đối tượng cụ thể mà chúng ta cũng có những cách tiếp rượu khác nhau sao cho phù hợp.

- Đối với đối tượng là khách quý hay cấp trên của mình, ta rót rượu vào ½ ly, chờ các sếp khởi đầu trước. Không mời lãnh đạo bên khách trước khi sếp mời và phải chờ người cấp cao hơn mình mời hết trước rồi mới đến mình mời. Trong thời gian đó có thể mời cấp dưới thấp nhất của bên khách. Ta cần lưu ý rằng chỉ rót đầy rượu khi có chỉ thị, họ mời mình đầy mình cũng mời lại chén đầy điều đó thể hiện sự tôn trọng. Tuyệt đối không tự ý mời sếp bên mình, chỉ mời khi bên khách gợi ý và sếp đồng ý. Nếu sếp ngồi 1 lúc không ai mời mà mọi người trong mâm đang rôm rả rót một chút chúc sức khỏe sếp mình. Hạn chế nói để sếp có không gian trò chuyện, chỉ hưởng ứng những thì mình biết và góp ý thêm. Cần lưu ý thêm rằng tuyệt đối không ép rượu người khác.

- Đối với các đối tượng là khách ngang cấp, quen hay đây chỉ là buổi giao lưu, không quan trọng thì khác với trường hợp trên, trường hợp này ta có thể giao lưu thoải mái với mọi người trong bàn, nhưng cần chú ý hạn chế mời sếp mình, không nên mời những người không uống được, cũng như những người không thật sự cởi mở.

Ta cũng cần lưu ý ở một điểm rằng khi rót một là rót 1 tay và tay kia đỡ chai rượu, 2 là cầm chén sếp lên rót thể hiện sự tôn trọng, tránh rót 1 tay.

2.2.2. Cùng sếp đi tiệc do khách mời

Khi cùng với sếp mình đi dự tiệc thì thường sẽ là cấp dưới mời cấp trên, hoặc 2 đơn vị ngang hàng trường hợp này sẽ dễ thở hơn.

- Quy tắc 1: Quan sát trong mâm nếu khách toàn người đứng tuổi thì mọi công việc phục vụ thuộc về mình. Còn nếu trong mâm có phụ nữ ít tuổi, người trẻ thì việc của mình là ngồi vào mâm để họ làm công việc của chủ nhà.

+ Đối với những người ngang cấp bậc với mình, ta có thể mời mỗi người một chén mời từ ai đến ai thì như trường hợp đi tiếp khách nếu nhiều mâm tiếp tục mời mỗi mâm một chén. Nên chú ý rằng hãy để chủ nhà mời mình trước.

+ Đối với đơn vị cấp dưới, đơn vị mình quản lý, nếu bạn là nhân viên mới và đây là lần đầu bạn gặp mọi người thì hãy uống nhiệt tình để họ biết bạn là ai, đang công tác tại phòng quản lí của họ. Sau khi uống mâm mình trước thì quay ra mời từ mâm sếp trở đi. Nếu quá đông tìm các trưởng phòng, phó phòng để uống riêng với họ (thường là họ sẽ mời bạn trước xong bạn đi các mâm nếu có họ thì mời riêng).

+ Đối với những người đã quen thì hãy uống thoải mái nếu tửu lượng bạn cho phép. Đây cũng là nơi bạn có thể từ chối không uống nhiều, có thể uống ít hơn hoặc chỉ nhấp môi. Giám đốc, phó giám đốc, trưởng phòng là những người bạn cần uống cùng, những người còn lại quý ai thì bạn có thể uống riêng hoặc không. Cần phải lưu ý rằng dù là với những người đã thân quen nhưng vẫn cần phải mời rượu một cách lịch sự, không suồng sã và khi uống rượu cũng chỉ nên uống ở một mức độ vừa phải, không được phép say, không định nói linh tinh.

- Quy tắc 2: Không được phép ép rượu người khác

Khi uống rượu nhất định không được ép ai cả, nhất là sếp và phụ nữ, chỉ được ép trong trường hợp lúc đầu họ ép mình, lúc sau mình mời họ không uống theo mình đó là lúc mình phải ép. (không áp dụng với đi tiếp khách cấp trên, chức vụ cao hơn mình). Không ép

người khác uống rượu không những thể hiện sự tôn trọng của bản thân mình đối với người khác mà còn thể hiện rằng mình là người quan tâm đến sức khỏe cũng như tôn trọng mối quan hệ của bản thân và đối phương.

Chương 3. So sánh sự khác nhau giữa rượu sake Nhật Bản và rượu nếp Việt Nam

3.1. Những điểm giống nhau

- Về lịch sử hình thành và phát triển:
 - + Đều có lịch sử lâu đời và trở thành một nét truyền thống được lưu giữ cho đến ngày nay
- Về nguyên liệu sản xuất:
 - + Đều làm từ gạo và men rượu
- Về cách nấu rượu
 - + Đều có các công đoạn là nấu chín, trộn men, lên men và chưng cất
- Về cách tiếp khách:
 - + Khi đi uống rượu thì ta không tự rót rượu vào chén mà để đối phương rót cho mình.
 - + Khi rót rượu cho đối tác, khách hàng ta đều phải cầm bình rượu bằng cả 2 tay.
 - + Cấp dưới phải rót rượu cho cấp trên, chủ tiệc phải rót rượu cho khách.

3.2. Những điểm khác nhau

- Về cách thưởng thức:
 - + Rượu Nhật Bản chỉ uống thuần: không ngâm với các loại thảo dược hoặc động vật khác, có thể uống theo các cách là uống nóng, uống lạnh hoặc để nguyên.
 - + Rượu Việt có thể ngâm với thuốc (gọi là rượu thuốc). Loại rượu này tốt cho sức khỏe và chỉ có thể uống thường và lạnh.
 - + Người ta thường rót rượu Việt Nam trực tiếp từ chai, còn rượu Nhật Bản sẽ rót vào các bình gốm trước rồi mới mang ra phục vụ.
- Về cách nấu:
 - + Rượu Sake có cách nấu sử dụng nhiều thời gian và cầu kì hơn về các công đoạn được giám sát chặt chẽ.
- Về nguyên liệu:
 - + Rượu Việt chỉ đơn thuần sử dụng rượu và men rượu.
 - + Rượu Nhật cần phải rắc thêm nấm Koji để đẩy nhanh quá trình lên men.
- Về các quy tắc khi tiếp khách:
 - + Tại Nhật Bản: có phần thiên về việc rót rượu cần phải chú ý những gì, ví dụ như là sử dụng những đạo cụ đi kèm như thế nào...
 - + Tại Việt Nam: có phần thiên về việc trong lúc uống cần lưu ý những gì, ví dụ như là đối với từng đối tượng uống thì phải mời rượu như thế nào, uống bao nhiêu thì đủ,...

3. Kết luận

Qua khảo sát điều tra và phân tích chúng tôi đã đưa ra được kết luận là hơn 90% người Việt Nam và cứ ba người Nhật lại có một người sử dụng rượu để tiếp khách trong công việc. Bên cạnh bản khảo sát đã tiến hành, chúng tôi cũng đã tìm hiểu và tham khảo các tài liệu liên quan để có thể đưa ra được những kết luận về sự giống và khác nhau giữa Nhật Bản và Việt Nam ở một khía cạnh nhỏ của văn hóa cũng như đời sống con người của cả hai đất nước.

4. Lời cảm ơn

Trước tiên, chúng tôi xin trân thành cảm ơn cô Lại Xuân Thu – giảng viên ngành Ngôn ngữ Nhật, Đại học FPT Hà Nội đã nhiệt tình hướng dẫn và hỗ trợ trong suốt quá trình thực hiện bài nghiên cứu khoa học.

Tiếp theo, chúng tôi xin được cảm ơn các bạn bè tại trường Đại học FPT Hà Nội, các đồng nghiệp tại VTI Corporation, Relipa Software và FPT Software đã luôn sẵn sàng hỗ trợ và động viên chúng tôi hoàn thành bài nghiên cứu.

Cuối cùng, xin cảm ơn Ban tổ chức đã đồng hành trong suốt chặng đường và tạo ra một sân chơi bổ ích, hấp dẫn dành cho sinh viên, và xin chúc buổi Chung kết Hội nghị sinh viên Nghiên cứu khoa học 2018 diễn ra thành công rực rỡ.

Tài liệu tham khảo

- [1] Central Research Services Inc, “Từ kết quả khảo sát người dân về việc uống rượu” (Báo cáo số 548), tháng 6/2003. [Online] [Available] http://www.crs.or.jp/backno/old/No548/5483.htm?fbclid=IwAR1OiTj7t2944N48cXkRGkXwnnW-69lOVqyQYqEkS42_ZGhPyB-PkPb9yyk . [Accessed: 20/10/2018]
- [2] Giang, Hiền, T. H., Phụng, H. T., Thắng, A. T., Vân, “Quy trình sản xuất rượu trắng truyền thống”, Luận văn thực hành, tháng 6/2012.
- [3] Kimura Katsumi, “Giáo trình về rượu Nhật Bản”, tháng 1/2010.
- [4] Yamamoto Youko, “Hiểu từ con số 0! Nhập môn sơ lược về rượu Nhật Bản”, 2018.
- [5] Anastacia, Arai, Kachaconni, “Sự ngạc nhiên của người nước ngoài về cách người Nhật uống rượu“, 8/9/2017. [Online] [Available] <https://toyokeizai.net/articles/-/188826> [Accessed: 19/10/2018]
- [6] Sekine Takeo, “Cách kinh doanh hoàn hảo”.

Impact of customers' personal factors on green consumption behaviors

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Abstract

At present, environmental issues are becoming a global concern for humanity. Therefore, ecological awareness, as well as environmental knowledge, has arisen worldwide, and accordingly green consumption behavior is increasingly encouraged among consumers. As an emerging economy with growing awareness of environmental issues, Vietnam is not out of this trend. There are numerous factors that influence consumers' green consumption behavior, and it is vital to learn about the influential factors to consumers' engagement in green consumption behaviors. Hence, this study focuses on analyzing the impacts of consumers' psychological factors and attitudes towards green consumption on customers' performance of green consumption behaviors. Data were collected from customers in Viet Nam through a convenience sampling method. The results indicate significant influences of consumers' psychological factors on green consumption behaviors. With the findings, the study suggests useful implications for companies in Vietnam in an attempt to foster and promote customers' performance of green consumption behaviors.

Key words: Environmental awareness, ecological affect, attitude towards green consumption, Green consumption behaviors, Environmentally-friendly.

1. Introduction

According to international environmental experts, in the next 10 years, Vietnam's GDP may double, but if environmental protection is not paid attention, with a 1 per cent increase in average GDP, environmental pollution will lose about 3 per cent of GDP. At present, in the socio-economic development strategy 2016-2020, Vietnam considers environmental protection an important part of renewing the green growth model and towards people, sustainable development and protection of the health and physical well-being of the people (Nguyen Tan Dung, 2015). In addition, the Organization for Economic Cooperation and Development (2016) said that consumers play an important role in sustainable production in OECD countries because they account for over 60 per cent of final consumption. Meanwhile, there is evidence that nearly 40 per cent of environmental pollution is due to household consumption activities (Grunert, 1993). In other words, when customers buy environmentally friendly products and change their behavior to support environmental protection goals, it will have a great impact on green growth (OECD, 2016). Moreover, a global study by Nielsen (2014) shows that 55 per cent of the respondents said they were willing to pay more for products and services from companies with positive social and environmental impacts. This shows that consumers are more aware and have a positive attitude towards the environment. Hence, numerous countries around the world have considered environmental protection as one of the criteria for product evaluation and the sustainable development of enterprises. Customers are willing to boycott the products and services of the enterprises that do not fulfil social responsibility as well as responsibility for the environment. More importantly, when consumers have high levels of environmental, ecological, or green purchases awareness, enterprises will have to adopt the concept of green marketing in their operations.

In Vietnam, the requirements for environmentally friendly products in the market and consumer awareness are still limited. Furthermore, Vietnamese enterprises are not active in

investing and producing green products. However, the trend of globalization requires businesses to change, to meet the market demand for green products. This is also one of the major reasons that companies should learn about green consumption to better understand the environmental movement in Viet Nam and from that to have appropriate practices in their business operations.

It can be seen that environmental issues are receiving attention not only in Vietnam but also in the world because of its urgency. Over the past three decades, there have been numerous scientific papers and research articles on green consumption behavior published in newspapers and scientific forums. Researchers around the world have conducted a number of studies on green consumer behavior such as exploring the delicate relationships between environmental concerns and ecologically conscious consumption behavior (Roberts & James, 1999). For instance, Laroche et al. (2001) identify factors that make consumers willing to pay more for green products. These studies have made a great contribution to the study of green consumer behavior. Most studies confirm that green consumer behavior is the future behavior, contributing to environmental protection.

In Viet Nam, studies on green consumer behavior have not been diversified and have not received much attention. In recent years, there have been a number of studies on green consumer behavior such as Nguyen Dan Thi (2013) studied the impact of green marketing tools on consumers' green purchasing behavior in Ho Chi Minh City; Nguyen Thanh Tuan (2013) conducted research on factors influencing the intention to buy green products of consumers Viet Nam. However, there is no study on the effect of consumers' personal factors including environmental knowledge, ecological affect, perceived effectiveness, and attitude towards green consumption on customers' green purchase and green consumption promotion behavior. This research attempts to grasp a better understanding of customers' personal factors affecting green consumption. It also aims at understanding whether attitude towards green consumption is significant mechanism for green purchase and green consumption promotion. With the empirical results, the study may provide valuable suggestions for marketing practitioners and policy makers, particularly in Vietnam, for designing appropriate practices and devising progressive policies to foster customers' engagement in green consumption behaviors.

2. Theoretical background

2.1. Literature review of study's variables

2.1.1 Green Consumption

Along with protecting the values of the environment, green consumption is one of the major contributing factors of environmental change. Ajzen (1985) showed that green purchase intention stands for a willingness and distinct kind of environmentally friendly behavior by individuals to give preference to green products compared to conventional products to express their concern to the environment. Green products are product that are harmless to human health, atmosphere and environment. In addition, the Organization for Economic Cooperation and Development (OECD) has approved that green products can be prevented, reduced environmental damage, such as ecosystems, waste, noise, water, air and soil. Jaganath (2016) showed that environmental attitude have a positive

influence on green purchasing behavior of young consumers in India and the study suggested that the young people are an important target group for the future. Young consumers can serve as a leadership in the family when they receive information about new products, in particular, they have more power to purchase and spread word of mouth about products information even though some young consumers do not have an income (C. Teerachote, P. Kessomboom, A. Rattanasiri, and R. Koju, 2014).

Nowadays, awareness is increasing and green products are becoming more and more diversified as the process of changing consumer behavior changes. Apparently, attitude will subsequently has its effect on consumer behavior. For example, an inward environmental attitude will stimulate green purchasing intention, and an outward environmental attitude will lead to general pro-environmental actions. In other words, a person with an outward environmental attitude can act in a friendly way to the general environment, but is not necessarily involved in a green purchasing behavior (Leonidou, Leonidou and Kvasova, 2010). Green consumption is seen as a necessary human action to counteract the environment, which is predicted to be a future consumption trend.

2.1.2 Customers' personal factors pertaining to green consumption

Environmental Knowledge

Environmental issues and their impact on human health has become a major issue among academics, governments and organizations (D. L. Haytko and E. Matulich, 2008). Moreover, the environment is an important link to the complete ecosystem of human life, so environmental knowledge is the level of information individuals have concerning environmental issues and their ability to understand and evaluate consumer behavior. According to the state of the environment and the ecosystem, human beings are the most affected by environmental pollution and humanity is the essential factor causing the current situation.

Environmental knowledge is the amount of information individuals have concerning environmental issues and their ability to understand and evaluate its impact on society and the environment (Igi-Global, 2016). According to Stutzman and Green (1982), environmental knowledge is important in creating the necessary attitude toward green consumption. The people who have awareness about environment can lead to environmental impact and environmental responsibility of the individual, which may contribute to sustainable development (Fryxell and Lo, 2003 According to D'Souza, Taghian and Lamb (2006) environmental knowledge evolves in two forms: (1) consumers have to educated to be understand the impact of a product to environment; (2) consumer knowledge about the product itself being produced in an environmentally friendly way. There are many ways on how consumers seeking for knowledge and evidences suggest that consumers are seeking knowledge by reading product label, internet, social network or word-of-mouth (D'Souza et. al, 2006). If the consumer has knowledge about the environmental problem, then their awareness level would increase and thus would, potentially, promote favorable attitudes towards green products. Furthermore, previous researchers reported that environmental knowledge has significant positive influence on consumers' environmental attitude. Environmental knowledge significantly influences youth's environmental attitude towards green products. Environment knowledge is a key factor in the consumer's decision to consumption green products.

Ecological Affect

Ecological affect refers to consumers concerned about environmental and ecological condition. For consumers, to choose the green product is difficult because they need to consider a number of different factors (Wen and Hi, 2013). Since the 1970s, researchers had already begun to study consumers concern for the environment (Anderson & Cunningham, 1972) and concerned ecological issues (Kinneer, Taylor & Ahmed, 1974). The study also found that the ecological environment will affect consumers' choice of food (Tobler, Vivianne Viviance & Siegrist, 2011). Overall, consistent empirical evidence has been found to support a positive association between ecological affect and behavior (Dispoto, 1997; Li, 1997; Maloney and Ward, 1973). It is reported that there exists an average correlation of around 0.37 between the two variables (Hines et al., 1987). So this study find out relationship between the ecological effect and the green consumptions from a consumers' point of view. Aim to understand the ecological environment will affect their green consumptions.

Perceived consumer effectiveness.

Perceived consumer effectiveness is understood as the level the consumer believes that their personal efforts can contribute to the solution of a problem. (Ellen, Weiner, and Cobb-Walgren, 1991). Perceived consumer effectiveness is defined as “the evaluation of the self in the context of the issue” (Berger and Corbin, 1992, pp. 80-81), and it differs from an attitude that reflects an evaluation of an issue (Tesser and Shaffer, 1990).

A lot of studies point out the difference between stated consumer values and purchasing practices. Perceived Consumer Effectiveness (PCE) helps explain this difference. It is necessary to change their attitude towards green consumption (Vermeir, 2006). From awareness to become action is not easy; however, individuals with a strong belief that their environmentally conscious behavior will result in a positive outcome are more likely to involve in such behaviors in support of their concerns for the environment. So, perceived consumer effectiveness may affect the performing of green consumption behavior.

2.1.3 Attitude Toward green consumption

Eagly and Chaiken (1993) said that a psychological trend to make a positive or negative evaluation of a phenomenon in a way is called attitude. For environmental attitudes, it is understood as one belief or perceptions that are always directed toward positive or negative evaluation of the ecosystem, natural environment, and the factors that affect them (Milfont, 2007). In other words, environmental attitudes are the opinions and perceptions of the individual about the environment and the issues involved. To classify, environmental attitudes are divided into general environmental attitudes and specific environmental attitudes. Inside, general environmental attitudes are considered to be a set of environmental emotions, behaviors and intentions (Schultz, 2004). According to sociologists Dunlap and Jones (2002), it includes environmental value, environmental sensitivity and environmental trust. While specific environmental attitudes are defined as the individual's thinking and attitudes toward specific environmental behaviors. The attitudes of green consumption in this study belong to specific environmental attitudes. More specific, consumers are aware that the environment, as well as the existence and development of human beings, is threatened by pollution, waste, etc., and they must be responsible for improving the environment (Chan, 2001). Furthermore, attitudes towards green consumption is a major factor that guides human's green consumption behavior (Bredahl, 2001). On the topic of attitudes and

behavioral distances, some studies suggest that consumers have positive attitudes about the environment, but this does not mean that they have actual buying behaviors (Pickett-Baker and Ozaki, 2008). Based on the attitudes and willingness to pay for green products analyzed through the German National Household Survey (2012), the results showed that the attitude did not significantly influence the purchase behavior of green (Moser, 2015). There was an inconsistency in the studies on the level effect of attitudes to buying behavior. Hence, the next study should not rush to affirm the attitude towards green consumption as a direct determinant of actual green behavior.

2.1.4 Green consumption behaviors

Green purchase

Green purchase is understood as the purchase of environmentally friendly products and avoiding products that harm the environment (Chan, 2001). Some other researchers say that green purchase is most often measured as attitude toward of green consumption and behaviors. When customers have positive attitude of green products leads to consumers' willingness to purchase green products. Intentions capture the motivational factors that influence green purchase behavior of consumers (Ramayah, Lee, and Mohamad, 2010)

Besides, some other researchers have added as well green purchase can lead to the act of consuming products that are conservable, beneficial for the environment, and responding to feels strongly that he/she can do something about pollution and tries to consider the social impact of his/her buying behavior. Green purchase is considered as ethical decision-making behavior and is a type environmental concern (Lee, 2009). Webster (1975) found that the socially conscious customer of socially responsible behavior. As a socially responsible consumer, the green consumer "takes into account the public consequences of their private consumption and attempts to use their purchasing power to bring about social change" (Moisander, 2007).

Green consumption promotion behaviors

According to Jacques Ellul (1973), promotion is the introduction of information and problems that aim to push people's attitudes, thoughts and opinions in the direction the informant wants. The goal of modern promotion is not only to change the mindset or attitude of the community, but also to act in them. Promotion not only changes individuals from old beliefs but also needs to make them believe in new thinking and bring about beneficial actions and promotion for others. For green consumption, promote the propaganda about the benefits of green products as well as practical benefits in protecting the environment to the community, this will attract the consumption of green products and raise awareness about green consumption (VietnamPlus,2013). Mansvelt and Robbins (2011) also assert that green consumption promotion behavior is encouraging people to use environmentally friendly products without harming human health and not threatening the diversity of natural ecosystems. Thus, this behavior derives from the desire to protect the resources of future generations and to improve the quality of human life.

2.2 Previous models of green consumption

In order to better understand people's green purchase behavior, Maloney and Ward (1973) argued that identifying people's knowledge of ecology, what they perceive from the

environment and what they are willing to do for the environment is very important. Consumer behavior researchers also assert that an individual's ecological behavior will be highly dependent on environmental influences, ecological knowledge, and their intent (Chan & Yam, 1995). In addition, Webster (1975) advocates that consumers have a knowledge of the environment and are strongly conscious that they can do something to reduce pollution and struggle to consider the environmental impact of their buying behavior. Such a view is consistent with the classic behavioral theory which states that cognitive, affective and conation are three important and essential components for identifying corresponding behaviors (Bagozzi, Tybout, Craig, & Sternthal, 1979). However, in the field of environmental research, many experiments have found that the distance from knowledge to behavior is far from clear (Martin & Simintiras, 1995). In the analysis of Hines, Hungerford, and Tomera (1987), a moderate correlation was found between knowledge and ecological behavior. A number of studies have also shown that environmental knowledge does not have a significant impact on ecological behaviors (Geller, 1981; Schahn & Holzer, 1990). In research related to the purchase of Grunert's green foods (1993), that statement was also observed and verified. The results of empirical reports have suggested to researchers the more complex relationship between ecological knowledge and behavior (Chan, 1999). Then Arbuthnot and Ling (1975) were noted for their suggestion that attitudes can act as an intermediary variable for ecological knowledge and behavior. Recently, Davis (1993) also asserted that when consumers have a better understanding of the environment they will lead to a more positive ecological attitude.

Similarly, attitudes have been found as a positive relationship between ecological and behavioral influence (Maloney & Ward, 1973; Li, 1997). In his study Benton (1994) also argued that ecological influence has a great impact on attitudes, which represent the level of individual sentiment towards ecological issues. Further, maintaining the behavior of consumers related to ecological impact, they will show ecological concern by adopting green purchase behavior (Schwepker & Cornwell, 1991). Evidence suggests that the relationship between attitudes and behaviors will be enhanced when attitudes to environmentally friendly behavior reduce ecological problems (Hines et al., 1987). This observation is very consistent with Ajzen and Fishbein's (1980) theoretical behavioral model on the relationship and correlation between attitudes, behavioral intention and behavior.

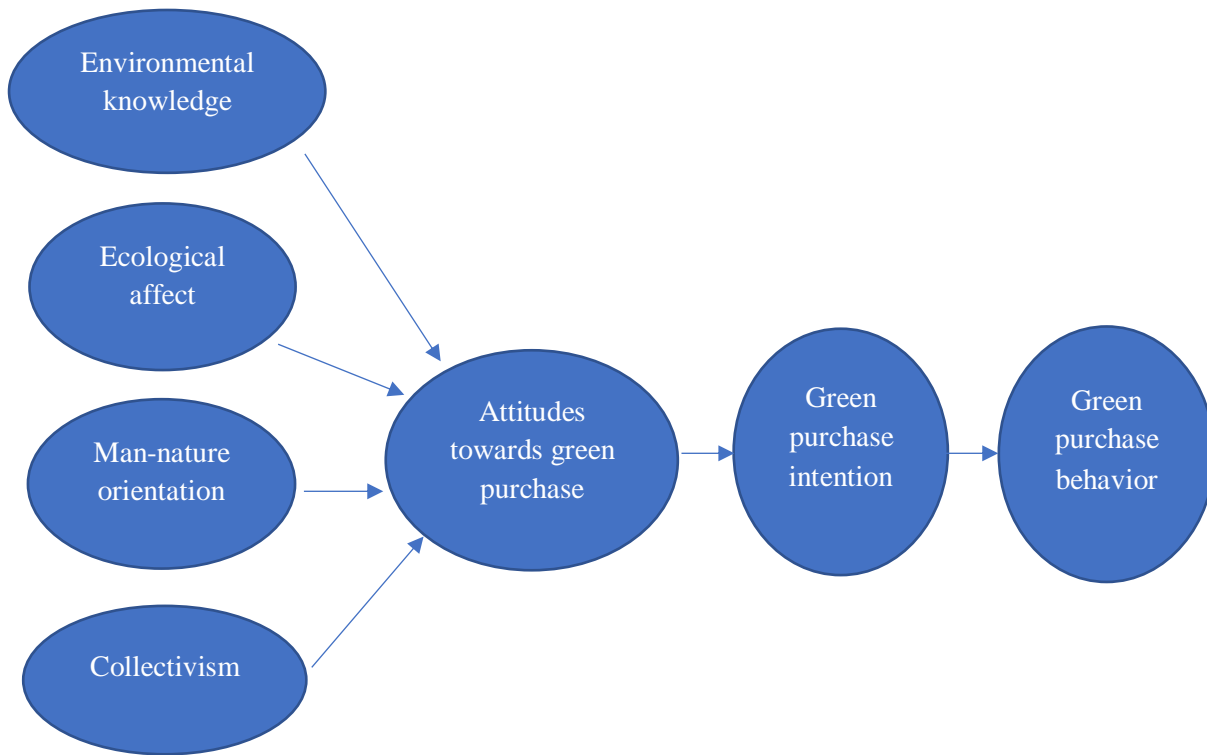


Figure 1: Model of the determinants of Chinese consumers' green purchase behavior (R.Y.K Chan, 2001)

By and large, studies have positively demonstrated the correlation between ecological attitudes and behavior (Li, 1997; Maloney & Ward, 1973). Meanwhile, meta-128 analysis prior to Hines et al. (1987) identified a significant correlation of 0.49 between the two variables: attitudes and ecological behavior. This is a solid basis for advocating the classical behavioral theory of Ajzen & Fishbein (1980).

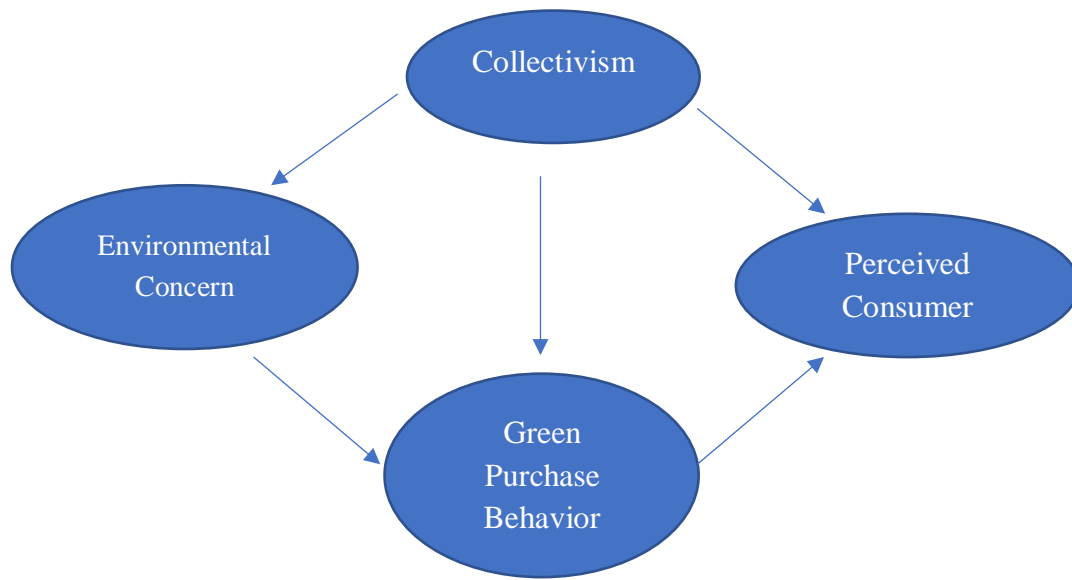


Figure 2: Model of antecedents of green purchase behavior (Kim and Choi, 2005)

Kim and Choi (2005) also proposed and tested a model of green purchase behavior to which customer environmental concern and perceived consumer effectiveness are two predictors for customer green purchase behavior.

3. Hypothesis development and research model

In conclusion, all of the definitions, theories, and models have been mentioned and analyzed in this chapter were based on previous studies. The green consumption promotion behavior variable is added to make a complete model for the case of green consumption in Vietnam because the number of people involves in social networks is large in Vietnam while this creates favorable conditions for them to engage in acts of promoting others to have green consumption.

Environmental knowledge may affect one's attitude toward green consumption, such as research conducted by Amanetal (2012) which found an influence of environmental knowledge on green consumption or eco-friendly products. Similarly, the results of a study by Mei et al.,(2012) show that environmental knowledge affects the intention to buy eco-friendly products to consumers. Following this line of research, the current study proposes:

Hypothesis 1: Customers' environmental knowledge positively affects attitude towards green consumption.

The ecological-affect is items were adopted from the ecological scale to assess respondents' affect relating to general ecological issues (Maloney et al., 1975). The ecological affect instrument consists of multiple-choice questions. Also, this ecological scale has been widely used in previous environmental studies and is one of the most popular scales for studying ecological concern (Benton, 1994). An individual's ecological affect were postulated as

affecting his/her attitudes toward green consumption. This postulation is to reflect the cognitive and affective structure of attitudes as discussed earlier. Moreover, it is hoped that the incorporation of the perceptive, affective, and attitudinal constructs into the same model would make available further insights into how an individual's affective responses toward, general ecological issues, effect his/her attitudes toward performing a specific kind of ecofriendly behavior, that is to say attitude towards green consumption. Therefore:

Hypothesis 2: Customers' ecological affect positively affects attitude towards green consumption.

A lot of studies point out the difference between stated consumer values and purchasing practices. Perceived Consumer Effectiveness (PCE) helps explain this difference. It is necessary to change their attitude green consumption behaviors (Vermeir 2006). PCE was first defined by Kinnear et al. (1974) as a measure of an individual belief that he or she can have an effect on environmental issues and was named as locus of control in some studies such as Shwepker and Cornwell (1991). Among the top 10 prognosticators of environmentally conscious behavior, PCE was originate to be the best to predict ecological attitude (Kinnear et al., 1974) Also people with higher PCE have proven to be more environmentally concerned (Kim and Choi, 2005) that was make them have attitude towards green consumption. Hence:

Hypothesis 3: Customers' perceived consumer effectiveness positively affects attitude towards green consumption.

Green consumption comes from the desire to protect resources for future generations and to improve the quality of life of people. Today, consumers around the world are gradually turning to green products, friendly to the environment and considered it a standard for high-quality products and services. Given the growing interest in global green products, many companies have begun to produce green products that are environmentally friendly and represent an effort to protect the environment. Governments are also working on ways to promote green consumption. Most developing countries in Asia have developed environmental laws. The number of people willing to pay more for eco-friendly products has recently shown that the market for environmentally friendly products is expanding (Tsakiridou et al., 2008). Therefore:

Hypothesis 4: Customers' attitude towards green consumption positively affects green consumption.

Green consumption is now seen as a consumer trend of the century as the environment becomes a major concern in many countries around the world (Lorek & Funchs, 2013). Policies and programs have been put in place to successfully transform the industrial structure, making the production process cleaner and more efficient. However, businesses can only reduce the environmental impacts associated with production rather than addressing the environmental impacts associated with the selection process.

Select, use and dispose of consumer products (Partidario & Comes, 2013). Consumption therefore plays an increasingly important role in addressing environmental issues; Co-operation among producers, consumers and other stakeholders can bring about more sustainable solutions in the production-consumption system (Briceno, 2006). In that context, integrating stakeholder efforts is key to promoting green consumption in the world in general and in Vietnam in particular. Green consumption is now widespread in developed countries and has made initial progress in developing countries, as individual incomes and consumer sentiment are increasing. Therefore, Vietnam needs to study policies and international experiences in order to further promote green consumption, which is a new concept here. Therefore:

Hypothesis 5: Customers' attitude towards green consumption positively affects green consumption promotion

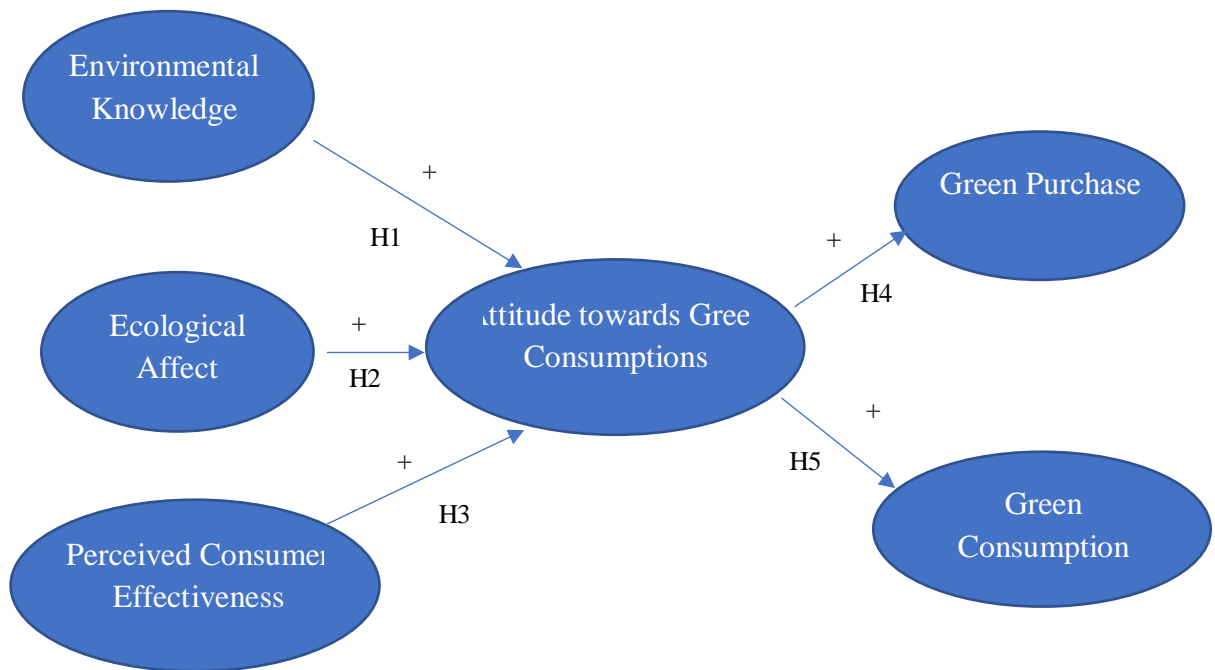


Figure 3: The proposed research model.

3. Researching method

3.1. Sample

We conducted a survey on 230 people in the Vietnamese market, in which the majority of respondents were female, accounting for about 60 percent followed by male with 36.5 percent. The average age is under 35 years, accounting for about ninety percent, mainly office workers, civil servants account for about seventy percent. Most of them have an average income of about 7 to 10 million. Most of the respondents had university graduate of 73.9 percent, undergraduate 15.2 percent and masters accounted for about 11 percent.

3.2. Data collection procedure

An original questionnaire in English was used. The questionnaire has two main parts. The first part involves the questions asking about demographic characteristics of respondents. These items were measured using nominal scale. The second part involves the items for measuring the study's variables for which the respondents are required to rate basing on Likerts scale with five points: 1- totally disagree, 2- disagree, 3- moderate, 4- agree, and 5- totally agree.

The original English questionnaire underwent multiple translation tools at the same time and with the assistance of four highly qualified foreign language instructors to increase the accuracy of the questionnaire.

In pilot testing, a selected group of end users try the system under test and provide the feedback before the full deployment of the system. Pilot testing helps in early detection of bugs in the system. Before data collection process, questionnaire has been in pilot testing with 35 respondents with 30 student studying University and 5 Doctor in Marketing. After that, almost respondents strongly agree with the questionnaire. After the pilot test, the questionnaire was set up on Google form and was widely shared via social networking, sending mail by link "<https://goo.gl/forms/r4spYfCk8GnzSLKT2>"

Sample size is calculated based on ratio 5:1 (Hair, et al., 1998). This ratio means the minimum sample size should be at least five times compared with the number of survey questions in the questionnaire. There are 33 questions in the questionnaire, therefore, the minimum sample size should be at least $n = 5 \times 33 = 165$. On the other hand, Fidell and Tabacknick (1966) measured the sample size for six levels: excellent – 1000 or over, very good – 500, good- 300, fair-200, poor -100, and very poor 50.

With these calculation and measurement which are mentioned above, to increase the level of reliability, the expected sample size is 200. After data collection process, the final number of sample size is 230.

3.3. Measures

Five items were used to measure environmental knowledge that adopted from Aman (2012). Four items adopted from Maichum (2017) was used to measure ecological affect. Perceived consumer effectiveness was measured with five items, adapted from Kim and Choi (2005). Scale of attitudes towards green consumption was taken from Eagly and Chaiken (1993) combined with Dunlap and Jones (2002), consisting of three items to measure. Green purchase was measured with seven items, adapted from Chan and Yam (1995) and Chan (1999). Four items were developed to measure green consumption promotion behavior, basing on a review of the prior research pertaining to green consumption behaviors, an interview with a marketing professor, and a pilot test on 30 customers.

All of the scales have Cronbach's alpha values of above 0.65, suggesting adequate reliability of the variables. Importantly, green consumption promotion behavior has a Cronbach's alpha value of .873, indicating that this new measure is highly reliable.

4. Results

4.1. Reliability and validity

Bernard (2011) claimed that reliability refers to whether the same answer is received for an instrument to measure something more than once. In simple terms, research reliability is the degree to which research method produces stable and consistent results.

Variables	N of Items	Cronbach's Alpha
Environmental knowledge (EK)	5	0.755
Ecological affect (EA)	4	0.812
Perceived consumer effectiveness (PCE)	5	0.650
Attitudes towards green consumption (ATG)	3	0.892
Green purchase (GP)	7	0.882
Green consumption promotion behavior (GCPB)	4	0.873

Table1: Results Reliability Statistics of Variables

Cronbach's Alpha values show that the variables used for testing are reliable. It can be seen that the lowest level is 0.65 (PCE) and the highest level is 0.892 (ATG). Cronbach alpha coefficients of variables > 0.6 so that variables are accepted and used to run correlation analysis.

Validity of the variables was tested through exploratory factor analysis (EFA), and the results show that six factors emerged, accounting for 64% (higher than the cut-off of 50%) of variance. The largest factor explained 39% (less than the cut-off of 50%) of variance. These results suggest acceptable validity of the study's variables.

Correlational test was also conducted. The purpose of running Pearson correlation is to test the linear correlation between the dependent variable and the independent variable, as the condition for regression is first to correlate. The results from correlational analysis suggest that all of the study's variables have significant correlational values.

Variables	Mean	SD	1	2	3	4	5	6
1.GP	3.970	0.998						
2.GCPB	3.636	1.009	.640**					
3.EK	3.768	0.991	.608**	.456**				
4.EA	3.948	1.050	.582**	.464**	.494**			

5.PCE	3.578	1.024	.634**	.480**	.516**	.603**		
6.ATG	4.220	0.959	.617**	.403**	.600**	.557**	.554**	

Table 2: Descriptive statistics and correlation for all variables.

Notes. N=230; GP: green purchase; GCPB: green consumption promotion behavior; EK: environment knowledge; EA: Ecological knowledge; PEC: perceived consumer effectiveness; ATG: attitude toward green consumption.

** Correlation is significant at the 0.01 level (2-tailed).

4.2. Hypothesis testing

• Regression analysis

After establishing the reliability test and exploratory factor analysis, the regression analyses were carried out. Regression analysis is an analysis to help researchers find out the linear relationship between independent variables and dependent variables. Additionally, the relationships which were given in the hypothesis model can be summarized and concluded. The results of regression analyses are shown in table 3, and it indicates that all of the proposed hypotheses are supported.

Direct effects	Coefficients	T values	Sig.	Outcomes
Customers' environmental knowledge → attitude towards green consumption (H1).	0.600	11.334	.000	Supported
Customers' ecological → attitude towards green consumption (H2).	0.557	10.117	.000	Supported
Customers' perceived consumer effectiveness → attitude towards green consumption (H3).	0.554	10.042	.000	Supported
H4: Customers' attitude towards green consumption → the green purchase (H4).	0.617	11.838	.000	Supported
H5: Customers' attitude towards green consumption → green consumption promotion (H5).	0.403	6.648	.000	Supported

Table 3: Results of direct effect

Through the regression indices in the table above, we can conclude that environmental knowledge has a great influence on consumer attitudes towards green consumption. The next is the ecological effect and perceived consumer effectiveness. It can also be seen that attitudes toward green consumption greatly influence the decision to buy green products. By examining hypotheses given by regression functions, the conclusion is that the behavioral model is consistent with the behavior of green consumption. Attitudes towards green consumption always have a positive effect on green consumption behavior. This has been

proven for all behaviors included in green consumption. This includes buying and using green products and promoting green consumption.

In each type of green consumer behavior, the level of influence of these factors is different. Green consumer behavior is positively influenced by consumer attitudes. Meanwhile, the attitude of consumers towards green products is affected by the following factors: environmental knowledge, ecological affect and perceived consumer effectiveness. A new conclusion derived from the above test is that consumers' attitude towards green consumption has a positive impact on behavioral promotion for green consumption. That means that a person who is interested in environmental issues and who has a positive attitude toward green consumption is more likely to engage in promotion behaviors for green consumption.

5. Discussion and Conclusion

To conclude, in this chapter there is the research progress out. Basing on this research progress and knowledge about methodology, this chapter is pointed the appropriate methods to research. Moreover, the sample size was chosen and even the research scale was established through five independent variables (quality, price, packaging, promotion and purchase intention) and one dependent variable (customer satisfaction). In addition, the approach processes data (SPSS) were also illustrated clearly. The last but not least, there is the limitation that were considered carefully.

5.1 Implications

Theoretical Implications

The results of this study provide theoretical contributions to the understanding of the green consumption behavior of Vietnamese consumers. Specifically, the results indicate that customers' personal factors like as perceived consumer effectiveness, environmental knowledge, ecological affect and attitudes toward green consumption significantly influence the behavior under investigation. For the contribution of research into the theoretical basis, this is the first empirical study to assess the effect of personal factors of the customer (perceived consumer effectiveness, environmental knowledge, and ecological affect) on green consumption behaviors in Vietnamese context. Meanwhile, most of the other studies in Vietnam on green consumption behavior are qualitative research and did not focus on the factors like the present study's.

Thus, this study provides a detailed view of the consumer behavior of green consumers in Vietnam. It also adds and reinforces the factors that influence the relationship between attitudes and behavior of green consumption. Furthermore, research has developed a new measure of green consumption promotion behaviors that is valuable for future empirical research of green consumption behaviors.

• Managerial Implications

The results from the equation modelling, by and large, support the hypothesized relationships of the proposed model. Specifically, it confirms the significant influence of ecological knowledge and perceived consumer effectiveness on attitudes toward green consumption. The results also confirm that attitudes toward green consumption impact on green purchase

behavior and green consumption promotion behavior. Hopefully, this better understanding of the process and antecedents of green purchases can provide the Vietnamese government and green marketers with some useful insights into improving the communication effectiveness of their educational and promotional campaigns. Especially for businesses, they should promote environmentally friendly products on the mass media or use e-commerce to provide knowledge, information about the environment, products and the benefits the product brings to the environment. Green marketers can take advantage of launching events, contests, and environment or green consumption events to reach potential green clients as well as improve perceived consumer effectiveness about green products.

5.2 Limitations and recommendations for future research directions

There are some limitations that this study has to face during researching. First, all of the variables in the research model were measured from one source known as customers which may cause some biases in relationships. Future research should use various measures for evaluating the relationships. Second, this study was conducted on customers in Ha Noi and the study object is people of over 18 years old. It is very hard to study with a large market, huge sample because of lack of time, human resources and cost. Future research may study on a larger scope with more customer groups and in larger areas.

6. References

1. Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting behavior*. Englewood Cliffs, NJ: Prentice-Hall.
2. Allen, Chris T. (1982), "Self-Perception Based Strategies for Stimulating Energy Conservation," *Journal of Consumer Research*, 8 (March), 381-390.
3. Aman, A. H. L., Harun, A., & Hussein, Z. (2012). The Influence of Environmental Knowledge and Concern on Green Purchase Intention the Role of Attitude as a Mediating Variable. *British Journal of Arts and Social Sciences*, 7.
4. Antil, John H. (1984), "Socially Responsible Consumers: Profile and Implications for Public Policy," *Journal of Macromarketing*, (Fall), 18-39.
5. Arbuthnot, J., & Lingg, S. (1975). A comparison of French and American environmental behavior, knowledge and attitudes. *International Journal of Psychology*, 10, 275 – 281.
6. B. C. Tan, and T. C. Lau, "Examining sustainable consumption patterns of young consumers: Is there a cause for concern," *The Journal of International Social Research*, vol. 2, no. 9, pp. 465-472, 2009
7. Bagozzi, R. P., Tybout, A. M., Craig, C. S., & Sternthal, B. (1979). The construct validity of the tripartite classification of attitude. *Journal of Marketing Research*, 16, 88 – 95.
8. Benton, R. (1994). Environmental knowledge and attitudes of undergraduate business students compared to non-business students. *Business and Society*, 33, 191 – 211.

9. Bredahl, L., (2001). Determinants of consumer attitudes and purchase intentions with regard to genetically modified food – results of a cross-national survey. *J. Consum. Policy* 24 (1), 23–61.
10. C. Teerachote, P. Kessomboom, A. Rattanasiri, and R. Koju, “Improving health consciousness and life skills in young people through peer-leadership in thailand,” *Kathmandu University Medical Journal*, vol. 11, no. 1, pp. 41-44, 2014. Abdul Wahid, N., Rahbar, E., and Shyan, T. S. (2011)
11. Chan, R. Y. K. (1999). Environmental attitudes and behavior of consumers in China: Survey findings and implications. *Journal of International Consumer Marketing*, 11, 25 – 52.
12. Chan, R. Y. K., &Yam, E. (1995). Green movement in a newly industrializing area: A survey on the attitudes and behavior of the Hong Kong citizens. *Journal of Community and Applied Social Psychology*, 5, 273 – 284.
13. Chan, Ricky Y. K. (2001).Determinants of Chinese consumers’ green purchase behavior. *Psychology and Marketing*, 18(4),389–413.
14. Consumers: Who Are They?" *Journal of Marketing*, 38 (April), 20-24.
15. D. L. Haytko and E. Matulich, “Green advertising and environmentally responsible consumer behaviors: Linkages examined,” *Journal of Management and Marketing Research*, vol. 1, pp. 2, 2008.
16. Davis, J. J. (1993). Strategies for environmental advertising. *Journal of Consumer Marketing*, 10, 19 – 36.
17. Dunlap, R. E.,& Jones, R.E. (2002).Environmental concern: Conceptual and measurement issues. In: R.E.Dunlap & W. Michelson, Editors, *Handbook of Environmental Sociology*. Greenwood Press, Westport, CT,482-524
18. Eagly, A., & Chaiken, S. (1993).*The psychology of attitudes*. New York: Harcourt Brace Jovanovich
19. G. E. Fryxell and C. W. Lo, “The influence of environmental knowledge and values on managerial behaviours on behalf of the environment: An empirical examination of managers in China,” *Journal of business ethics*, vol. 46, no. 1, pp. 45-69, 2003.
20. Geller, E. S. (1981). Evaluating energy conservation programs: Is verbal report enough? *Journal of Consumer Research*, 8, 331 – 335.
21. Grunert, S. C. (1993). Everybody seems concerned about the environment but is this concern reflected in (Danish) consumers’ food choice? *European Advances in Consumer Research*, 1, 428 – 433.
22. Hair, J. F., Celsi, M. W., Oritinau, D. J. and Bush, R. P. (2013). *Essentials of Marketing Research*. New York, U.S.
23. Hines, J. M., Hungerford, H. R., &Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education*, 18, 1 – 8.

24. Joseph F. Hair, Ronald L. Tatham, Rolph E. Anderson and William Black (1998). *Multivariate data analysis* (5th Edition). New York.
25. Kinnear, Thomas, James R. Taylor, and Sadrudin Ahmed (1974), "Ecologically Concerned
26. Laroche, M., Bergeron, J., Barbaro-Forleo, "Targeting Consumers Who are Willing to Pay More for Environmentally Friendly Products", *Journal of Consumer Marketing* 18 (2001), 503..
27. Laroche, M., Bergeron, J., Barbaro-Forleo, G., (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *J. Consum. Mark.* 18 (6), 503–520.
28. Li, L. Y. (1997). Effect of collectivist orientation and ecological attitude on actual environmental commitment: The moderating role of consumer demographics and product involvement. *Journal of International Consumer Marketing*, 9, 31 – 53.
29. Maloney, M. P., & Ward, M. P. (1973, July). Ecology: Let's hear from the people: An objective scale for the measurement of ecological attitudes and knowledge. *American Psychologist*, 583 – 586.
30. Maria Rosario Partidario, Rita C. Comes, "Ecosystem Services Inclusive Strategic Environmental Assessment", *Environmental Impact Assessment* 40 (2013) 36.
31. Martin, B. & Simintiras, A. C. (1995). The impact of green product lines on the environment: Does what they know affect how they feel? *Marketing Intelligence and Planning*, 13, 16 – 23.
32. Milfont, T. L. (2007). *Psychology of environmental attitudes: A cross-cultural study of their content & structure*. Unpublished doctoral dissertation, University of Auckland, Auckland, New Zealand
33. Moser, Andrea K. (2015). Thinking green, buying green? Drivers of pro-environmental purchasing behavior. *The Journal of consumer marketing*, 32 (3), 167-175
34. N. Noor, A. Muhammad, A. Kassim, C. Jamil, N. Mat, N. Mat, and H. Salleh, "Creating Green Consumers: How Environmental Knowledge and Environmental Attitude Lead To Green Purchase Behavior?" *International Journal of Arts and Sciences*, vol. 5, no. 1, pp. 55-71, 2012
35. N.T Dung (2015). Bài phát biểu của Thủ tướng Nguyễn Tấn Dũng tại Hội nghị Bộ trưởng Môi trường ASEAN lần thứ 13 - Cục Quản lý tài nguyên nước. [online] [Dwrn.gov.vn](http://dwrn.gov.vn). Available at: <http://dwrn.gov.vn/index.php?language=vi&nv=news&op=Hop-tac-quoc-te/Bai-phat-bieu-cua-Thu-tuong-Nguyen-Tan-Dung-tai-Hoi-nghi-Bo-truong-Moi-truong-ASEAN-lan-thu-13-4695> [Accessed 25 Nov. 2018].
36. Nielsen. (2014). *Global consumers are willing to put their money where their heart is when it comes to goods and services from companies committed to social responsibility*, 6-17-2014 ed.

37. OECD. (2016). Green Growth and Consumer Behavior. <<http://www.oecd.org/greengrowth/greengrowthandconsumerbehavior.htm>> [accessed 28.10.18].
38. Pickett-Baker, J., Ozaki, R., 2008. Pro-environmental products: marketing influence on consumer purchase decision. *J. Consum. Mark.* 25 (5), 281.
39. R. Jaganath, "A study on green purchasing behaviour of young consumers in mettupalayam (Coimbatore District)," *IJAR*, vol. 2, no. 3, pp. 678-681, 2016
40. Ritchie, J.R. Brent and Gordon H.G. McDougall (1985), "Designing and Marketing Consumer Energy Conservation Policies and Programs: Implications From a Decade of Research," *Journal of Public Policy & Marketing*, 4, 14-32.
41. Robert, D.S., James, A.R., (1999). Environmental segmentation alternatives: a look at green consumer behavior in the new millennium. *J. Consum. Mark.* 16 (6), 558.
42. Schahn, J., &Holzer, E. (1990). Studies of individual environmental concern: The role of knowledge, gender and background variables. *Environment and Behavior*, 22, 767 – 786.
43. Schultz, P.W., Shriver, Chris, Tabanico, J. J., & Khazian, A.M. (2004).Implicit connections with nature. *Journal of Environmental Psychology*,24(1), 31-42.
44. Schwepker, C. H., Jr., &Cornwell, T. B. (1991). An examination of ecologically concerned consumers and their intention to purchase ecologically packaged products. *Journal of Public Policy and Marketing*, 10, 77 – 101
45. Sylvia Lorek, Doris Funchs, "Strong Sustainable Consumption Governance Precondition for a Degrowth Path?", *Journal of Cleaner Production* 38 (2013) 36.
46. T. M. Stutzman and S. B. Green, "Factors affecting energy consumption: Two field tests of the Fishbein-Ajzen model," *The Journal of Social Psychology*, vol. 117, no. 2, pp. 183-201, 1982.
47. Tania Briceno, "The Role of Social Processes for Sustainable Consumption", *Journal of Cleaner Production* 14 (2006) 17, 1541.
48. Webster, F. E., Jr. (1975). Determining characteristics of the socially conscious consumer. *Journal of Consumer Research*, 2(3), 188–196.
49.). Factors Influencing The Green Purchase Behavior of Penang Environmental Volunteers. *International Business Management*, 5(1), 38-49.
50. Armstrong, G., and Kotler, P. (2009). *Marketing: An Introduction* (9th ed.). United States of America: Pearson Prentice Hall.

Communicating history to the youth through media: How to increase the interest and memory of youth for Vietnam's history

The research was carried out based on the level of historical reception and the interest of young people in history nowadays.

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Abstract

The research was carried out based on the level of historical reception and the interest of young people in history nowadays. The content of the research was based on long-term memory theories (The storage in sensory memory and short-term memory generally has a strictly limited capacity and duration), Maslow's hierarchy of needs (The physical needs of people are the desire to have enough food, water, rest, etc. These basic needs are inevitable because if people do not meet these needs, they will struggle to survive in their daily life.), and the Gratifications theory (The approach to understanding why and how people actively seek out specific media to satisfy specific needs).

The process of conducting a survey with respondents being mainly young people (in this case, students) has shown actual attentive situations such as the low-level interest of young people in history, the roles of the national media in creating the interest in history of the country, and the significant differences in the knowledge of youth about the cultural history of Vietnam and other countries.

This research aimed to address the limitations of the Vietnamese media in communicating history to the youth, as well as identify the channels of media that can increase young people's interest. Furthermore, suggestions were made to improve the media communication of Vietnam's history in order to achieve positive effects on the viewers or readers.

Keywords

Vietnam, Vietnam's history, young people, youth, history, interest, long-term memory, Maslow's theory, gratification theory.

1. Introduction

This research will analyze the result of the survey collecting opinion of young people about their interest in history, especially Vietnam's history and find out the channel of media, which have the most effective impact to deliver the knowledge.

In preparation, we made a Google-Form-survey asking people, mostly youth to understand the current situation in order to solve it. There are 263 people, who took part in this survey.

The approaching methods are used in our research:

Maslow's hierarchy of needs

Maslow's hierarchy of needs is a theory in psychology proposed by Abraham Maslow in his 1943 paper "A Theory of Human Motivation" in *Psychological Review* (Maslow, 1943). The theory represented as a 5-stage pyramid with the more basic needs at the bottom. These stages (from bottom to top) are physiological, safety, love/belonging, esteem and self-actualization.

Uses and Gratifications theory

Uses and gratifications theory (UGT) is an approach to understanding why and how people actively seek out specific media to satisfy specific needs. UGT is an audience-centered approach to understanding mass communication. The UGT assumes the audience chooses what it wants to watch for different reasons like information and education, entertainment, personal identity, integration and social interaction, escapism... (Anon., n.d.)

Long-term memory

Long-term memory (LTM) is the stage of the Atkinson–Shiffrin memory model where informative knowledge is held indefinitely. It means that you can recall something that happened recently or even longer. These memories can last for a few days, or for many years. (Anon., n.d.)

2. Problem

We have read some articles about historical movies of Korea which were shown on cinema have even made profit as much as the action, rom-com or blockbuster movie from Hollywood. They said that on holiday in Korea, families tend to take their members to cinema to watch movies together, and they are happy to watch some movies, which can bring them knowledge and make them proud and understanding about their countries.

Comparing to our country's situation, Vietnamese movies are normally rom-com and comedy. The cinema audiences choose the movies based usually on the need of entertainment, more than receiving knowledge or education. We realize that we ourselves like to watch the historical movies or films of China, Korea or Japan too. Although our history has as much stories as other to tell or even more, unfortunately our media still do not focus on this area, so that the approach of audiences is limited.

Seeing that situation we decided to do a research, in order to identify the reason and find out which way can improve the interest of people, especially young people. The result of survey showed that through the scale from 1 to 5, there were about 61% of people feeling not really interested in history, took over more than half of the responses (Figure 1). Some opinions said that they could not sense the importance of the media in delivering history to the audiences. The media mostly focus more on entertainment but education, especially history. The sources of history knowledge are still limited and objective.

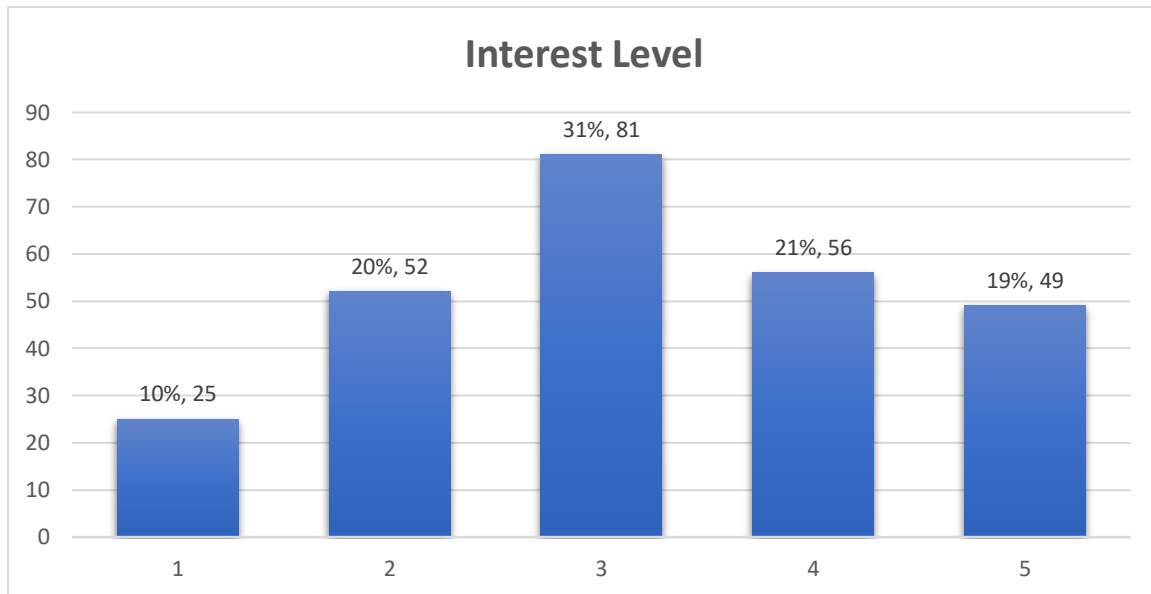


Figure 1- Interest Level in History

3. Plan implementation

To conduct the research, we used the Google Form – a survey administration app that allows collecting information and data from responses. We created a survey includes questions with multiple choices and short answer, in order to approach the youth to answer these. The survey was shared mostly through Facebook, to some universities, high schools and secondary schools.

Data was collected and analyzed by using both Google Form tool and Microsoft Office (Excel and Word). We also consult the opinions of our instructor and the references from internet.

4. Analysis

4.1 Demographic profile

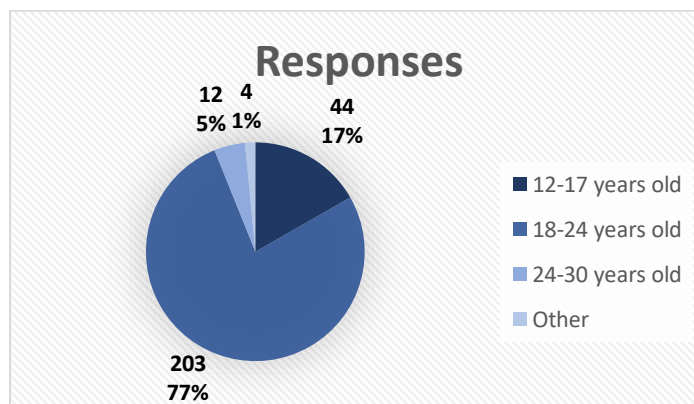


Figure 2- Age group of responses

The main target of our research is young people. The main age group is from 18-24 years old (77% of 263 responses). The other age group are 12-17 years old (17%), 24-30 years old (5%) and other (1%)

The people with age from 18-24 mostly have finished their high school, attended to college or just started to work. They have already had the knowledge base after graduated. They want to be updated, want to learn something new and can learn things fast, besides they are easy to be distracted by other factor.

4.2 Level of knowledge of several countries' history

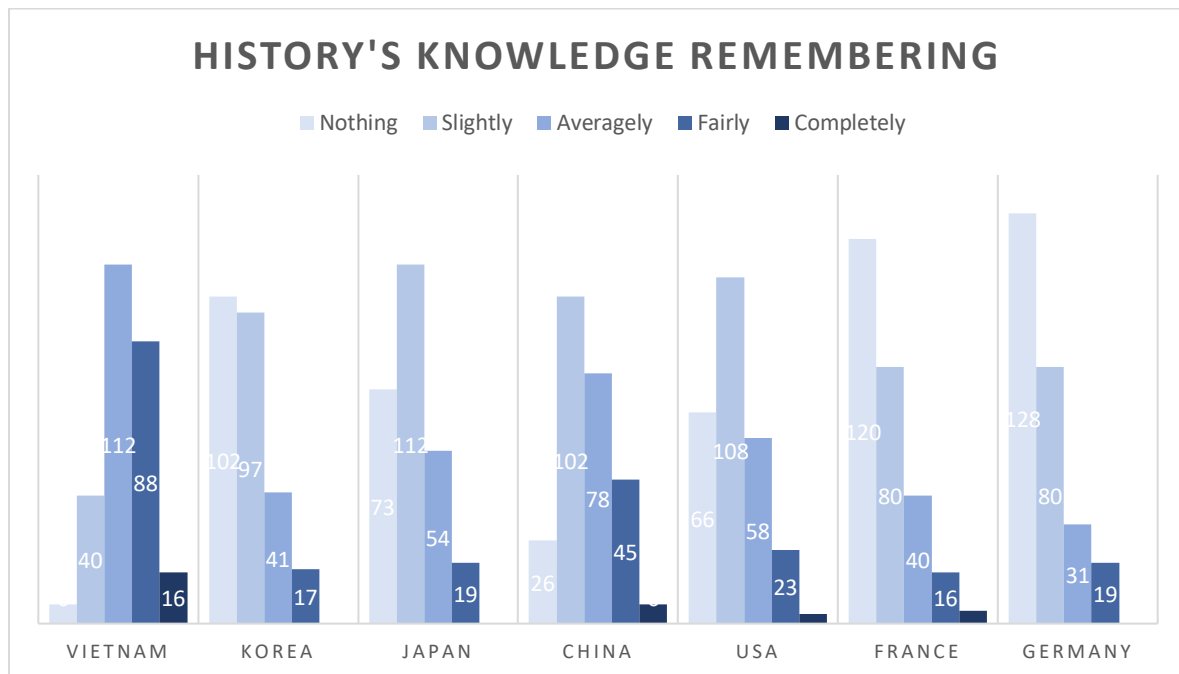


Figure 3- Level of History's Knowledge Remembering

Even though history is a cold lesson and might not create the interest for the young people, according to the figure 3, the data of level of self-evaluation about Vietnam's history's knowledge remembering is quietly high (82% averagely, fairly and completely), especially 6% (16 people out of 263) have perfectly knowing about our country's history. However there are still 17% (46 people) not be confident about their historical knowledge.

The youth approaches Vietnamese history mostly through education at school. However the other countries' history, although not be focus on at school, but some young people still have standard knowledge. We can see that there are still some people have completely knowledge of China, USA and France's history.

4.3 Rate of occurrence of searching history's information through the channels of media

Looking to the figure 4, the traditional channels of media like books, documentaries and newspaper are approached less by youth to gain information about history (60% books, 44%

documentaries, 52% through newspaper out of 263). Books here are mainly textbooks, not other type of historical books. These channels are difficult to create interest for youth in history.

The “unofficial” channels are movies, cartoons, comics, internet...Nowadays with the development of technology as well as the demand of entertainment, the youth usually goes online to search information and entertainment. Through our survey, we realized that the frequency of using these channels to discover history is higher than the above (68% movies, 49% cartoons, 55% comics, 80% through internet out of 263). With these channels, media can create more interest for young people and from that they might have intend or volunteer using these channels as a tool for gaining knowledge.

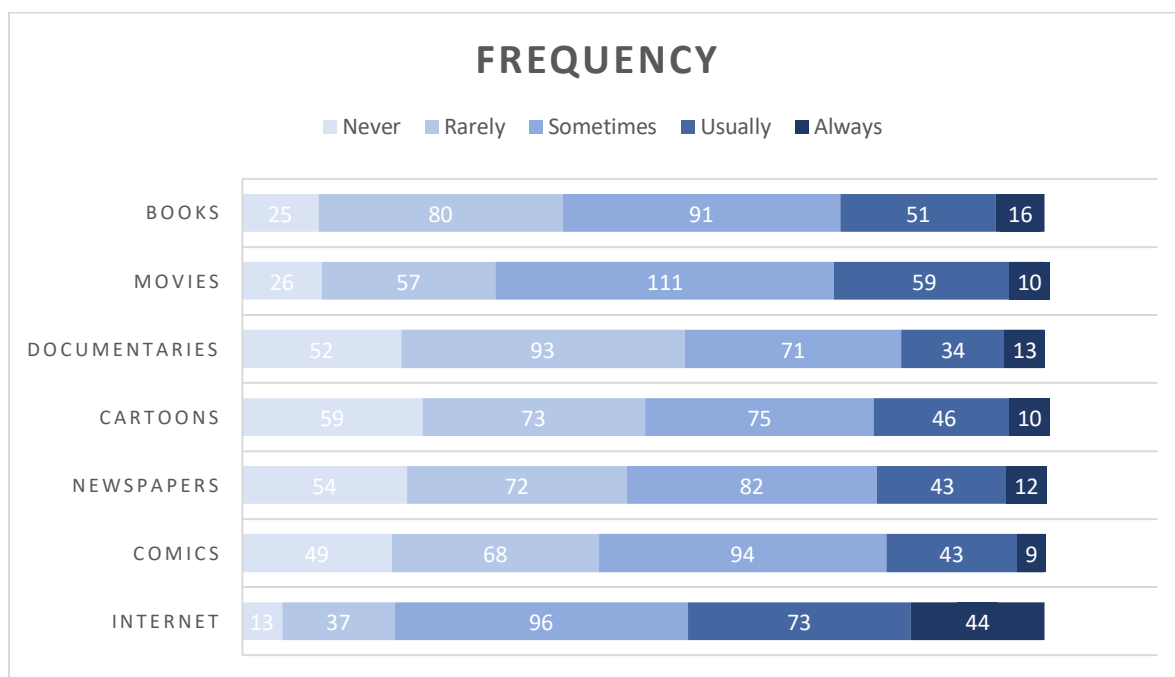


Figure 4- Frequency of searching history

4.4 Remembering percentage of history' knowledge through the channels of media

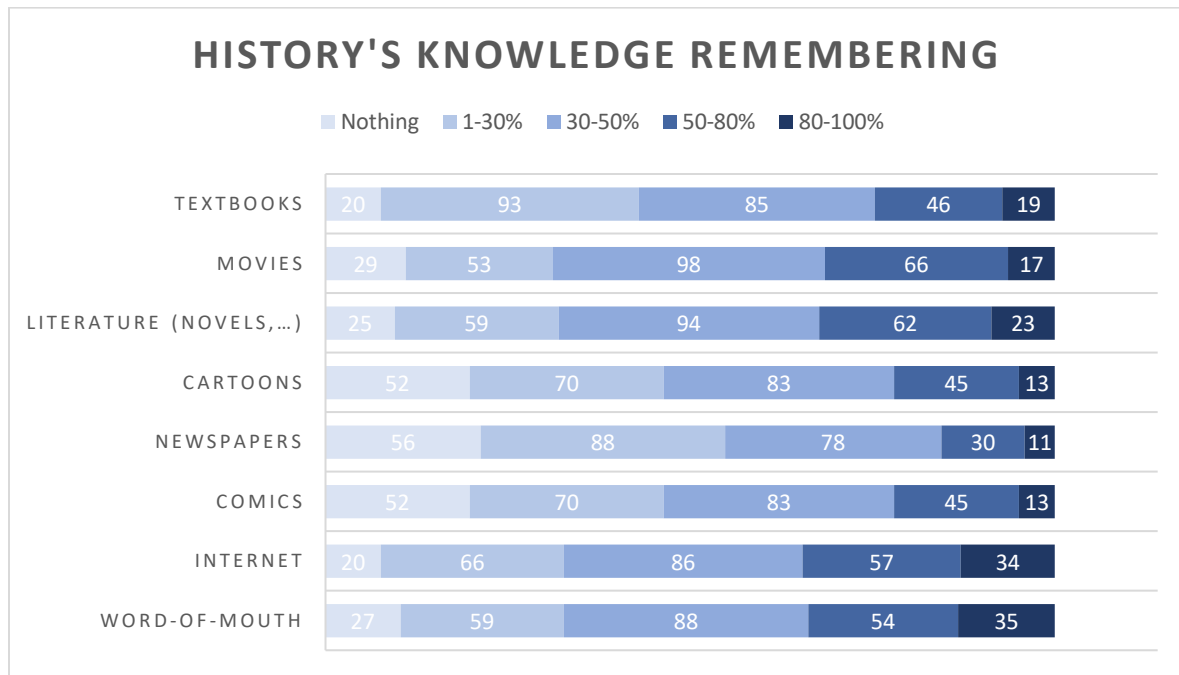


Figure 5- History's knowledge remembering

The channels with mainly script or calligraphy play small role in helping youth remember history. 43% and 56% said that through textbooks and newspaper they recall nothing or to 30% historical knowledge. The role of these two “official” channels in communicating history is as big as cartoons and comics, which are not related mainly to history. We can realize the lack of impact of textbooks and newspaper.

Movies and internet have the same amount of people who said they could recall 30-100% of history (69% and 67%). With colorful images and motions, with sounds and interaction, these channels have success in transferring historical information and attaching it to the memory of audiences. Literature like novels are mainly calligraphy but still have the ability to help the reader remembering (68%) because of fiction and imagination. Word-of-mouth contains interaction between people and most of information came from experience. The empathy and belief make people remember longer.

4.5 The impact of some channels of media in creating interest

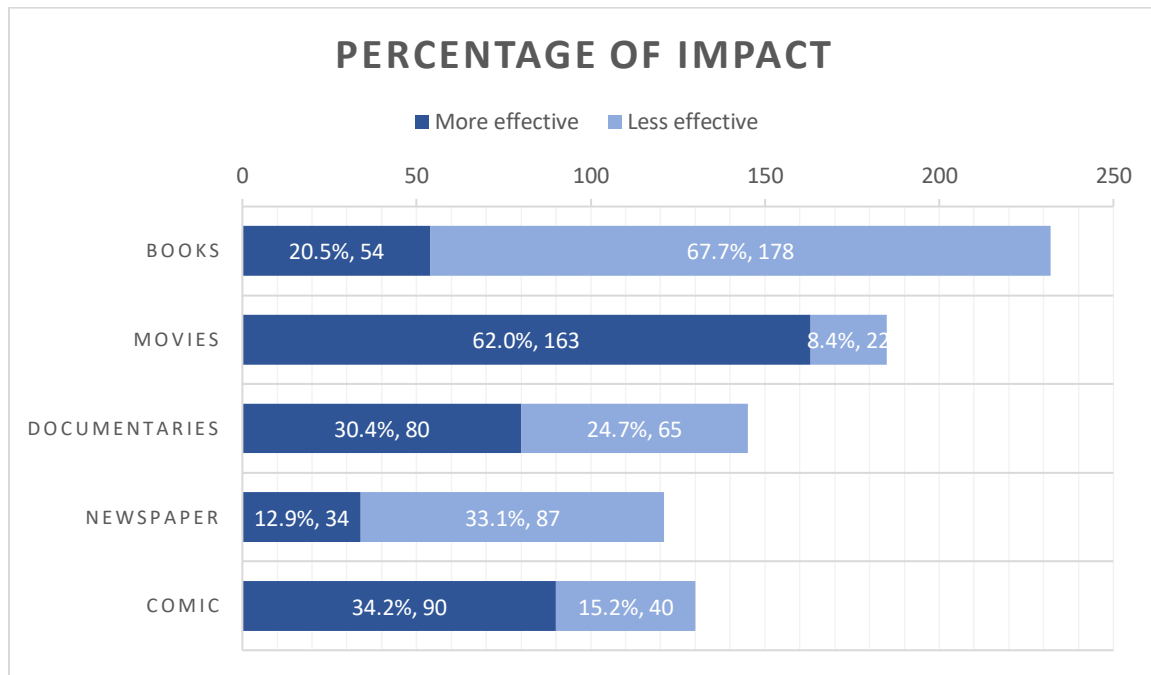


Figure 6- Impact of Media channels in creating interest

The bar chart shows that young people remember history effectively from movies (62%), comics (34.2%) and documentaries (30.4%). The least effectively channels are books (20%) and newspaper (13%). In conclusion, the “unofficial” channels create more interest as well as effective in remembering history knowledge for the youth than “official” ones.

4.6 Some opinions of responder

When being asked about the role of Vietnamese media, some said:

“Media has made an attempt to bring history closer to young people, yet transmits in a dry, stereotyped way, so it's hard to get into young people's minds and create interest.”

“Vietnamese media plays a very important role in the communicating of history, but not really appropriate. For students, learning history through textbooks is just learning to answer the teacher, then the knowledge left in the head very little or nothing at all because they are not persuaded to remember this subject. As a person who loves history, I myself cannot remember the knowledge through the dry lines that I study in pictures, newspapers or other available resources.”

“I feel most Vietnamese have little knowledge about the history of the country. What is known (other than historians) is Chinese history through movies and the Internet, but those sources may not yet be 100% authentic.”

“I think the transmission of history in Vietnam focus too much on knowledge, make it difficult for beginners. There should be historical products which are easy-to-read, to-watch so that people are first interested in history, and then look to more detailed research materials.”

After looking through some opinions, most of the responders appreciate the role of Vietnamese media, however they did not evaluate its impact high enough. Also the media still is stereotype, limited and objective, which is difficult to attract young audiences.

The people who answered the survey also gave us some solution to improve the situation:

“Consider cutting historical content in the school if possible, emphasizing to highlight importance and important parts of your knowledge. Also, there should be more active forms education so that people can easily learn and memorize.”

“Bringing history into the arts of entertainment, from which easy to go into our heart. See how Japanese preserve the beauty of tradition; how Koreans put their national characteristic on film to globalize; how Chinese restore the traditional culture after the Cultural Rift”

“Communicating history with things which are familiar to modern people. For example, Chinese use of historical material to make a film or even vary a little to make an attracting novel.”

5. Conclusion

With the results of survey and analysis of data:

The interest of Vietnamese youth to history is not high enough.

The capable of remembering historical knowledge is low.

The role of Vietnamese media in communicating history to the youth is limited and weak.

As we know, entertainment attract the attention of the youth more than a cold history lesson. In addition, information through entertainment will stay longer in memory. That why it is a better solution to combine education with entertainment in order to communicating history. We can make cartoons or anime with the historical content to approach the youth; we can learn from the other countries like Korea or China to product historical films, movies and novels as well. Teaching history at school should be improved in order to not create “history-phobia” before create interest for youth.

Acknowledgment

A complete research would not be done without any assistance. There for the authors who conducted this research gratefully give acknowledgement to their support and motivation during the time of doing this.

Firstly, we would like to acknowledge our thanks and gratefulness to our supervisor - Mrs. Trinh Thi Mai – Lecturer of Media Psychology. She always give us advices and support during this research. Without her motivation, instruction and encouragement, we might not be able to finish this work during the time of Final Exam.

Secondly, our research has been done with lots of help from our friends and families. They supported us by helping to share and answer the survey. We could not gather enough data for the research without them.

We also want to send our thanks and gratefulness to the organizers of the program, who have create opportunities for us to join the meaningful event.

References

Anon., n.d. brainHQ. [Online]

Available at: <https://www.brainhq.com/brain-resources/memory/types-of-memory/long-term-memory>

Anon., n.d. revision world. [Online]

Available at: <https://revisionworld.com/a2-level-level-revision/media-studies-level-revision/uses-and-gratifications-theory>

Anon., n.d. Wikipedia - The Free Encyclopedia. [Online]

Available at: <https://en.wikipedia.org>

[Accessed 26 November 2018].

Cutler, D., 2014. High School History Doesn't Have to Be Boring - The Atlantic. [Online]

Available at: <https://www.theatlantic.com/education/archive/2014/05/how-i-teach-history/361459/>

[Accessed 26 11 2018].

Harris, R. J. & Sanborn, F. W., 2014. A Cognitive Psychology of Mass Communication. 6th ed. New York: s.n.

Maslow, A., 1943. A theory of human motivaton - Psychological Review. In: s.l.:s.n., pp. 370-396.

Severin, Werner, Tankard & James, 1997. Communication theories: Origins, methods, and uses in the mass media. s.l.:Longman.

The impact of Facebook's communication strategies on the eating behaviors of young people in Hanoi

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Abstract

The eating habits of Hanoi's young people today are heavily influenced by the media and social networks. This research was conducted to determine the influence of forms of communication and advertising on Facebook - the largest social network today - to the consumption behaviors of young people in Hanoi. From there, we give recommendations on helping businesses in the food industry understand the customer psychology to build effective communication strategies.

Methodology: This research report is based on a survey of people aged 15 to 25 living in Hanoi. We built a questionnaire that met the goals of the research to determine the time it took to reach out to young people, learn about their eating habits and criteria for selecting products. The research content is ensured based on theories of Mass Communication, Albert Bandura's Social Cognitive Theory, and George Gerbner's Cultivation Theory.

In this research report, we have concluded that the ongoing development of Facebook communications has had a major impact on the behavioral change, eating habits, as well as selection criteria of food related products of Hanoi's young people. From there, we suggest different ways to help businesses develop communication strategies based on customer psychology, as well as to promote food consumption among young people.

Keywords

Eating habits, Facebook, Young people in Ha Noi.

1. Introduction

Today, social networking in general and Facebook is a very important part of our lives. So social networking and Facebook will influence our habits and interests. Not only the daily habits, but also the eating behavior and the way we choose food.

Online eatery service is becoming more and more friendly and professional, demanding the stores need enthusiastic as well as experienced team. Quality of service not only good, but also beautiful, delicious, strange. That is what makes the store always dedicated to customers and develop directions to meet the tastes and needs of consumers.

In this research report, we have concluded that the ongoing development of Facebook communications has had a major impact on the behavioral change, eating habits, as well as selection criteria of food related products of Hanoi's young people. From there, we suggest different ways to help businesses develop communication strategies based on customer psychology, as well as to promote food consumption among young people.

2. Problem and Solution plan

After designing the research question system. We recorded 500 data from 500 different people. Research checked and removed questions failed or People not at the research age need. The result is 445 data tables (88,2%) ensure reliability for evaluation. The survey is distributed by the elements:

1. The purpose of the research

- Find out about Facebook's impact on customers' choice of food
- Find out what are the current consumer needs about food on Facebook.
- From there, we give recommendations on helping businesses in the food industry understand the customer psychology to build effective communication strategies.

2. Research Methods

- This research has been investigated through online interviews in the famous food groups on Facebook and form filling.
- The survey is divided into 7 main objectives:

Part 1: Personal information (age, accommodation)

Part 2: Find out the social network that has the greatest impact on young people finding food

Part 3: Determined the most period of time the media access to Hanoi's youth

Part 4: Determine the criteria for choosing food products

Part 5: Determine the eating habits

Part 6: Find out the way customer buy food products

Part 7: Extent affect eating habits through Facebook

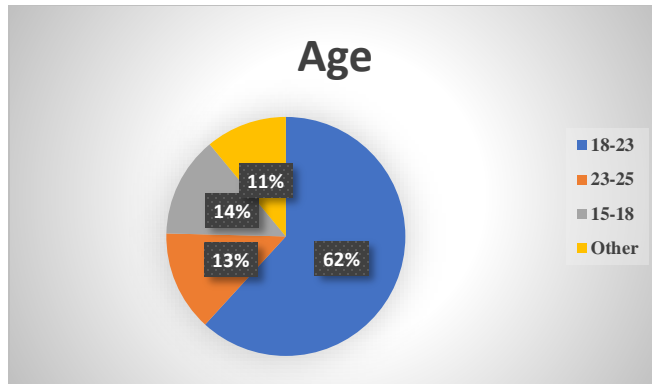
- Research location: Hanoi (Fanpage and group about food on Facebook)

3. Plan implementation

- We do online interviews in the famous food groups on Facebook and form filling.
- We refer in the relevant research and survey.

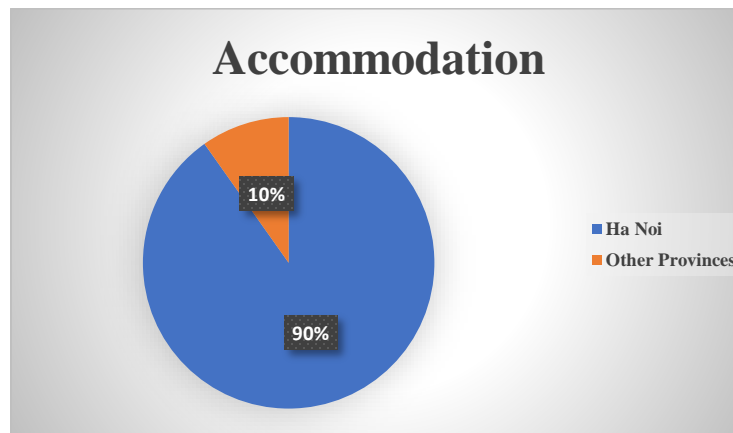
4. Analysis

4.1 Determine the age of the object of research



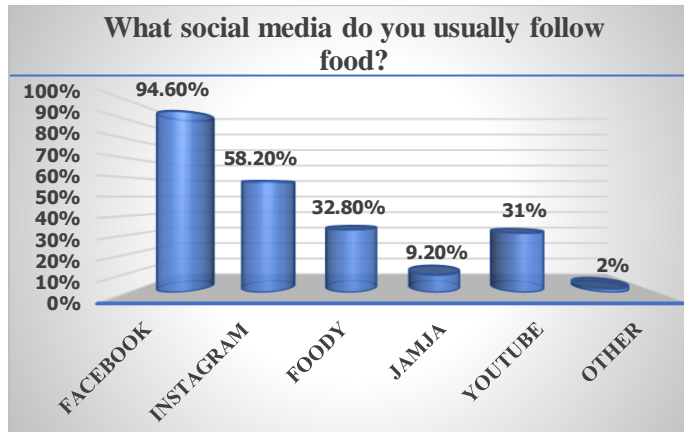
Zoned groups of research subjects are 18 to 25 years old, students, students and those new to work. From about the age chart shows, in this survey, the majority of the audience is in the 15-18 age group 3 (11%), 18-23 (62%), 23-25 (13%) of the remaining 14% is composed of different ages from 25 to 60 years.

4.2 Zoned area of the object of research



From the chart, we see the objects we study amounts to 90% is living in Hanoi and only 10% live in other provinces, from which the survey focus right audience needs study and survey results are accurate.

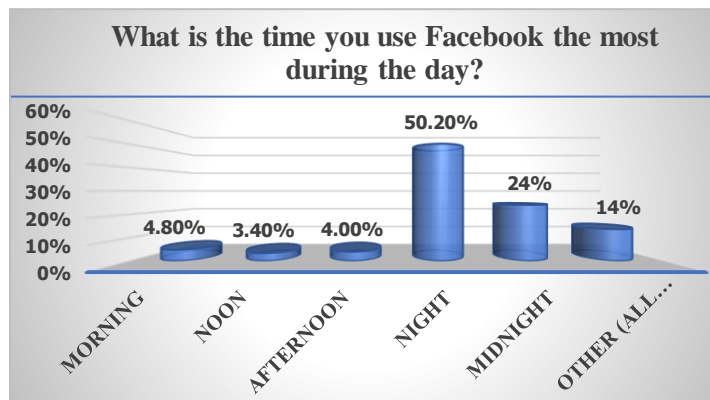
4.3 Social Networking was the young use the most, the biggest impact for youth in choosing the food



From the chart, we notice, 2 social network that clients access objects primarily to track food as Facebook (94.6%) and Instagram (58.2%). Other social networks are people mentioned there are some other applications such as: Delivery Now, Tumblr, etc.

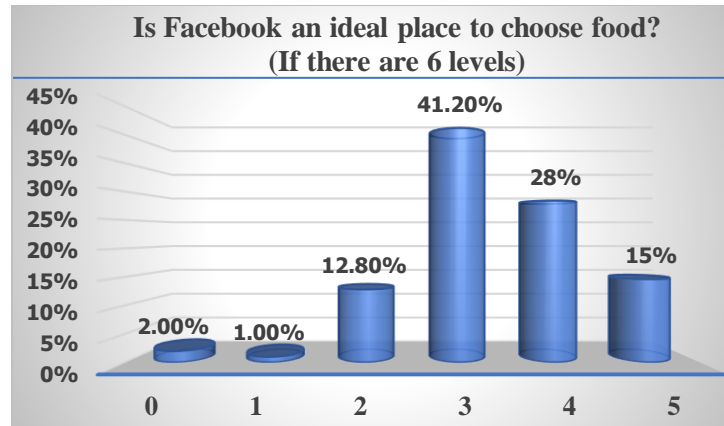
Facebook is the target market and the potential for sales of food products and promotion of food and beverage venues.

4.4 Identify the time it takes to reach out to young people on Facebook



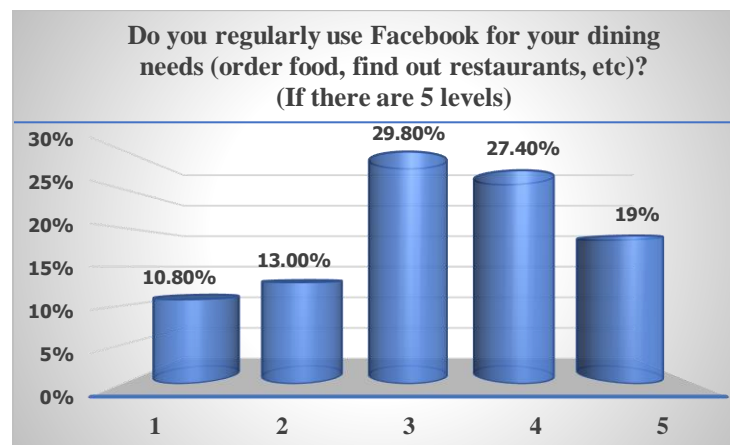
From the chart, the time that most people use Facebook is the evening (50.2%), followed by the night (24%). This is the second "golden" period for us to set up advertising programs or product communications on Facebook channel (Group, Fanpage, etc) to achieve the most interactive.

4.5 Assess the ideal level of Facebook in choosing food



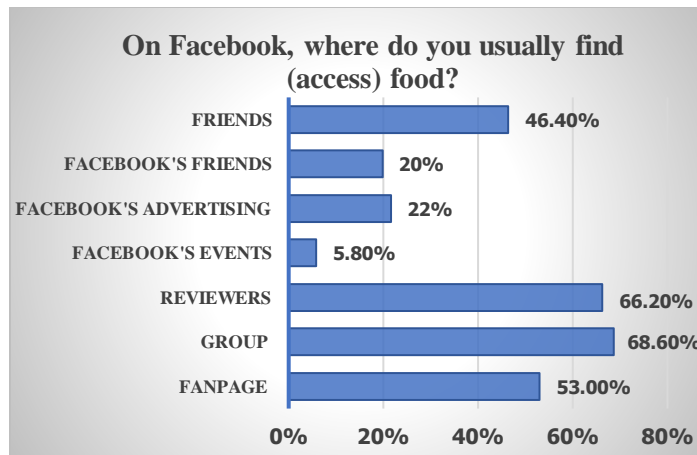
- According to survey results, most customers choose the level of 3,4,5 for the ideal of Facebook in the choice of food. The highest percentage was at level 3 (41.2%). This was the average level, followed by level 4 (28%) and level 5 (15%).
- This proves that Facebook needs more aggressive advertising campaigns about food, to attract more customers.

4.6 Assessment the level of using Facebook to choose food in the present time



- From the chart, the frequency of using Facebook for food choices running along three levels is 3, 4, 5. Again, Facebook claims its position with the customers. It is a place to satisfy your eating needs: order food, find restaurants, etc.).

4.7 Reviews of the channels on Facebook that the client can reach the food



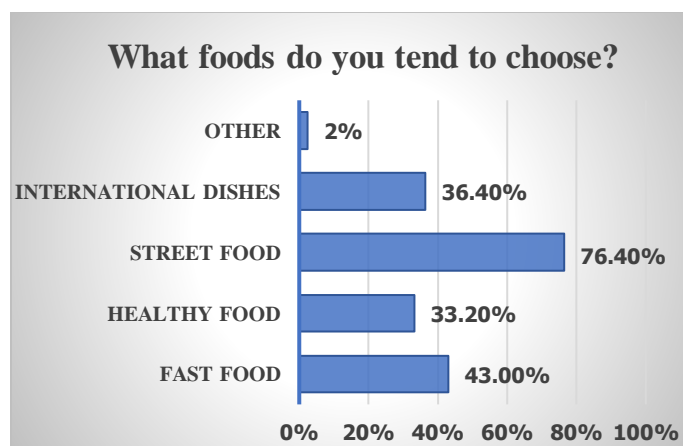
Facebook has a lot of small channels and all of them can be exploited so that customers can access the food. According to survey, Facebook's favorite channels are food groups (68.6%), reviewers (66.2%), fan sites (53%) and friends (46.4%). There are events or ads on Facebook, but they account for a much lower percentage.

We can leverage these channels to launch strategies and campaigns to promote food related products, resulting in high levels of interactivity and reach.

4.8 Analysis of eating habits of Hanoi youth aged 15-25:

The eating habits of Hanoi's young people aged 15-25 will be determined by the main contents: food choice trends such as healthy food, street food, fast food, food traditional and international ...

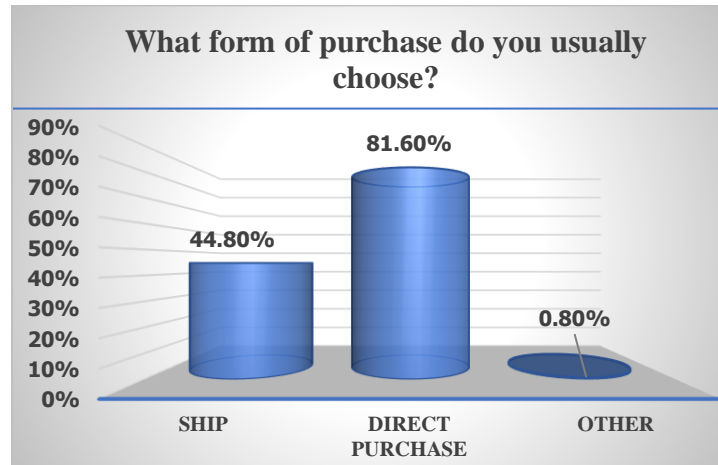
- Based on the research results, the foods have a fairly even distribution. However, the largest selection was street food with 76.4% (382 votes). The others foods such as: fast food, health food, traditional and international food have a fairly equal selection rate. This reflects the eating habits of young people in the 15-25 age who are most concerned about street food.



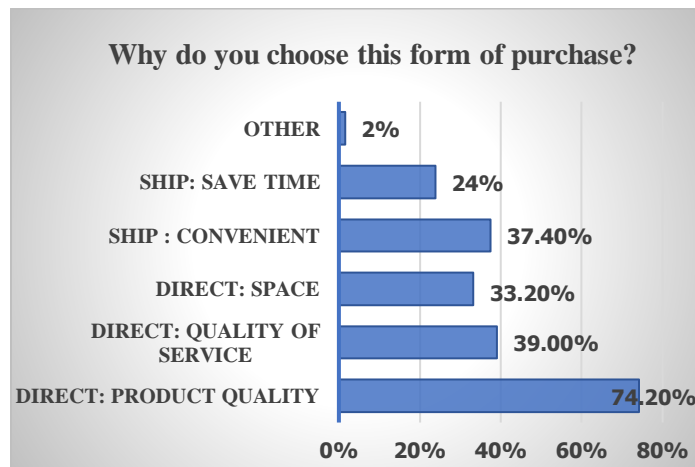
4.9 Buying, eating behavior and their impact on young people:

Trends in buying and eating food of youth people in Hanoi:

- Demonstrated through the purchase method of the object. There are two main ways to buy: buying directly at the store and call the delivery. In which the number of people choosing to buy directly accounted for more than 408 votes (81.6%). The other 224 votes (44.8%) were chosen as delivery options.

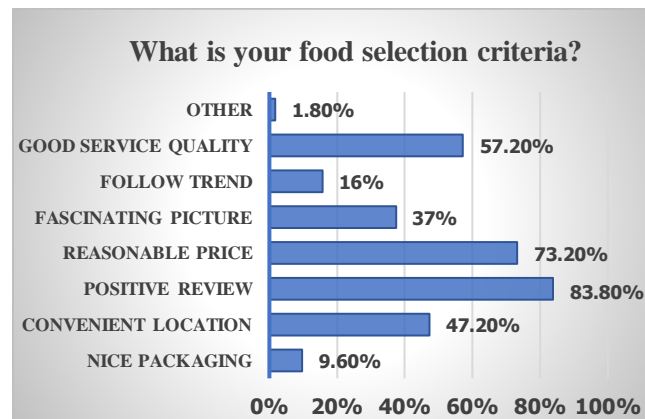


- In which, the main reason for young people to choose the direct purchase are: ensure the quality of products 74.2%, service quality 39% and location 33.2%. In addition, 37.4% of the respondents for home delivery and 23.8% save time. In general, Vietnamese youth are very active in buying food products. The forms of purchase are also diversified and the form of delivery is also becoming quite popular because of the convenience. The purchase of food through the form of transportation has become a habit for many people. However, young people still put high standards of quality products and services on the top.

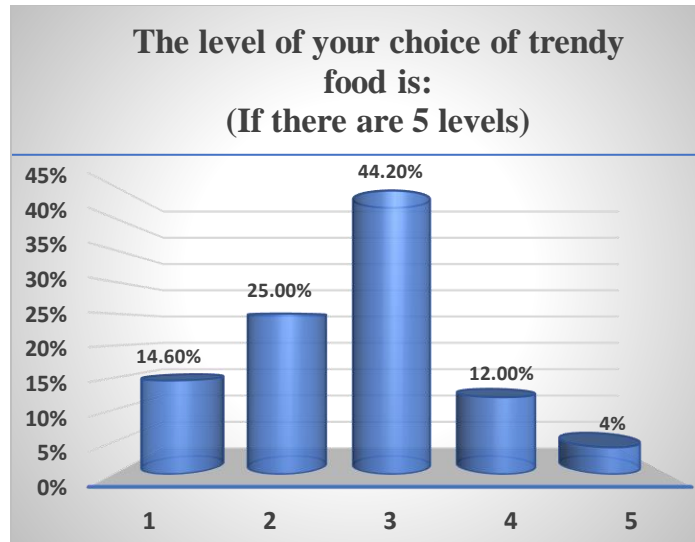


Factors affecting the determination of food consumption among young people in Hanoi:

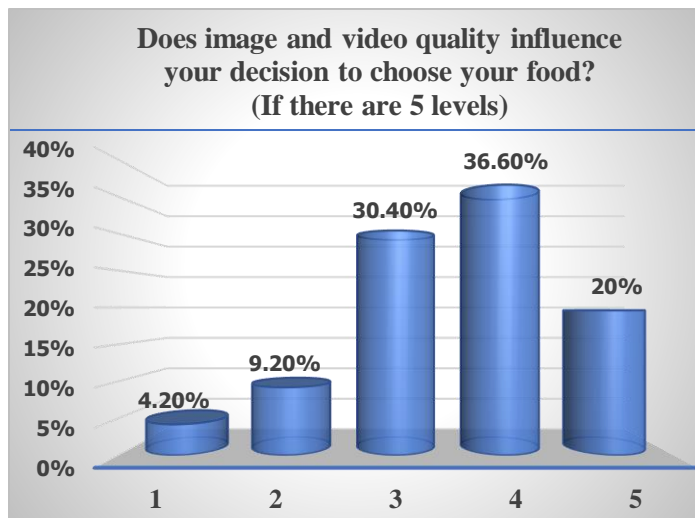
- Factors affecting the determination of food consumption among youth in Hanoi: Statistical results show that there are seven main criteria that affect the decision to select the product of the object. Among the four most important criteria for the majority of respondents were: based on positive evaluation of relatives, friends (419 participants or 83.8%), affordable (366 participants or 73.2%), good (286 people or 57.2%) and convenient (236 people) people) or 47.2%). In addition, there are other secondary criteria, most of the images and media of the product also affect the decision to choose food of the youth: attractive ads (187 votes (equivalent to 37, 4%), beautiful packaging (9.6%) and product "trend" update (79 votes equivalent to 15.8%). This indicates that although the criteria that affect each person's choices are different, it is based on two basic needs: quality and packaging.



- Degree of selection of food according to the trend, the trend of the object is quite often. This is shown in the Likert scale of 5 steps. The average of the scale (quite interested) has 221 votes equivalent 44.2%. This is a fairly high level in the scale, reflecting the influence of young consumers on trendy products. None of which is completely unaffected, That means choosing the product of the object is not based on the trend. In addition, the number of people who are interested in the product updated according to the trend is 12%, while there are people who do not care about 14.6%. This confirms the importance of campaigns, media creation and trend updates that have a great influence on young people's choice of products.



- Besides, the image quality, video advertising food also have a great influence on the decision to choose the product. This is showed from the results of the survey, with the majority of respondents choosing the image quality, video hype (86.6%).



5. Experimental results and conclusion

After making the general operation, analysis, reviews, research draws a number of conclusions:

- Facebook is an ideal medium for promoting food and eating places.
- The main time people spend on Facebook is late night and night, and we need to take advantage of this time to offer the right campaign.
- More than half of people surveyed regularly use Facebook to choose their food, which shows how popular Facebook is with today's diet.
- Facebook has a number of small channels for consumers to access, and the most accessible are Reviewers, Group, Fanpage and Friends.
- In general, young people aged 15-25 living in Hanoi tend to be more active in eating behavior as well as in food shopping.
- There are seven main factors that affect the decision to eat by young people: affordable, good service quality, positive reviews from relatives, friends, convenient location, nice packaging and trend updates.
- There is no difference in the level of behavior occurring in demographics.

In addition, contributing to promote the restaurant business, food business targeting young people aged 15-25 in Hanoi. In addition to supporting businesses and restaurants to improve the quality of their services for clients, the study has several recommendations as follows:

- Make the most of the "golden" time of the evening and night to promote products as well as eating places, media campaigns to bring in and interact.
- In addition, the use of effective communication channels: Reviewers, Group, Fanpage and Friends, have great impact on customers, become the main communication channel, this will bring high efficiency, accurate impact. Into the target audience without taking too much time to learn.
- Promote the frequency of communication, promote on Facebook. Many customers have not selected Facebook because there are few appearances of communication channels, information is not enough and quality to reach the target customers.
- Diversify product categories with product quality. Advertising many traditional products, street snacks, healthy products.
- Invested , concentrate on pack products. The video images advertise on the media. Especially the Facebook -social network has the most influence on young people today.
- Build trust with consumers. Origin of goods must be clear, honest, ensure food hygiene and safety.
- Focus on the location: clean, spacious, young, dynamic, stylish design to attract young people. Create a friendly space while eating and shopping with young people
- Add delivery service. Deliver on time and ensure good product quality when it reaches the consumers.
- Organizing programs, advertising activities, promotions to stimulate shopping to attract the attention of consumers. The results of the study show that price factors determine a great deal of consumer behavior, so price or product promotions will be a viable channel to draw young people to shopping, dining at the shops, restaurants.
- Standardize to customer care policy. Researchers should be provided with support services when using the services of the restaurant such as delivery services. The exchange channel answers the customer's question, channels of customer complaints. In addition, the activities to create the link and loyalty of the customer should also be interested.

Acknowledgment

First of all, I would like to express my endless thanks and gratefulness to my supervisor Ms. Mai (Trinh Thi Mai). Her kindly support and continuous advices went through the process of completion of my research. Her encouragement and comments had significantly enriched and improved my work. Without her motivation and instructions, the research would have been impossible to be done effectively. I would like to state my thanks to FPT University and the organizers for allowing us to participate in this research competition for more new experiences.

References

- [1] Social Cognitive Theory (Social Learning, Observational, Learning, Modeling) first developed by social psychologist Albert Bandura and his associates in the 1960s (Bandura, 1977 ;Bandura, Ross, & Ross, 1961 , 1963 ; Bandura & Walters, 1963).
- [2] Cultivation theory - Developed by George Gerbner and his colleagues.

The level of psychological impact the audience has when communicating with media products has a detailed description of the criminal form

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Abstract

This report was based on the current situation of the media spread with violent content and especially offenses described in detail without the protection of information. The research covers the content based on the theories of mass communication, such as the Social Cognitive Theory by social psychologist Albert Bandura, or the Cultivation Theory by George Gerbner and his colleagues in the Cultural Indicators, etc. In this research report, we aim to prove that the overwhelming presence of the media has strongly influenced the viewer's emotions, perceptions and behaviours, as well as how to identify the level of influences. Moreover, after the research, we will be able to synthesize and classify the audience with psychological levels at each level. From that, we will offer suggestions on how to reduce the negative impact on the psyche of the viewers / readers. Our research also aims to reach all audiences, irrespective of age, gender, religion, or ethnicity. The number of people approached for this research is 300, and the average interaction with the survey is over 90% of the number of people approached.

Key word: *Emotions, Perceptions, Behaviour.*

1. Introduction

No longer arguing, we are slowly becoming dependent on a technological development that allows billions of individuals worldwide to connect. But, are we being exposed to the best from the media? In today's digitized world, people are more likely to come in contact with the mass media at virtually every moment of the day. They are free to do what they like, are not limited to exploring and are not sufficiently aware to filter information online.

With this vision, the media is wandering into the lives of individual families and enticing people into a virtual world, with false values of living and frivolous levels. In the future, the influence of the media is becoming more intense and many aspects of social life are more seriously disturbed. This is a very big and challenging problem for young people, parents, the Church, and society.

Columbia University Research Center (USA) - CASA Columbia - discovered the relationship between adolescents, social media habits and drug abuse. Researchers have found that 70% of teens aged 12 to 17 - about 17 million users - spend most of their time on social networking sites. This study also found that teens who regularly used social networking sites had a five times higher probability of using tobacco, three times as high for alcohol, and twice as high for marijuana.

In addition, about 40% of the teens surveyed said they saw the image of people who were on social networking sites making them more interested in marijuana than four times more

likely Who does not come in contact with these images. The data collected shows that those who see drug and alcohol images tend to be curious and want to try.

2. Problem and solution plan

Studies on violence in the mass media analysis the correlation between violent themes in media sources (especially violence in video games, television and film) with realism and violence in the real world over time. Many social scientists support the relationship. However, some scholars believe that communication research has problems in methodology and that these findings are exaggerated. (Ferguson & Kilburn, 2009; Freedman, 2002; Pinker 2002; Savage, 2004).

Complaints about the detrimental effects of the media appear throughout history, and even Plato is concerned about the impact of the plays on young people. Multimedia / genre, including dime, comic, jazz, rock and roll, role play / electronic games, television, film, internet (computer or mobile) and many Other have become aggressive, rebellious or immoral.

Therefore, the study was conducted to examine the psychology of a group of people who, after exposure to the media, have detailed descriptions of the offense. From there, there are solutions, the selection before contact with the media. Especially for parents who can control the communication channels that their children can receive.

3. Plan implementation

- The object of study: Most of the students are students in Hanoi, and there are people from different ages from 34-60 in Hanoi from October to December.

- Research Methods:

Research uses the questionnaires for The level of influence of the audience when interacting with the communication products described in detail the forms of crime, most of them are FPT University students over 18 years old.

This is one of the scales in the evidence- based assessment system, developed by Dr. Thomas M. Achenbach. This checklist has been Vietnamese and like to write in Vietnam.

The checklist consists of 13 questions selected for the reader, so that they can follow the perceptions they experience when exposed to media that depicts criminal behaviour.

The majority of media refers to communication devices, which are used to communicate and interact with multiple users in different languages. Regardless of the means of communication, it is certain that it is an integral part of our lives. There are three types of media communication printing, electronic communications and next-generation communications.

- Calculation method:

We based on the raw data from the messages in the survey for the amount data, continue to use the data to convert through a chart for each question. After the following data to get the image level with the focus of your browser of 3 of the present of the 3 of the present: emotional, cognitive, action.

- Identification of research sample:

Our target group is mostly young people aged 18 and above, students of FPT University. Media has a great influence on everyone's life, especially with teenagers. The influence of the media plays a big role in shaping behaviour in adolescents. Studies show that some youth groups tend to behave aggressively because of the influence of the media. Communication. Teenagers have misconceptions about sex (the media depicts sexuality as a natural and normal behaviour that everyone has "enjoyed", regardless of anything else). , making them practice what they see and can lead to pregnancy or sexually transmitted diseases. Advertising and movies bring bad habits into mind, "great," Teenagers start smoking at the age of 14 - 15, even using drugs and alcohol at a young age. The hard-shelled influence of music videos, movies (adult-only movies), commercials and television shows.

To ensure representative representation of the sample, the sample was randomly selected for the system, reaching a wide range of age distributions, not only for adolescents in the Hanoi area. Before collecting data, we shared the questionnaire on social networking sites, where people interacted and cared, asking everyone to fill out the questionnaire to share their experiences.

- Number of research samples collected in practice:

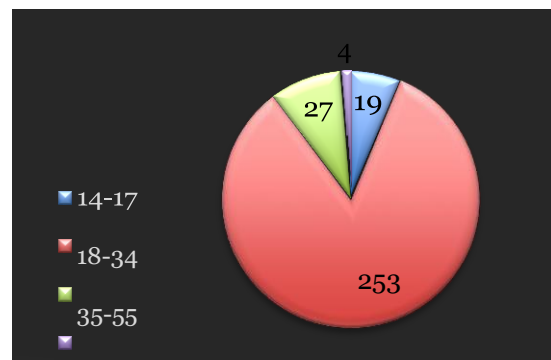
Based on the sampling methods, our research design has shown that the study will be conducted on students of FPT University over the age of 18 and other age groups in Hanoi. After collecting the coupon, we remove the slip.

3. Analysis

1. General characteristics of the research team

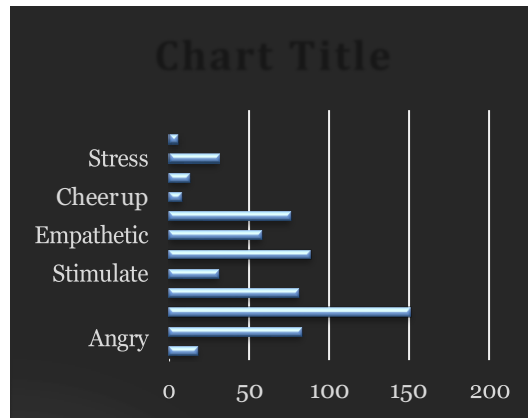
Zoned groups of research subjects are 14 to >60 years old. From about the age chart shows, in this survey, the majority of the audience is in the 18-34 age group 2 (83%), 14-17 (6%), 35-55 (13%) of the remaining 1% is composed of different ages from 55 to upper 60 years.

Chart 1: Ages



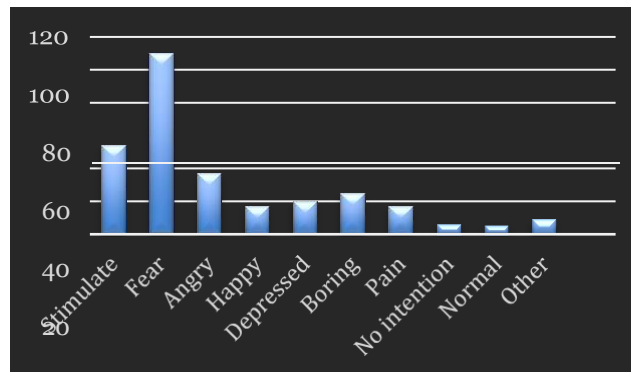
2. The extent of the emotional impact of audience

Chart 2: Your emotions after watching those forms of crime on the media



This chart shows that most of the people surveyed felt angry after watching those forms of crime on the media (49.8%). In addition people also felt creepy (25.1%), mercy (29.4%), fear (26.7%), normal (27.4%). And many other people felt other emotions such as: stimulate (10.2%), empathetic (19.1%), stress (10.2%)..... But there are some people who don't have any emotions (5.9%).

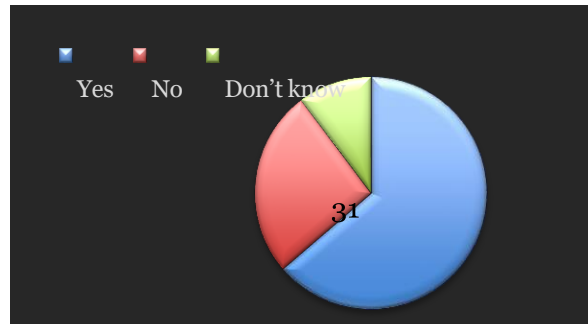
Chart 3: Feelings when you intend to commit a crime like something in the media



As the chart show almost of people will fear when they intend to commit a crime like something in the media: 42%. While others people feels so stimulate (18.1%), angry (15.1%) A few others feel another emotions such as: happy (6.8%), depressed (7.8%), boring (10.7%).

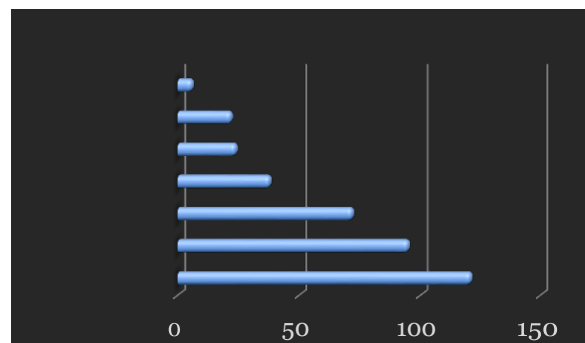
3. The extent of the perception impact of audience.

Chart 4: Do you think reading / viewing criminal information will affect your audience's emotions, perceptions, or behavior?



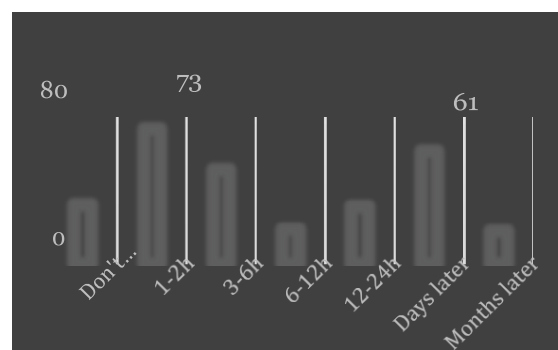
It can be seen that most people agree with reading / viewing criminal information that affects the emotions, perceptions and behavior of the audience: 63.7%. But some other people do not think it affects: 26.1%. The rest do not know whether the news is impacting or not? 10.2%.

Chart 5: How do you feel about the fact that the media products have a detailed description of the nature of the crime being rampant?



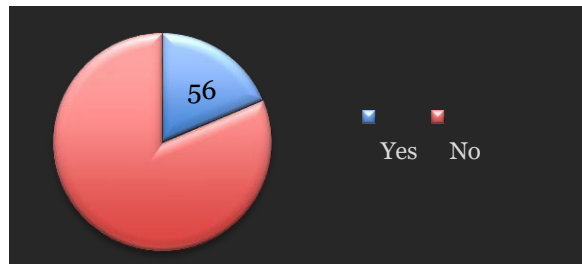
The chart shows that everyone is normal with the problem, others feel curious, or uncomfortable with it. Up to 12.5% of people feel scared when the media is being rampant. However, 7.9% enjoys in this issue. And many others idea such as: no interested, scary

Chart 6: The thoughts of criminal news that you read remain in your mind for as long as possible after exposur



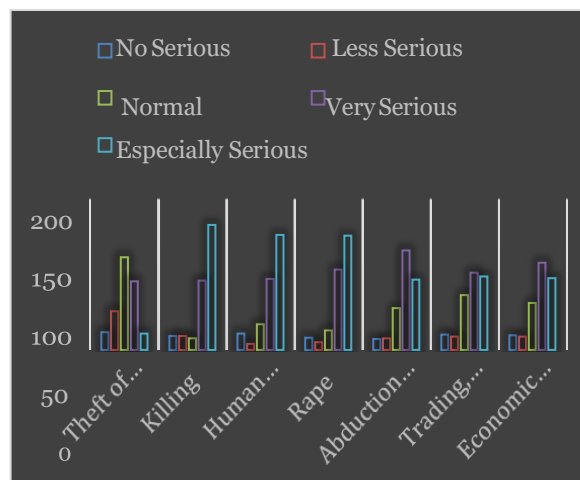
It can be seen that after contact with criminal information, people often forget quickly when the chart shows that 11.2% is not remembered and 24.1% only remember the range 1-2h, 16, 8% only remember 3-6h. However, there are also 20.1% obsessed in the following days, 5.9% in the next few months ... Other cases accounted for about 10%.

Chart 7: Have you ever intended to commit a criminal offense after being exposed to it through the media?



As many as 81.2% of respondents have never intended to commit crimes after being exposed to it through the media. And only 18.8% of them intend to commit criminal offenses.

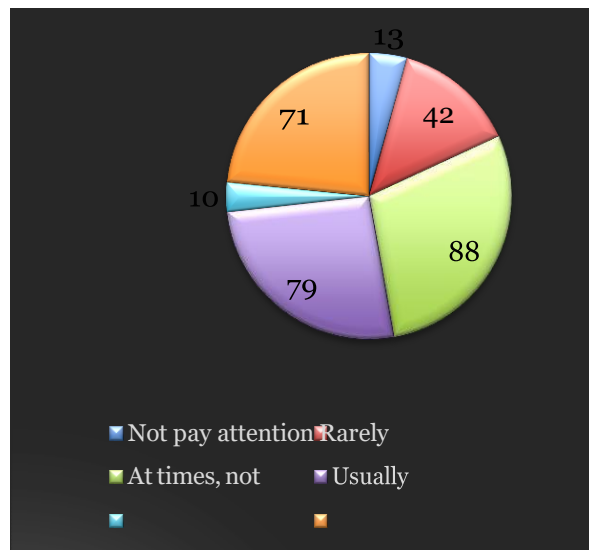
Chart 8: Evaluate the seriousness of the offense



Throughout the chart, it can be said that the murder (162/300) is the most serious crime, human trafficking (149/300) and rape (148/300) are also considered especially serious. Economic Crime (113/300), Ban on the sale of banned substances (100/300), Abduction of property (124/300) is very serious. Only property theft is normal offense (120/300).

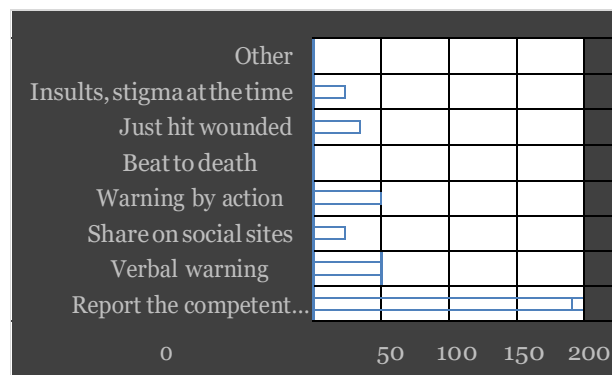
4. The extent of the behaviour impact of audience

Chart 9: The level of interest with the news about the offense in the media



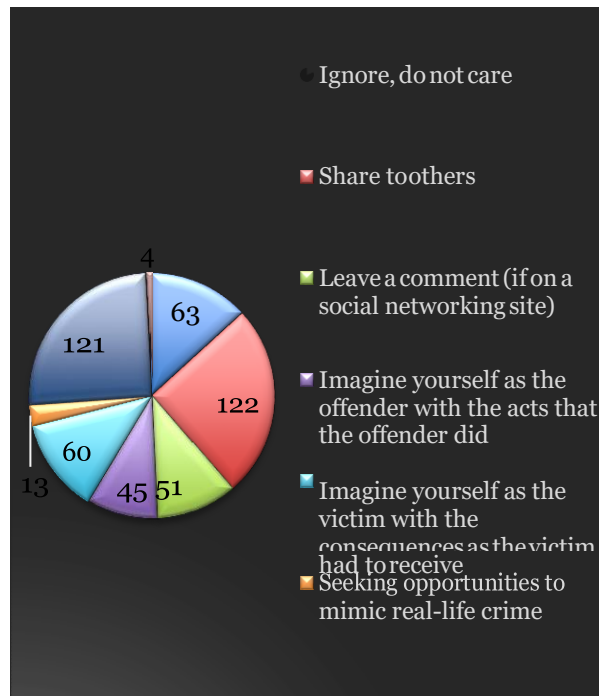
It can be seen that people often do not pay attention to information about crime in the media (29%). However, the number of people who pay attention to it is not a small number also accounted for 26.1%. Number of people exposed to a normal person also accounted for 23.4%. Rarely 14%. And always care about at least 3.3%.

Chart 10: Situation: When you catch your property thief, what will you do? (Dog theft, burglary, money ...



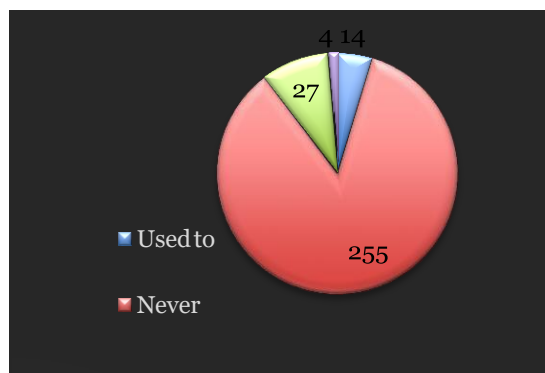
In this situation, everyone chose to report to the competent authority (81.3%), and to avoid insults at the time (8.9%).

Chart 11: What do you do after watching reading about news, crime forms on the media



It can be seen that after watching / reading about the news, criminality forms on the media people will often share to others: 40.3% or to take precautions and find ways to avoid contact with those who be like the offender. Others imagine themselves as victims with consequences such as victims receiving 19.8% or leaving comments on social networks.

Chart 12: Have you ever done an act of imitation in the form of a crime on the media?



The chart shows that the number of people who have never done an act of imitation in the form of crime on the media is quite.

5. Experimental results and conclusion

Research on the extent of the psychological impact of exposure to media products has a detailed description of the forms of crime, is relatively new to current psychological research in Vietnam. Almost some research has been done on this topic, especially in Vietnam, where the number of such studies is quite rare. Our study is the first study conducted by students in North Vietnam with a detailed and realistic survey system.

The proportion of students and students taking the survey is 83.5%. It can be seen that the level of interest of students and students in our survey is quite high. In addition, the level of interest in the questionnaire about the psychological impact of the participants was high > 50%. Results based on age independent variables suggest that there is no significant correlation between this independent variable and the psychological problems of the subject when exposed to communication products containing detailed information on the offense.

The research was conducted at FPT University in Hanoi with the participation of students in the school as well as parents and the elderly in the North. Our sample was selected as one of three representatives of FPT University, so the proportion stated in this study will be representative of FPT University students in Hanoi. Research results may be the premise for policy recommendations in the prevention and psychological interventions of students of FPT University in particular and the country in general. In particular, research results can be used to classify media products that are appropriate for each age, especially for parents who can choose the right kind of film for childr.

Acknowledgement

A completed study would not be done without any assistance. First of all, I would like to express my endless thanks and gratefulness to my supervisor Ms Trinh Thi Mai. Her kindly support and continuous advices went through the process of completion of my dissertation. Her encouragement and comments have greatly enriched and improved my work. Without his motivation and guidance, the thesis would not be able to be done effectively. As part of the project: The level of psychological impact that audiences have when communicating with media products has a detailed description of the criminal form, my thesis has been made by the contribution of all the students involved. So far, I would like to thank Nguyen Chung Anh for collecting and importing data for this study as part of the project. I also acknowledge my gratitude to all who spend their precious time and support in participating in the survey. I would like to thank the University of FPT, who has supported the project for us to pursue and complete our degree. I also want to thank you, my brothers and sisters for supporting me and taking care of me all the time. Finally, our deep thanks to all our friends during my time at FPT University. Their kindly help, care, motivation gave us strength and lifted me all the trouble for our project.

REFERENCES

1. Albert Bandura. The Social Cognitive Theory, 1989.
2. George Gerbner and his colleagues in the Cultural Indicators. The Cultivation Theory, 1976.

3. Richard Jackson Harris and Fred W. Sanborn. Book: A Cognitive Psychology of Mass Communication, 1988
4. Anderson, C. A. & Bushman, B. J. (2001) Media Violence and the American Public: Scientific Facts Versus Media Misinformation. American Psychologist
5. Crime: Effects of Media Exposure and Personal Experience on Issue Salience by Edna F. Einsiedel, Kandice L. Salomone, Frederick P. Schneider.
6. Media Violence Commission, International Society for Research on Aggression (Isra) (2012). "Report of the Media Violence Commission". Aggressive Behaviour.
7. Freedman, Jonathan L. (2002). Media violence and its effect on aggression: Assessing the scientific evidence.
8. Weaver, A.J. (2011). "A Meta-Analytical Review of Selective Exposure to and the Enjoyment of Media Violence". Journal of Broadcasting & Electronic Media.
9. The Henry J. Kaiser Family Foundation. (2003). TV violence.
10. Slater, M. D. (2003). "Alienation, Aggression, and Sensation Seeking as Predictors of Adolescent Use of Violent Film, Computer, and Website Content". Journal of Communication.
11. Johnson, JG; Cohen, P; Smailes, EM; Kasen, S; Brook, JS (2002). "Television viewing and aggressive behaviour during adolescence and adulthood".
12. Lewis, Jeff (2015). Media, Culture and Human Violence: From Savage Lovers to Violent Complexity, Rowman and Littlefield, London/Lanham.
13. Tedeschi, J. T.; Quigley, B. M. (1996). "Limitations of laboratory paradigms for studying aggression". Aggression and Violent Behaviour.

The influence of service quality on customer satisfaction:

The case of Langmaster

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Abstract

Nowadays, with the growth of educational service, the index of customer satisfaction plays an important role in the success of business. In this research, we aim to find the influence of Service Quality on Customer Satisfaction in the case of Langmaster by quantitative method (SPSS 23). Moreover, we also use SERVQUAL model to help us measure customer satisfaction index as well as service quality. Regarding to the result of this research, we concentrate on five crucial factors affecting customer satisfaction of Langmaster: (1) Tangible, (2) Reliability, (3) Responsiveness, (4) Assurance, and (5) Empathy which are resulted from analyzing 301 data in online and offline.

Keywords

AS: Assurance, CS: Customer Satisfaction, EM: Empathy, RE: Reliability, RS: Responsiveness, TA: Tangible

1. Introduction

To maintain the long-term profitability of the company and increase number of loyal customers, customer satisfaction about service quality is one of the key mission for any competitive company. This issue also raised topic which interested researchers around the world for many years. However, there are not really much studies show this problem deeply, especially English center in Vietnam.

Based on a research about English training center in 2016, “Service Quality” is the most popular topic people discuss before choosing an educational center. Therefore, it is clearly that service quality is a crucial role in success of educational business.

Although Langmaster is a leading English center in Hanoi, Langmaster also has some scandals and bad feedbacks due to problems with customer satisfaction in terms of service quality as well.

To find out what factors influence customer satisfaction at Langmaster in Hanoi, this research will take place in 3 main centers: Langmaster Nguyen Luong Bang, Langmaster Dai Co Viet and Langmaster Ho Tung Mau from 24/9/2018 to 24/10/2018. Our target sample characteristics are online and offline survey, between 18-25 years old, both male and female, 301 expected number respondents.

Moreover, in order to assess quality and current customer satisfaction in Langmaster center, we implement the following objectives. Firstly, understand definition of customer satisfaction and which factors affect it. Secondly, evaluate the current level of Langmaster’s customer satisfaction depending on relevant theoretical approaches. Thirdly, justify

significant determinants of customer satisfaction and how they affect Langmaster 's customer satisfaction. Finally, propose some feasible recommendations for Langmaster to enhance its current customer satisfaction.

2. Theoretical basic & literature review

2.1 Theoretical basis and analysis framework

Based on the theoretical framework of customer satisfaction which are shown below and SERVQUAL model of Parasuraman et al. (1988) as well, this research will conduct theoretical framework with five basic dimensions which are Tangible, Reliability, Responsiveness, Assurance, and Empathy.

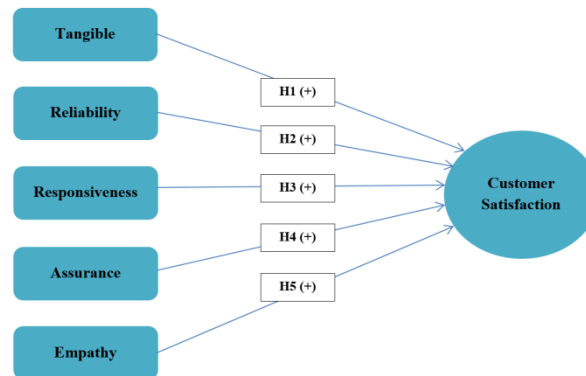


Figure 1. Conceptual Framework and Research model

2.2 Literature review

Firstly, there are not many research about service quality and customer satisfaction in English center. So this study uses SERVQUAL method to define clearly the concepts and theories. However, the authors also selected carefully define the market close to Vietnam's economy.

Secondly, Langmaster is new English center in Hanoi in recent years. Therefore, there are some researches to determine the satisfaction of customer in the service industry. Likely other industry such as restaurants, retail, travel, health, bank, so on, this study only use and exploit the elements affect customer satisfaction.

According to Zeithaml and Bitner (2003) defined that service quality is measurement focus on the awareness of customer about service, ensure reliability, responsiveness, assurance and empathy. The role of service quality is the customer service (Londe et al, 1988) while Zeithaml and Bitner (1996) mentioned that service quality is not only customer service, it includes all of different service surround customer.

Finally, one of the most popular methods to measure service quality is the SERVQUAL model.

3. Methods & data

3.1 Data

In this study, quantitative research method and nonprobability sampling method have been chosen to collect numerical data that are using mathematically based methods (in particular statistic). Because quantitative research method and nonprobability sampling method can

make the research problems easy to control and handle more than another method. It can then give accurate predictions about how factors in the market and how customers behave can influence one another, getting a clearer picture of the relationship between factors and behaviors and verify the accuracy of the hypothesis.

3.2 Methods/Framework

In this study, the deductive research approach will be applied as this is the most appropriate analytical method for the study. The study of the influence of quality services in customer satisfaction should be inductive research approach difficult to apply to the analysis of research. Through a deductive research approach, the paper builds hypotheses based on theoretical knowledge. Then, the results obtained will be used to re-examine previous hypothesis. This is the method most suitable for this study.

In addition, there are two main types of scale were selected that are nominal scale and likert scale. Gender, age, current career and study program which customer studied will follow the nominal scale. Likert scale will help customers express their satisfaction with the service in Langmaster.

In general, SPSS was chosen to analysis data. Through data processing with SPSS, our team will conduct descriptive analysis, reliability analysis, correlation analysis and regression analysis.

4. Result & finding

4.1 Survey result

The survey was collected in two weeks (from 24 September to 24 October) in three main departments of Langmaster which are Langmaster Hoang Quoc Viet, Langmaster Dai Co Viet and Langmaster Nguyen Luong Bang. Total of collected sample is 312 which include 201 online survey samples and 111 offline survey samples. After rejecting invalid samples from both online and offline research, there are 301 samples are accepted for analyzing.

In 301 samples was collected, there are 124 samples was participated in by female and 177 samples done by male (accounted 41% and 59% respectively). Age of this study was divided into 4 main groups which are under 18, 18 – 25 years old, 26 - 35 years old and above 35. The largest proportion is group 18-25 years old (accounted 90%). In occupation section, it was divided into 3 main groups which are student, business man and others and a very large majority is student account 87%. In Langmaster, there are three types of English course which are basic (for beginners), advance (for people who have higher level) and VIP course (included basic and advance course) and over a half respondent have learnt VIP course and it was accounted 52%. The percentage of basic and advance group are 26% and 22% respectively.

4.2 Descriptive analysis result

After collecting 301 results and analyzing descriptive, it can be seen that TA3 (Parking area is convenience and wide) with the mean equal 2.98 and RE3 (Output result has quality as well as promised) with the mean equal 2.51 have the mean lower than 3, which mean customer did not satisfy with both of determinants.

The highest mean is TA2 (Classrooms are fitted with all educational equipment such as projectors, furniture, etc.) with mean equal 3.66. They are exposed that consumer satisfied with this determinant.

In overall, most of variables have mean approximately above 3 to 4, which is closed with neutral option. Therefore, it can be seen that none of these determinants strongly affects to customer satisfaction about service quality.

4.3 Reliability analysis result

Cronbach's Alpha coefficient of TA is 0.787, RE is 0.883, RS is 0.886, AS is 0.855, EM is 0.867 and CS is 0.882 (greater than 0.6) that indicates a high level of internal consistency. The scale of components which includes TA1, TA2, TA3, TA5; RE1, RE2, RE3, RE4, RE5; RS1, RS2, RS3, RS4, RS5; AS1, AS2, AS3, AS4; EM1, EM2, EM3, EM4, EM5; and CS1, CS2, CS3, CS4, CS5, CS6 shows relatively high outcome in Corrected Item-total Correlation (greater than 0.3). Therefore, all variables are used in this study. However, TA4 has corrected item – total correlation value less than 0.3 so TA4 must be rejected. After removing TA4, the result of reliability of TA is 0.833.

4.4 Correlation analysis result

		CS	TA	RE	RS	AS	EM
CS	Pearson Correlation	1	.423**	.726**	.679**	.629**	.649**
	Sig. (2-tailed) N		.000	.000	.000	.000	.000
		301	301	301	301	301	301

Table 1. Customer Satisfaction Correlation

According to the result, Sig. (2-tailed) is 0.000 that means all of dimensions have correlation with each other.

The relationship between customer satisfaction and factors included tangible, reliability, responsiveness, assurance and empathy were described as follows:

Pearson Correlation between Customer Satisfaction (CS) and Tangible (TA) is 0.423 which show a moderate relationship.

Pearson Correlation between Customer Satisfaction (CS) and Reliability (RE) is 0.726 which show a strong relationship.

Pearson Correlation between Customer Satisfaction (CS) and Responsiveness (RS) is 0.679 which show a strong relationship.

Pearson Correlation between Customer Satisfaction (CS) and Assurance (AS) is 0.629 which show a strong relationship.

Pearson Correlation between Customer Satisfaction (CS) and Empathy (EM) is 0.649 which show a strong relationship.

In overall, there are some conclusions were stated which are:

Customer Satisfaction (CS) and factors included Tangible (TA), Reliability (RE), Responsiveness (RS), Assurance (AS), and Empathy (EM) have statistically significant linear relationship.

The direction of the relationship is positive that means these variables tend to increase together (for example, greater tangible is associated with greater customer satisfaction).

The strength of correlation between Customer Satisfaction (CS) and Reliability (RE), Responsiveness (RS), Assurance (AS) and Empathy (EM) are approximately strong. The strength of correlation between Customer Satisfaction (CS) and Tangible (TA) is approximately moderate.

4.5 Regression analysis result

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistic	
	B	Std. Error	Beta			Tolerance	VIF
1(Constant)	.009	.132		.065	.948		
RE	.339	.039	.357	8.577	.000	.561	1.781
RS	.272	.038	.291	7.152	.000	.587	1.704
AS	.183	.035	.208	5.249	.000	.619	1.615
TA	.107	.030	.123	3.632	.000	.849	1.178
EM	.112	.043	.115	2.613	.009	.502	1.994

a. Dependent Variable: CS

Table 2. Customer Satisfaction Coefficients

From the result of Coefficients, the linear regression equation is:

$$CS = 0.009 + 0.107*TA + 0.339*RE + 0.272*RS + 0.183*AS + 0.112*EM$$

According to this equation, the factor has the most impact to customer satisfaction is Reliability (with coefficient is 0.339). The next influence factors are Responsiveness (0.272), Assurance (0.183), and Empathy (0.112) respectively. The factor has the least impact to customer satisfaction in the case of Langmaster is Tangible.

4.6 Findings

4.6.1 Hypothesis verification

According to the result of customer satisfaction coefficients (Table 2), it can be seen that Sig. value of all of five elements include TA, RE, RS, AS and EM are less than 0.05. That means these independent variables affect to CS. Moreover, they also have Standardized Coefficients value greater than 0 then all of five elements have positive correlation with customer satisfaction.

Hence, the result of testing hypotheses will be shown in the following table:

Hypothesis	Content	Sig.	Result
H1	Tangible has a positive relationship with student satisfaction of service quality in Langmaster.	.000	Accepted
H2	Reliability has a positive relationship with student satisfaction of service quality in Langmaster.	.000	Accepted
H3	Responsiveness has a positive relationship with student Accepted satisfaction of service quality in Langmaster.	.000	Accepted
H4	Assurance has a positive relationship with student satisfaction of service quality in Langmaster.	.000	Accepted
H5	Empathy has a positive relationship with student satisfaction of service quality in Langmaster.	.009	Accepted

Table 3. Hypothesis Conclusion

4.6.2 Adjusted research model

After testing and analyzing, research model was adjusted as below:

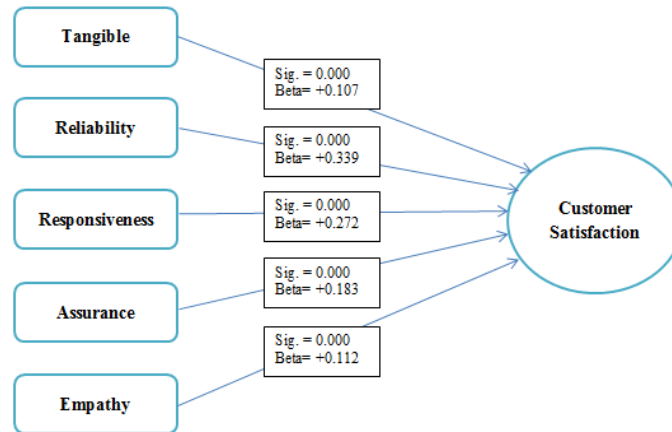


Figure 2 Adjusted research model

5. Recommendation & conclusion

5.1 Recommendation

Tangible

Switching the yellow light to the white light in the center. This suggestion is switching the white light because it makes the user feel comfortable and alert.

Build a lively, stimulating rest area or canteen for a break time. Rest breaks are important for employees, employers and the self-employed.

Reliability

Increasing the learning time from 200 hours to 350 hours. In fact, Langmaster students just spend 200 hours on each English speaking process.

Teachers often give assignments to test progress.

Encouraging students to self-study at home.

Responsiveness

Langmaster can create a group on Facebook which just includes all the members of a class. Each student can post comments or questions on this group.

Use pop-up auto-responder on the website and on the Langmaster fan page. It's the first thing that visitors see when they go to your site. It immediately catches their attention. It is very time-saving.

Assurance

Training professional skills for teachers.

Bonus perk for the teacher has students who got high scores on the last course and for staffs who get enough revenue.

Classification levels of employees. For example, internships, first-level employees, senior staffs, executives will give employees more effort and motivation to work.

Empathy

Determine the law of poor families and regulations on financial support.

Promoting communication and advertising on this humanitarian campaign to gain trust from students. Post news on social such as Facebook; newspapers, websites.

5.2 Conclusion

Through this in-depth interview, this study has achieved results that customers feel satisfied with the quality of service provided by Langmaster (71.4%). In terms of academic, this research shows SERVQUAL model is a perfect model to study quality of service and customer satisfaction. In fact, this survey results can help the business develop better and understand the needs of customers. Finally, with this research recommendation for influencing factors which are: Tangibility, Reliability, Responsiveness, Assurance and Empathy, Langmaster's Customer Satisfaction about service quality will be improved.

Appendix

Survey about the influence of service quality on customer satisfaction - The case of langmaster

Questionnaire:

Please circle the appropriate number indicating the level of satisfaction with the following assessments of the quality of service at Langmaster English Center according to the following scale:

(1): Very dissatisfied

(2): Not satisfied

(3): Normal

(4): Satisfied

(5): Very satisfied

(*): The question is required

No.	Description	Very dissatisfied	Not satisfied	Normal	Satisfied	Very satisfied
Tangible (*)						
1	The center has good space, clean and modern.	1	2	3	4	5
2	The center is equipped with learning equipment (projectors, tables, chairs ...).	1	2	3	4	5
3	Parking is convenient and spacious.	1	2	3	4	5
4	Staff dress neatly, seriously.	1	2	3	4	5
5	Textbooks and related materials are fully provided.	1	2	3	4	5
Reliability (*)						
7	The quality of the curriculum is provided as commitment.	1	2	3	4	5

8	The ability of teachers to meet the expectations of students	1	2	3	4	5
9	Output quality as committed.	1	2	3	4	5
11	Student are provided with accurate information about the curriculum	1	2	3	4	5
12	Class schedules, activities, workshops are scheduled on the center.	1	2	3	4	5
Responsiveness (*)						
13	Feedback is always received and processed quickly.	1	2	3	4	5
14	Teachers are always available to discuss and answer student questions at any time.	1	2	3	4	5
15	Students are informed about changes in classrooms and classrooms.	1	2	3	4	5
16	Student requirements (classroom change, reservations, etc.) are always resolved promptly and quickly.	1	2	3	4	5
17	Exam scores are updated regularly and quickly.	1	2	3	4	5
Assurance (*)						
18	Employees are polite and hospitable.	1	2	3	4	5
19	Teachers have good professional ethics.	1	2	3	4	5
20	Teachers are always available to teach and explain to students.	1	2	3	4	5
21	Employees have the skills to handle	1	2	3	4	5

	problems and provide accurate information.					
Empathy (*)						
22	Regularly survey the needs and expectations of the trainees.	1	2	3	4	5
23	Activities are designed to be practical.	1	2	3	4	5
24	A friendly and dynamic learning environment	1	2	3	4	5
25	Support for difficult situations of students (families with economic difficult)	1	2	3	4	5
26	Operation hours, schedule and classes are planned logical and suitable for students.	1	2	3	4	5
Customer satisfaction (*)						
27	Tangible (facilities, learning equipment, ...)	1	2	3	4	5
28	Reliability (meeting the committed services)	1	2	3	4	5
29	Responsiveness(responsive and fast response and flexible)	1	2	3	4	5
30	Assurance (create trust with students)	1	2	3	4	5
31	Empathy (individual individual interest)	1	2	3	4	5
32	You feel satisfied about Langmaster's quality of service.	1	2	3	4	5

References

- [1] Fornell, C., Johnson, M., Anderson, E., Cha, J. and Bryant, B. (1996). The American Customer Satisfaction Index: Nature, Purpose, and Findings. *Journal of Marketing*, 60(4), p.7.
- [2] Torres, E. and Kline, S. (2006). From satisfaction to delight: a model for the hotel industry. *International Journal of Contemporary Hospitality Management*, 18(4), pp.290-301.
- [3] Bolton, R. and Lemon, K. (1999). A Dynamic Model of Customers' Usage of Services: Usage as an Antecedent and Consequence of Satisfaction. *Journal of Marketing Research*, 36(2), p.171.
- [4] Fornell, C., Rust, R. and Dekimpe, M. (2010). The Effect of Customer Satisfaction on Consumer Spending Growth. *Journal of Marketing Research*, 47(1), pp.28-35.
- [5] HINTERHUBER, A. (2004). Towards value-based pricing?An integrative framework for decision making. *Industrial Marketing Management*.
- [6] Kristensen, Hans Jørn Juhl,, K. (2001). Customer satisfaction: some results for European Retailing. *Total Quality Management*, 12(7), pp.890-897.
- [7] Mihelis, G., Grigoroudis, E., Siskos, Y., Politis, Y. and Malandrakis, Y. (2001). Customer satisfaction measurement in the private bank sector. *European Journal of Operational Research*, 130(2), pp.347-360.
- [8] Edvardsson, B., Gustafsson, A. and Roos, I. (2005). Service portraits in service research: a critical review. *International Journal of Service Industry Management*, 16(1), pp.107-121.
- [9] Lewis, B. and Mitchell, V. (1990). Defining and Measuring the Quality of Customer Service. *Marketing Intelligence & Planning*, 8(6), pp.11-17.
- [10] Oh, H. (1999). Service quality, customer satisfaction, and customer value: A holistic perspective. *International Journal of Hospitality Management*, 18(1), pp.67-82.
- [11] Cronin, J. and Taylor, S. (1992). Measuring Service Quality: A Reexamination and Extension. *Journal of Marketing*, 56(3), p.55.
- [12] Askariazad, M. and Babakhani, N. (2015). An application of European Customer Satisfaction Index (ECSI) in business to business (B2B) context. *Journal of Business & Industrial Marketing*, 30(1), pp.17-31.
- [13] Wisniewski, M. (2001). Using SERVQUAL to assess customer satisfaction with public sector services. *Managing Service Quality: An International Journal*, 11(6), pp.380-388.
- [14] Parasuraman, A., Zeithaml, V. and Berry, L. (1985). A Conceptual Model of Service Quality and Its Implications for Future Research. *Journal of Marketing*, 49(4), p.41.

The effect of stimulus toward the problem recognition of consumer decision-making process in the textile industry: A case of Zara in Ho Chi Minh City

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Abstract

Zara is considered a popular fashion brand in the world. With very good branding strategies, Zara comes to Vietnam as a high-class brand for middle-class consumers. However, the authors believe Zara can do more than that, so they decided to find out the effect of stimulus toward the problem recognition of consumer decision-making process, and determined whether there are differences in problem recognition in term of gender, age, and income. After having the key findings, the researchers also gave some recommendations for Zara Company to help them attract more customers to buy their products.

Keywords

Problem recognition, consumer decision-making process, stimulus, Zara.

1. Introduction

1.1. Research Background

Zara is the largest clothing and accessories retailer in the world founded in 1975 based in Arteixo, Galicia, Spain. After forty three years, Zara has more than 2,000 stores around the world.

Zara stores in Vietnam are operated by Inditex's Indonesian partner, Mitra Adiperkasa (MAP). According to data from Vietnam Research and Consultancy (VIRAC), by the end of 2016, with less than 4 months' launching time, Zara Vietnam reached the revenue of 321 billion VND, average revenue was 2.8 VND billion/day. From the data released by MAP, by 2017, with the opening of Pull & Bear, Stradivarius, and Massimo Dutti stores in September and the opening of Zara store in Hanoi by November, the revenue of the whole corporation system in Vietnam soared more than 1,100 billion VND. Furthermore, in the first half of 2018, their revenue continued to grow 133% over the same period to nearly 950 billion VND, which means that about 5.3 billion VND per day. With this growth momentum, it is likely that Zara's revenue and brother, sister brands in Vietnam may be able to reach \$100 million equivalent to 2,300 billion VND this year.

In order to do the research, the researchers used quantitative method with the sample size of 350 respondents who live in Ho Chi Minh City and have already purchased Zara products.

As a result, the authors found out four factors which affect to the decision-making process of consumer. These factors include Personal influences, Product attributes, Sales promotion, and Enjoyment. Moreover, the problem recognition of different age group will be stimulated differently by these effects.

1.2. Research Objectives

In order to obtain high turnover, Zara has various strategies, but this research only focuses on figure out the factors that impact the problem recognition of the consumer decision-making process with 5 main objectives, which include:

- Understand the effect of stimulus toward the problem recognition of consumer decision-making process in the textile industry
- Find out stimulators affecting the problem recognition
- Find out the relationships between these stimulators
- Identify the different effects of stimulus toward the problem recognition between gender, age, and income
- Suggest the implication to improve the effect of stimulus toward the problem recognition.

2. Literature review & theoretical framework

2.1. Consumer decision-making process

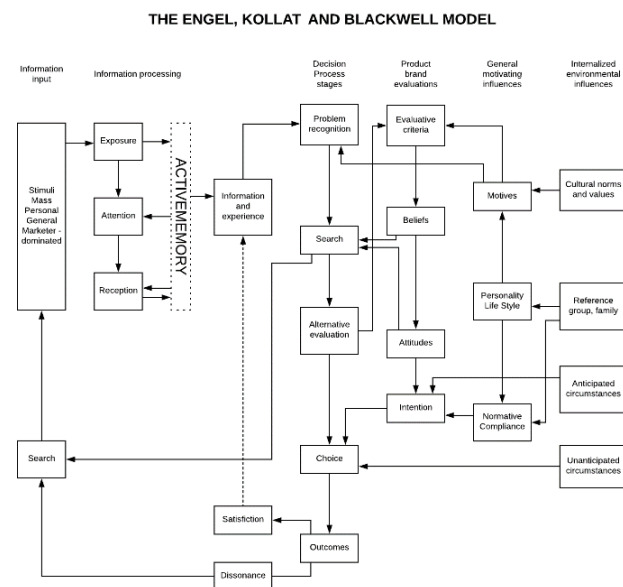


Figure 1. Consumer decision-making process

2.2. Product attributes, Sales promotion, Personal influences, and Enjoyment

During the 1980s until now, there has been a number of research examining the link between product attributes and the way customers realize they need an apparel product. According to Cassill and Drake (1987), there were thirteen attributes to the process, including prestige, color, fashion, beauty or attractiveness, ease-of-care, fabric kind and quality, fitness, buying method, price, fiber content, construction's quality, and brand [5]. A short time later, Eckman, Damhorst and Kadolph (1990) developed the previous research and went to the conclusion of other 14 attributes, which are fabric and construction, quality, durability, care, fiber content, fabric, fit, color, style, product composition, coordination with wardrobe, brand, and price [7]. However, these researchers just attempt to link product attributes to shoppers' ultimate choice of retail format. Only in the report of Shim and Kotsiopoulos (1992) [19], Shim and Bickle (1994) [18] and Moore and Carpenter (2006) [14], the influences of product attributes are presented for multiple retail formats.

Their research investigates the linkage between a comprehensive group of five product attributes sought by apparel purchasers, which includes price attributes ("although the product is not on sale, its price is still low", or "on sale or at a discounted price"); brand attributes ("before you've already purchased this brand", "brand is currently popular", "high-end or design brand"); physical attributes ("construction and fabric with high quality", "appealing and finishing clothing details", "fabric is natural"); usage attributes ("fabric is easy to care", "can wear for multiple seasons"); and, fashion attributes ("it takes a long time to face with a desuetude", "currently, it's popular", "clothing can use for a lot of purposes such as go to work, participate in the social program, or casual wear", "it's easy to buy a coordinating clothing"). Besides, Kahle (1986) [13] and Baker et al. (2002) [4] said that shoppers highly consider the value, the fashion level of the item and the price. Therefore, the following hypothesis is developed:

H1: There is a significant relationship between Product attributes and Problem recognition.

The development of the world economy was not only followed by the advance of mass media advertising but also new kinds of marketing including below the line sales promotion. From the result of Gilbert's research (1999), the popular tools of sales promotion include free sampling, buy-one-get-one-free or in-pack premium item [9]. These tools encourage consumers to purchase more product. Some others believe that they are more enjoyable when purchasing sale products or having a discount on the items. A discount program can bring them their feeling to a winner in a game or satisfaction as reaching their goal and fulfilling their personal achievement (Westbrook et al., 1985) [20]. As Chaharsoughi and Yasory (2011) pointed out that sales promotion has positively influenced consumers' attitude to purchase [6]. In conclusion, the potential of using sale promotion can make a customer realize that they want something. In this case, H2 is developed to examine this relationship.

H2: There is a significant relationship between Sales promotion and Problem recognition.

According to three researchers, Schiffman & Kanuk (2004) [17] and Assael (1995), there are four factors that influent the consumers' recognition and buying process, which includes

attractiveness, information and experiences, the power of the reference group and conspicuousness of the goods, and credibility [2]. The consultation of influencers can affect a person who first experiences something.

About the personal influences from the third environmental influence. As Engel et al. (1995) said that, direct or indirect personal influences are one of the best forms of persuasion on consumer decision-making and purchasing behavior [8]. They explain that personal influences present two main forms, which are reference groups and word-of-mouth communication. When the customers purchase something, reference groups serve as an important input to the consumer decision-making process. Schiffman & Kanuk (2004), a customer evaluates goods or specific values, attitudes, or behavior by using another person or group as a point of comparison (or reference) for he or she [17]. Reference groups are not limited by size or membership, but it requires that consumers should identify with a tangible group such as owners of small businesses or golf professionals. The second personal influence on consumer decision-making and behavior is word-of-mouth. The frequency of consumers turns to the opinions of others (especially family and friends), regarding products and services is clearly considered as word-of-mouth. As Assael (1995) said that, with the most trustworthy than any other commercial channel, friends and relatives not only have a big influence on customer's decision but also can make them glad about their decision by minimizing the risks they must be faced [2]. The reason for this is, by using the experiences of someone who bought this kind of product before, the customer will make a more intelligent decision. In conclusion, in order to indicate the effect of Personal influences to the consumer's problem recognition, the authors develop the following hypothesis:

H3: There is a significant relationship between Personal influences and Problem recognition.

The long time ago, researchers have indicated that there is a link between enjoyment and people's recognition process. As the research of Babin et al. (1996), the longer time people spend in the shopping environment, the more interest they have [3]. Rajamma et al. (2007) found that people who are going to the store have stronger feeling towards buying than people who choose shopping online, for either tangible products or service, also, shopping for their relatives gain them the same enjoyment [15]. On the other hand, Josiam et al. (2005) pointed out that relaxed and casual feeling when customers get to walk around and choose whatever products that they want [12]. On the other hand, as Arnold et al. (2003) said that stress and alleviate a negative mood will be it is easy to relieve or even makes the customers obtain a better mood during shopping time [1]. A lot of shoppers get positive feelings when they are shopping for their friends and family. They feel excited and interested when finding a perfect gift for their relatives. On the other hand, browsing shopping to look at the products without spending money can increase customers' enjoyment. To examine if the indication is true, the hypothesis H4 discuss:

H4: There is a significant relationship between Enjoyment and Problem recognition.

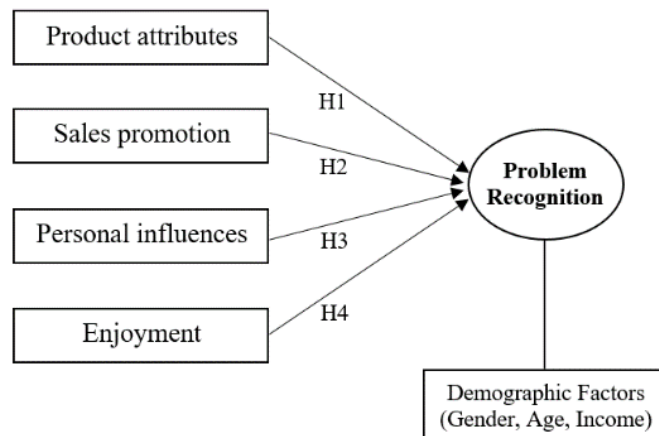


Figure 2. The overall model

3. Methodology and data overview

3.1. Methodology

This research uses a quantitative approach with the data is collected from a questionnaire which includes three parts: screening questions, main questions, and demographic information. The Vietnamese language is used for this questionnaire because all of the respondents are Vietnamese people.

3.2. Data overview

The primary data is collected from 350 Zara's customer in Ho Chi Minh, Vietnam at the age of 18 to 60. After doing this research, having 30 responses is invalid.

4. RESULTS AND FINDINGS

4.1. Reliability test

Factor	Item	Corrected Item - Total Correlation	Cronbach's Alpha if Item Deleted
PRODUCT ATTRIBUTES	Cronbach's Alpha = .816		
	PA1	0.685	0.754
	PA2	0.617	0.779
	PA3	0.644	0.768
	PA4	0.480	0.817
	PA5	0.619	0.776
SALES PROMOTION	Cronbach's Alpha = .854		
	SP1	0.661	0.826
	SP2	0.754	0.800
	SP3	0.604	0.849
	SP4	0.695	0.821
	SP5	0.666	0.824
PERSONAL INFLUENCES	Cronbach's Alpha = .759		
	PI1	0.539	0.787
	PI2	0.574	0.700
	PI4	0.715	0.566
ENJOYMENT	Cronbach's Alpha = .813		
	EN1	0.648	0.757
	EN2	0.684	0.739
	EN3	0.650	0.756
	EN4	0.545	0.803
PROBLEM RECOGNITION	Cronbach's Alpha = .766		
	PR1	0.556	0.720
	PR2	0.557	0.716
	PR3	0.583	0.703
	PR4	0.582	0.702

Table 1. Preliminary evaluation of Cronbach's Alpha reliability scale (after delete PI3)

Table 1 presents the Cronbach's Alpha for four independent variables and a dependent variable.

According to Hoang T and Chu N.M.N (2005), the reliability of the scale is estimated by using the Cronbach's Alpha coefficient and the acceptable one are ranged from 0.6 to smaller than 1 [11]. The result in this table shows that the value range is from 0.759 to 0.854. Besides, the value of Corrected Item–Total Correlation needs to higher than 0.3, if not, it will be excluded (according to Hair et al, 1998) [10]. All of these values are greater than 0.3, except PI3 (0.214). Hence, PI3 will be eliminated.

4.2. Exploratory Factor Analysis (EFA)

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.822
Bartlett's Test of Sphericity	Approx. Chi-Square	2393.996
	Df	136
	Sig.	.000

Table 2. Summary Result of EFA

In order to analyze the Rotated Component Matrix, the researcher has to ensure criteria such as KMO and Bartlett Sig.

Kaiser Meyer Olkin (KMO) measures the sampling adequacy (which determines if the responses given with the sample are adequate or not) which should be more than 0.5 for a satisfactory factor analysis to proceed. Kaiser (1974) recommend 0.5 (value for KMO) as a minimum (barely accepted), values between 0.7 and 0.8 are acceptable, and values above 0.9 are superb. With the result from table 2, KMO is 0.822 which is higher than 0.5, so factor analysis is appropriate. Besides, Bartlett with a sig. equal 0.000 is lower than 0.05, so observed variables are correlated in overall.

	Component			
	1	2	3	4
SP3	.802			
SP2	.798			
SP4	.777			
SP5	.739			
SP1	.735			
PA1		.810		
PA2		.799		
PA3		.712		
PA5		.688		
PA4		.676		
EN1			.809	
EN3			.794	
EN2			.788	
EN4			.743	
PI4				.853
PI2				.784
PI1				.718

Table 3. Rotated Component Matrix

Exploratory Factor Analysis (EFA) is a technique to reduce a set of observational variables to a smaller number of factors but these still demonstrate most of the information content and statistical significance of the initial set of variables (Hair et al, 1998) [10]. Each observational variable will be weighted as a factor called Factor Loading, which tells the researchers which factor each variable will belong to.

The selected observational variable is the factor whose Factor Loading is greater than or equal to 0.5. Table 3 illustrates the Rotated Component Matrix, every factor is higher than 0.5, so these factors can ensure about meaning and do not eliminate anyone.

4.3 Multiple Linear Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.725 ^a	.526	.520	.38665	.526	87.428	4	315	.000

Table 4. Model Summary^b

A simple linear regression analysis was conducted separately for each of the four hypotheses to test the relationships between the dependent and independent variables. Simple linear regression is the simplest form of regression analysis considering only one independent variable. As a result, the expected relationship is depicted as a straight-line relationship that can be either positive, negative or neutral. The beta value (B) represents the slope of the regression line (Anderson, Sweeney, Williams, Camm & Cochran, 2013).

From table 4, Adjusted R Square is 0.520. It means that 52% dependent variable's variation (PR) can be represented by five independent variables (PA, SP, PI, and EN). In addition, the value of Sig. F Change is lower than 0.05, so the regression analysis model is accepted.

Coefficients								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.659	.165		4.003	.000		
	PA	.223	.033	.278	6.747	.000	.886	1.128
	SP	.165	.034	.214	4.865	.000	.780	1.282

	PI	.273	.033	.373	8.375	.000	.760	1.316
	EN	.131	.030	.179	4.362	.000	.892	1.122
a. Dependent Variable: A								

Table 5. The Meaning of Particle Regression Coefficients

In order to identify the independent variable influent on the dependent variable or not, the value of Sig. must be smaller than 0.05. For all five independent variables here, sig. values are smaller 0.05. Therefore, this result shows that independent variables have the influencing on the dependent variable.

Besides, the author has to consider VIF. If the Variance inflation factor (VIF) is higher than 10, the collinearity may occur. In this research, all of 4 factors' VIF is lower than 10 (range from 1.122 to 1.316), so that situation will be rejected. After this condition is fulfilled, the researchers used a Standardized Coefficients Beta to identify which variable influences the most to invest in the most compared to other variables.

Among the value of standardized beta, the value beta of Personal influences (0.373) is the highest. Therefore, this factor has the greatest impact on problem recognition of the consumer decision-making process. Next factors are Product attributes, Sales promotion, and Enjoyment.

4.4 Independent Samples T-Test

	GD	N	Mean	Std. Deviation	Std. Error Mean
PT	1	164	3.5854	.53943	.04212
	2	156	3.6090	.57864	.04633

Table 6. Group Statistics

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	.197	.658	-.378	318	.706	-.02361	.06250
Equal variances not assumed			-.377	313.479	.706	-.02361	.06261

Table 7. Testing the differences in attitude by Gender

Ho: There is no difference in mean of the effect of stimulus toward consumer's problem recognition between male and female.

According to Hoang and Chu (2005), if the value of Significant in Levene's test is more than 0.05, the variance of two independent groups are equal [11]. Then, the result of Equal variance assumed will be used. In table 7, Sig. value of Levene's test is higher than 0.05 (0.658), so Equal variances assumed is valid. With the value of the Sig. (2-tailed) is 0.706, the null hypothesis is accepted. Therefore, it has no difference in mean of the effect of stimulus toward consumer's problem recognition between male and female.

4.5. Anova

4.5.1. Age

Test of Homogeneity of Variances			
Levene Statistic	df1	df2	Sig.
1.083	3	316	.357

Table 8. Testing the differences in attitude by Age

Because Sig = 0.357 > 0.05, the homogeneous covariance condition is satisfied that there is no difference in covariance between the groups, so ANOVA method is appropriate, and then look at ANOVA table below.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.783	3	.928	3.035	.029
Within Groups	96.589	316	.306		
Total	99.372	316			

Table 9. Testing the differences in attitude by Age (continue)

In ANOVA table, the Sig. = 0.029 < 0.05, it means that there is a difference in mean of the effect of stimulus toward the problem recognition between age groups.

4.5.2 Income

Test of Homogeneity of Variances			
Levene Statistic	df1	df2	Sig.
3.759	3	316	.011

Table 10. Testing the differences in attitude by Income

In this table, it shows that Sig. = 0.011 < 0.05, it means that the homogeneous covariance condition is not satisfied that there is a difference in covariance between the groups, so

ANOVA method is inappropriate, so Welch method is appropriate, we have to see the table below:

Robust Tests of Equality of Means				
A				
	Statistic ^a	df1	df2	Sig.
Welch	.461	3	36.131	.711

Table 11. Testing the differences in attitude by Income (continue)

In table 11, we can see that $\text{Sig} = 0.711 > 0.05$, so we can claim that it has no difference mean about the effect of stimulus toward the problem recognition between these income groups.

4.6 Findings

After researching and analyzing data, the authors clarified the research objectives. This research evaluates the effect of stimulus toward the problem recognition of the consumer decision-making process:

Finding 1: Following this research, there are four main factors which influent to the consumer's problem recognition, it includes: Personal influences, Product attributes, Sales promotion, and Enjoyment.

Finding 2: In summary, it only has the difference in the effect of stimulus toward the problem recognition of consumer decision-making process among the age group, not among gender and income group.

5. Conclusion and policy implication

In conclusion, the research objectives have been achieved. The author already found out four key factors affect to the problem recognition of consumer decision-making process. Furthermore, in order to improve the problem recognition of consumer decision-making process, Zara can make something innovative in their Product attributes, Sales promotion strategy and increase their consumer's Personal influence and Enjoyment. However, the most important is to extend Personal influences.

In addition, the researchers also found out a new thing that each age group will be received different effects from the stimulators. Therefore, Zara should make the differentiation in product's design, color, and price for each age group.

References

- [1] Arnold MJ, Reynolds KE (2003) Hedonic shopping motivation. J Retailing 79, pp. 77–95
- [2] Assael, H. (1995). Consumer Behavior and Marketing Action. Fifth Edition. Cincinnati, South-Western College Publishing.
- [3] Babin BJ, Darden WR (1996) Good and bad shopping vibes: spending and patronage satisfaction. J Bus Res 35, pp. 201-206

- [4] Baker, J., Parasuraman A., Grewal, D. and Voss, G. (2002), "The influence of multiple store environment cues on perceived merchandise value and patronage intentions", *Journal of Marketing*, Vol. 66, pp. 120-41
- [5] Cassill, N. and Drake, M.F. (1987), "Apparel selection criteria related to female consumers " lifestyle", *Clothing and Textiles Research Journal*, Vol. 6, pp. 20-8
- [6] Chaharsoughi, S. A., & Yasory, T. H. (2011). Effect of sales promotion on consumer behavior based on culture. *African Journal of Business Management*, 6(1), pp. 98-102. <http://dx.doi.org/10.5897/AJBM11.739>
- [7] Eckman, M., Damhorst, M.L., and Kadolph, S. (1990), "Toward a model of the in-store purchase decision process: Consumer use of criteria for Kingston department stores: Wave III: evaluating women"s apparel", *Clothing and Textiles Research Journal*, Vol. 8, pp. 13-22
- [8] Engel, J.F. Blackwell, D.R., Kollat, D.T. (1978) *Consumer Behaviour* (3rd Ed.). The Dryden Press, New York, UK
- [9] Gilbert, D. (1999). *Retail Marketing Management*. Harlow: Prentice Hall.
- [10] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (1998). *Multivariate data analysis*. Uppersaddle River. *Multivariate Data Analysis* (5th ed) Upper Saddle River
- [11] Hoang T. and Chu N.M.N. (2005). *Phân tích dữ liệu nghiên cứu với SPSS*. Nhà xuất bản thống kê.
- [12] Josiam B, Kinley T, Kim Y (2005) Involvement and the tourist shopper: using the involvement construct to segment the American tourist shopper at the mall. *Journal of Vacation Marketing* 11, pp. 135-154
- [13] Kahle, L. (1986), "The nine nations of North America and the value basis of geographic segmentations", *Journal of Marketing*, Vol. 50, pp. 37-47
- [14] Moore, M. and Carpenter, J. (2006), "The effect of price as a marketplace cue on retail patronage", *Journal of Product & Brand Management*, Vol. 15, pp. 265-71
- [15] Rajamma RK, Paswan AK, Ganesh G (2007) Emerald Article: Services purchased at brick and mortar versus online stores, and shopping motivation. *J Serv Mark* 21, pp. 200-212
- [16] Schiffman L. G. & Kanuk L. L. (2007). *Consumer Behavior* (9th ed.). Upper Saddle River: Pearson.
- [17] Schiffman, L. G., & Kanuk, L. L. (2004). *Consumer Behavior*. Eighth Edition. New Jersey, Prentice Hall
- [18] Shim, S. and Bickle, M. (1994), "Benefit segments of the female apparel market: Psychographics, shopping orientations, and demographics", *Clothing and Textiles Research Journal*, Vol. 12, pp. 1-12
- [19] Shim, S. and Kotsiopoulos, A. (1992), "Patronage behaviour of apparel shopping: Part I. Shopping orientations, store attributes, information sources, and personal characteristics", *Clothing and Textiles Research Journal*, Vol. 10, pp. 48-57
- [20] Westbrook, R. A., & Black, W. C. (1985). A motivation-based shopper typology. *Journal of Retailing*, 61, pp. 78-103.

Conference Awards

First Prize

Combination of Facial Recognition and Interaction with Academic Portal in Automatic Attendance System

Vuong Viet Hoang, Tran Huu Tu, Le Tien Dat, Le Tien Dat, Hoang Duc Manh

Second Prize

DC Programming and DCA for power minimization problem in multi-user beamforming networks

Nguyen Van Nam, Nguyen The Nam

The Effect of stimulus toward the problem recognition of consumer decision-making process in the textile industry: A case of Zara in Ho Chi Minh City

Doan Kim Loan, Le Thinh Phat, Nguyen Trung Nghia

Third Prize

DCA-based algorithm for cross-functional team selection

Le Van Thanh

Sentiment analysis of customer (on thegioididong.com)

Tran Dong Phuong, Vo Van Hieu, Ho Ngoc Vinh Han

Factors affecting customers' green consumption behaviors in Viet Nam

Nhu Thuy Hien, Pham Thu Hien, Vu Duc, Do Thi Minh Anh, Le Trong Nghia

Potential Prize

The impact of Facebook communication strategies on eating behavior among young people in Hanoi

Nguyen Tuan Anh, Lam Thi Phuong Anh, Nguyen Vu Minh Anh

FU Student Data: Optimizing the Storage and Querying in the context of the number of Student increase significantly with Map-Reduce Framework

Pham Hoang Tuyet Ngan, Nguyen Trung Dung, Nguyen Danh Dac Sang, Le Dinh Thien Vu

Optical properties of One-dimensional Metal-Dielectric multiplayers

Nguyen Viet Dung, Chan Van Bac, Tran Quoc Viet

Popular Prize

DC Programming and DCA for Secure Guarantee with Null Space Beamforming in Two Way Relay Networks

Luong Thuy Chung, Nguyen The Duy

Diamond Prize

IoT Platform for Safety, Security, and Surveillance

Nguyen Minh Hieu, Le Dinh Duy, Ngo Thuc Dat, Ho Trong Duc

Gold Prize

Sitemap Generator and Spelling Test Tool

Nguyen Truong Thuy Vi, Le Ngoc Truong, Nguyen Duc Trinh, Tran Phuc Anh



