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PARALLEL PROCESSING IN COMPUTE UNIFIED DEVICE ARCHITECTURE (CUDA) FOR ENERGY SAVING GLASS

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ABSTRACT: *Energy saving glass is used to keep the warmth and temperature of a building instead of using thermal radiator or machine to generate the heat all the time during winter. Yet the coating structure of the glass is mostly in regular shape such as tripoles and circular with a very small size that limits the useful signal such as wireless signal and radio frequency to pass through. One way to allow more useful signals to go through the glass is by using complex shape coating structure. In order to develop a complex coating structure, genetic algorithm technique is used in this research. However, genetic algorithm require a fast processing speed in order to cope with the process of creating new chromosome from the population and undergoes the selection, crossover and mutation operation processes. Hence parallel processing is needed to overcome this problem with the use of both CPU and GPU to eliminate the need of purchasing high performance CPU and the needs of adding additional repeaters to increase the wireless signals. The coating structure will be presented in binary bits in a text file that shows the best chromosome. The result will be analyzed in a simulation tool that uses to check for the signal transmission efficiency and rate loss.*

KEYWORDS: parallel processing, parallel genetic algorithm, optimization, energy saving glass

1.0 NTRODUCTION

Energy saving glass is used in keeping the temperature of the room or it keeps the warmth of certain places using it. It has a special coating structure that prevents the heat energy from being released. Besides, it reflects the incoming UV ray from being penetrated into the building or vehicles, which more or less act like a filter but in a form of fabrication instead of plastics. The problem occur when the coating of the glass actually limits the signals such as infrared, radio wave (WIFI) from getting into the room due to the coating of the glass, as most of the useful signal cannot penetrate into the glass that causes the loss of useful signal in the room which can limits the bandwidth of the signal. Besides, the coating structure on the glass is varies and mostly are in regular shapes.

The current approach is to design a new coating structure that enables the [1] useful signals such as the radio frequency, microwave, and wireless signals (WI-FI) of GSM to pass through the building instead of being reflected back or lost. Several methods have been suggested in order to overcome this problem. One of the solution is by placing a repeater yet this solution lead to the use of electricity and cost of operation which no longer an ideal solution due to cost and environmental-friendly consideration.

The second solution is to develop a new coating structure. Based on the research [2] that stated irregular shape or known as the 3D-finite-different time-domain (FDTD) coating are introduced to overcome the signals losses or signal attenuated with energy saving glass by combining the regular shapes such as tripoles, and double squares to become another new coating structure, as one of the method to increase the signals, besides using repeater. in addition to it, a study has been conducted [3] that has stated the shape of circular loop has better transmission and less heat lost compare to the regular shape of the coating structure that shown at Figure 1 below [4].

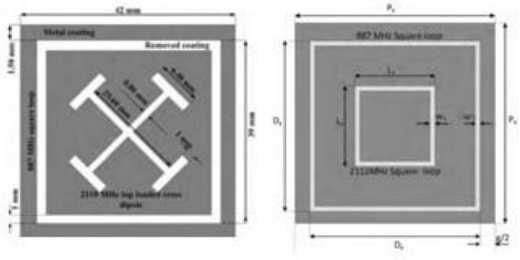

Figure 1: Double regular shape design

In order to generate complex and irregular coating structure, it may be a difficulty in implementation as the techniques that have been used, requires reaching an ideal result. By using the parallel Genetic algorithm techniques, it is able to create a new chromosome, and develop new population by using the chromosome. Parallel processing is used with the purpose of using parallel genetic algorithm technique as it can provide faster speed in generating and executing the coding which will then, by using the GPU (Graphic Processer Unit) together with CPU (Center Processing Unit) to execute the processes; as executing

genetic algorithm command and codes requires longer time to process due to the creation of the new chromosome and population. Hence, the project will focus on using CUDA programming language, the language that is used in NVDIA graphic card. By executing the process using both GPU and CPU, it will speed up the processing time more than usual as two processes can be run at the same time which will decrease the opportunity of having bottle neck and reduce the cost of purchasing high processing speed computer or devices. After the development of coating structure, it will then, be tested by Computer Simulation Tool (CST) to see the end result of the coating structure and decides which will be an ideal coating structure for the glass.

Signal such as infrared, wireless signals (WIFI) and radio frequency are known as the useful signals are lost due to the coating structure of the glass. Most of the signals cannot

penetrate the glass and causes most of the signal to being reflected or lost. It is difficult for useful signals to get into the room due to the coating structure of the glass, as most of the useful signal cannot penetrate into the glass that causes the loss of useful signal in the room which can limits the bandwidth of the signal. Besides, the current coating structure on the glasses are varied and most are in regular shapes. In order to generate complex and irregular coating structure, it may be difficult to implement as the techniques that have been used require reaching ideal results.

2.0 GENETIC ALGORITHM AND PARALLEL GENETIC ALGOTIHM

Genetic algorithms is inspired by the mechanism of natural selection. It is a search method used in computing to find exact or approximate solutions to optimize problems. First introduced by John Holland in 1975, it was proven to solve problem based on the natural selection[5][6]. It uses techniques inspired by the evolutionary biology such as selection, crossover and mutation. For over three decades, various problems in various applications were solved such as Travelling Salesman Problem (TSP), production scheduling, function optimization, machine language and so forth. Parallel genetic algorithm, that uses parallel GA may require fast processing time and speed for the processor in order to execute and run the processes and commands that is generated by creatingnew coating chromosomes and population, yet only processing unit itself will be processed? unless we have more than one processor, also known as central processing unit. In order to have more than one processor, we may need a very high-end technology computer to process the processes threads.

In order to generate large population and chromosome, fast processing speed is needed in order to cope with the execution of the application code. With the use of parallel processing, it can reduce the cost of getting or purchasing fast performance processor, as parallel processing is the use of both CPU (Central Processing Unit) and GPU (Graphic Processing Unit), which has been proven that the GPU has greater number of core compare to CPU which one core of GPU is 100 times the core of a CPU. CUDA is selected as it is based on the GPU that has been used or install in the current workstation. CUDA is an NVIDIA platform that has its own programming language using C++ or C to run the program. Other GPU vendor such as Intel AMD/ATI are among the popular vendor in GPU production yet different GPU may use different programming language [7].

Operations run in parallel as in its architecture of GPU that consists of multiple threads. Compared to genetic algorithm in CPU, parallel genetic algorithm in GPU is implemented in a general-purpose computation environment provided by NVIDIA named the CUDA environment. In CUDA environment, one should be familiar with the term 'host' and 'device'. The 'host' refers to the main memory which is CPU[8]. GPU is considered as a co-processor that is able to execute many threads in parallel [9]. CUDA environment employs single instruction or multiple-thread architecture.

In this research, parallel genetic algorithm is proposed to come out with the best solution of design structure for energy saving glass. Genetic algorithm has been used to solve optimization problems in many fields that involve electromagnetic field, which is related to this research. It was proven useful for designing purpose with optimum

3.0 PARALLEL GENETIC ALGORITHM PROCESS

The flowchart in Figure 2 below shows the main work of parallel genetic algorithm that involves employing the procedures using CUDA as the framework. It starts with pre-processing that happen in CPU. Same as in genetic algorithm in CPU, operations involve are generation of chromosomes, crossover operation and mutation. Operations run in parallel as in its architecture of the GPU that consists of multiple threads.

The next process is to generate a population of chromosomes in a binary form. In the program, the thread has to be declared first before the process started. Every single thread ID will have a single unique ID. Followed with parallel thread, it will launch them at the same time for every single ID. Next step is to declare threads according to the population size as inputted by the user. Then, it will launch exactly the number of the population size as desired by the user. The program will generate the chromosomes according to the chromosome length input by the user. After that, it will calculate the fitness of the population. The rules employed in this operation as discussed below. A thread is declared according to the population size (N). In parallel, chromosomes are generated according to chromosome length. As significance, the generated chromosomes calculated its fitness value according to the criteria stated. Fitness function or an objective function processes the randomly generated chromosomes to go through one kind of a pre-determined constraint. The program processes one single string of a binary or individual in binary, as follows: whenever there is one bit 0 in a string, the program will collect 1 mark or point to the string, and continues; whenever there are two neighboring bit 0, the program will collect 2 points to the string, and continues; whenever there are three neighboring bit 0, the program will collect 3 points to the string, and continues; whenever there are four neighboring bit 0, the program will again collect 2 points for this string, and continues; whenever there are five neighboring bit 0, the program will collect 1 mark point to the string, and continues; finally, whenever there are more than five neighboring bit 0, the program will collect 1 mark point to the string, and continues

The next process is; crossover that takes place in order to improve the selected chromosome fitness. The crossover operation starts by setting J to the value of zero. Getting into the loop, the program will make a decision whether J is equal to the best size or not. Best size refers to the percentage size of user input. If the result shows J does not fulfil the condition, it will generate a random number from 0 – 100. From this loop, it will go to another decision making, to test whether this generated random number is less than or equal to crossover rate. Crossover rate is input by the user in the first place. However, if J is equal to the best size, it will take the first chromosome and save it as J0. From here, the program will go to another random number generator. In another decision making, it will be checked whether the

generated random number second one is less than or equal to crossover rate. If no, it will generate another random number. If yes, it will go to the next step, which is to generate random crossover point. It is important, for crossover to happen. Then, the program will crossover the both pairs of chromosome with crossover point, and add two to them, which means add two to J. This will loop two more loops, to skip the next two. The crossover process employs looping process but not parallel. After crossover operation, the program will go back to main process to copy the result of the device (GPU) from crossover back to host (CPU). Again, a new array is declared before mutation operation process. In this operation, there are success and failure results that are kept in the memory.

After crossover, mutation process takes place where it works in parallel just as generation population process. It is compulsory to declare the name of thread for every single ID. It starts with thread declaration according to number of chromosome available (num). The number of size is depends on the number of chromosomes that is still in the population since in the previous process, there are success and failure of chromosomes. The available thread, which have been declare will do the same process which is to work in a parallel generating random number between 0 to 100. The outcomes will go through the decision whether the random number generated is lower than or equal to mutation rate. If yes, it will do almost the same process which is to generate random mutation point. A mutation point contains of 100-bits length of chromosome. Followed by that, it will mutate the bit of the mutation point, before calculate fitness of the population chromosome. It will save the mutation value back to the original array. However, if the random number generated is greater than mutation point, it will calculate fitness of the whole population.

The second final stage is the final selection process where the best chromosome with the highest fitness value is selected. In this selection stage, the program will perform a selection operation that is based on the rank selection method. The selection of the chromosome rank the fitness value result from accumulating points of each string before ranking it from lowest to highest fitness value. Selection is made based on the highest fitness value. Technically, based on the constraint stated in the fitness function stage, highest fitness value will have the most optimum number of bit zero and bit one. It is important to ensure that the selected chromosome has the right amount of bits according to the percentage stated in the constraint.

This final stage of the process works in order to output the results obtained after going through several genetic algorithm processes on GPU platform. This step applies in every CUDA program. After working with GPU, the results are copied from a device back to the CPU.

4.0 RESULTS

The program will generate a text file with extension .txt every time we execute the program. Figure 3 below shows an example of the results, that will be shown when we open the text file, which includes the chromosome number, the chromosome value and fitness value. The best chromosome is the one with the highest fitness value. Theoretically, the best result represents the best coating structure that has the highest transmission for useful signals and the lowest loss rate. However, it can only be proven when the coating structure is tested using a simulation software.

5.0 CONCLUSION

eveloping a new coating structure for energy saving glass with the use of parallel genetic algorithm in CUDA is one of the methods that have been developed to find an ideal coating structure. Other methods such as ant colony and particle swam optimization can be used in order to create new coating structures. Improvement can still be made with the combination of various techniques yet it require longer duration to develop and analyze, to allow maximum useful signal strength than can pass into the building. Useful signal strength can only be maximized and improved and cannot be 10 percent available that due to the air attenuation that causes loss of signals.

REFERENCES

[1] S.I.Sohail, G.I. Kiani, K.P. Esselle, "*Enhancing RF/Microwave Efficient Transmission through Energy Saving Glass Windows Using Frequency Selective Surfaces*," IEEE International Symposium On Antunnas and Propagation, p.2262-2263,2011

[2] I. Ullah, D. Habibi, and G. Kiani, "Design of RF/Microwave efficient buildings using frequency selective surface," 2011 IEEE 22nd International Symposium on Personal, Indoor and Mobile Radio Communications, pp. 2070–2074, Sep. 2011.

[3] U. Rafique, et al., "*Frequency Selective Surface Absorber for WLAN Security*," Proceedings of the 5th European Conference on Antennas and Propagation, pp. 872-875, 2011.

[4] G. I. Kiani, L. G. Olsson, A. Karlsson, and K. P. Esselle, "Transmission of infrared and visible wavelengths through energy-saving glass due to etching of frequency selective surfaces," IET Microwaves, Antennas Propag., vol. 4, no. 7, p. 995, 2010.

[5] P. Guo, X. Wang, and Y. Han, "The enhanced genetic algorithms for the optimization design," 3rd Int. Conf. Biomed. Eng. Informatics, (BMEI) pp. 2990-2994, Oct. 2010.

[6] M. Negvitsky, *Artificial Intelligence, Second. Essex: Pearson Ed. Ltd, 2005*, pp.1- 415.

[7] M.Wahib, A.Munawar, M.Munetomo, K.Akma, "*Optimization of Parallel Genetic Algorithm for NVIDIA GPUs*", Conference of Evolutionsry Computation(CEC), p.803-8011, June 2011.

[8] B. G. Xia, D. h. Zhang, Y. F. Zhao, and J. Meng, "Application of the Genetic Algoritm to the Design Optimization of Milimeter Wave Spaceborne Frequency Selective Surface," pp. 962-966, 2012.

[9] G. Manara, A. Monorchio and R. Mittra. "Frequency Selective Surface genetic algorithms." IEEE Electronics Letters