Visualization and Reconstruction of Real Medical Image using CUDA and GPGPU

Fajar Agung Nugroho, Erika Devi Udayanti, Candra Irawan
Faculty of Computer and Science
Dian Nuswantoro University
Semarang, Indonesia

Abstract

Medical images that is captured from CT-Scan machine are formatted on high resolution and often consist of hundreds of files per case per subject that is scanned. Each of these files are two dimensional (2D) image. Analyzing medical data in three dimensional (3D) model sometime is compulsory. However the transformation of these medical data from 2D into 3D took hundreds of seconds to minutes, even executed with modern CPU. The challenge of parallel process in this transformation is opened for all researcher in order to speed up the execution time. Among other 3D transformation image, Marching Cube (MC) algorithm is having its popularity. This is happened to the fact that MC's potential to be run in parallel. Graphical Processing Unit (GPU) currently has being utilize as General Purpose Processing GPU (GPGPU). NVIDIA as one of GPU producer has equip their device with Compute Unified Device Architecture (CUDA) as its parallel computing platform and programming model. This paper presents a framework to visualize 3D model of real medical data harnessing nVidia CUDA SDK on Marching Cube algorithm. The validation of the framework is provided using real medical data that was given by Dr. Kariadi General Hospital Medical Center of Semarang City. Finally, the speedup of execution time also presented at the end of this paper.

Keywords: *Real Medical Image, Marching Cubes, CUDA, GPU.*

1. Introduction

Visualization tool that is widely used in many hospitals is named as Syngo Fastview[6]. Fig 1 depict 2D images as result of this viewer. Trained professionals use these image to analyze the source of any problem of their patients. Analyzing medical data in three dimensional (3D) model sometime is compulsory. However the transformation of these medical data from 2D into 3D took hundreds of seconds to minutes, even executed with modern CPU. The challenge of parallel process in this transformation is opened for all researcher in order to speed up the execution time. Among other 3D transformation image, Marching Cube (MC) algorithm is having its popularity. This is happened to the fact that MC's potential to be run in parallel. Graphical Processing Unit (GPU) currently has being utilize as General Purpose Processing GPU (GPGPU).

NVIDIA as one of GPU producer has equip their device with Compute Unified Device Architecture (CUDA) as its parallel computing platform and programming model. This paper presents a framework to visualize 3D model of real medical data harnessing nVidia CUDA SDK on Marching Cube algorithm. The validation of the framework is provided using real medical data that was given by Dr. Kariadi General Hospital Medical Center of Semarang City. The authors have been given by two medical images. The first is images of patient with neck pain. These images is consist of 215 files with size of 512x512. Thus, the dimension of neck medical data is 512x512x215. The next data is images of patient with head pain. The images consist of 181 files with size also 512x512. Thus, the dimension of head medical data is 512x512x181.

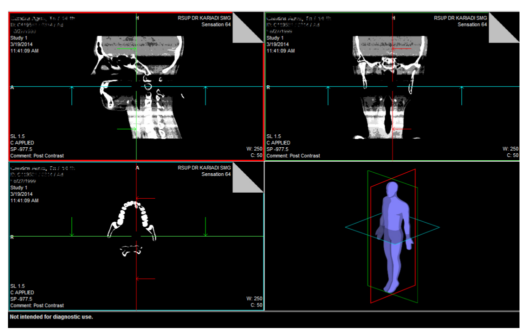

Fig. 1. Visualization of Syngo Fastview on Neck Medical Data

2. CUDA

CUDA (Compute Unified Device Architecture) is made by nVidia as its parallel computing platform and programming model. Scientist or programmer can use CUDA to utilize Graphical Processing Unit (GPU) as

general purpose processing (GPGPU). Research that is utilize CUDA as its core of parallel computing has been widely spread in many discipline. In database there is research of SQL database acceleration by [2]. in networking as an accelerator of intrusion detection, CUDA has done by [3]. There are also exist CUDA in computational biology by [4] and [5].
CUDA provide SDK of parallel implementation of Marching Cubes algorithm. The Marching Cube algorithm is a famous algorithm for visualizing 3D images because of its full potential in parallel processing. However, the implementation of MC algorithm from CUDA SDK hasn't being tested with real medical data. Section I has discussed that real medical data consist of hundreds of files. These files need to be processed and converted into raw file.

3. Framework

The framework of this paper is used to visualize 3D image from series of 2D images of real medical data. The framework is depicted on Fig 2. The first step is to collect medical data that is going to visualize. Next is to change the type of image to 8 bit image when it's not. The medical images that were used on this paper was originally on 16 bit. when it's done, images should be resized to 256x256. Originally, resolution of real medical images usually at 512x512. The conversion of type and resize of images is a must due to the capability of nVidia SDK Marching Cubes to process data.

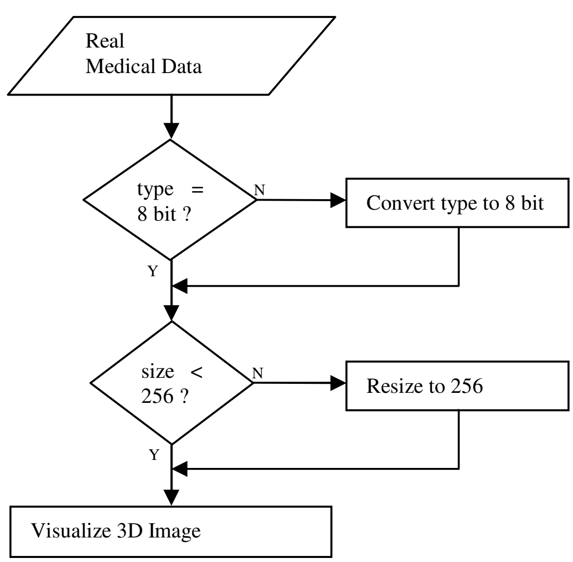

Fig. 2. Framework of 3D Image Visualization

The final step is to visualize the 3D image. The visualization is harnessing from nVidia CUDA SDK for MC algorithm

4. Implementation

The implementation of our framework was tested on a system that is summarized on Table 1.

Table 1 Experimental testbed

CPU	Intel Core i7 2.4 GHz
Memory	8 GB
GPU	nVidia GTX 660
OS	Microsoft Windows 8
CUDA Compiler	Microsoft Visual Studio 2008 (CUDA Toolkit 5.5)

The conversion process and resize process was done on CPU since those two processes can be categorized as low computation effort. The visualization of 3D image then, was done on GPU because of its high computation effort. The visualization of 3D image was done by harnessing CUDA's Marching Cube SDKs.

5. Result

The time taken as execution result of our two datasets is summarized on Table 2. The execution time was marked only on visualization process. The result indicates that GPU's execution time is faster that CPU's. The speed up is ranged from 100 to 145 times.

Table 2 : Execution Time Comparison

Dataset	CPU	GPU
Neck	145.322 s	1.0854 s
Head	102.649 s	1.0740 s

Section I has explained about the two datasets that were used in this research. Those datasets have been successfully visualized in 3D mode. The results are depicted on Fig. 3 and Fig. 4.

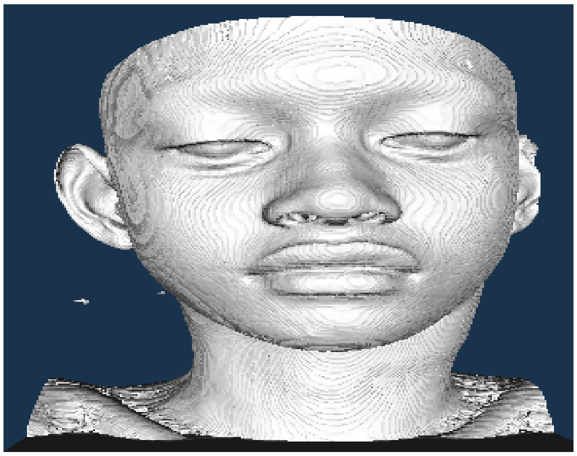

Fig. 3. Visualization result of Neck Medical Data

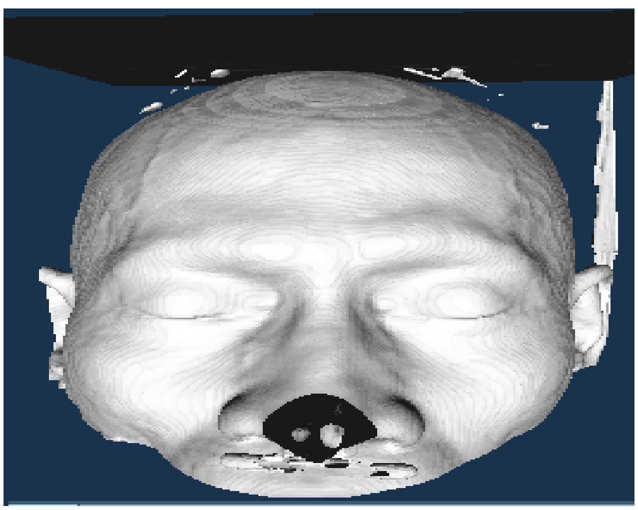

Fig. 4. Visualization result of Head Midical Data

6. Conclusion

Our proposed framework has successfully visualize real medical dataset taken from CT-Scan machine using MC Cubes algorithm enhanced with nVidia CUDA architecture. The algorithm has shown a significant speedup of 100 to 145 times than sequential process.

Acknowledgments

The author would like to give thanks to Dr. Kariadi General Hospital Medical Center of Semarang City for providing the real image sequence medical data captured from local CT Scan machine.

References

[1] W. Lorensen and H. Cline. Marching cubes: A high resolution 3D surface construction algorithm. In Proceedings of the 14th annual conference on Computer graphics and interactive techniques, volume 21, pages 163–169. ACM, 1987.
[2] Bakkum, P., & Skadron, K. (2010). Accelerating SQL Database Operations on a GPU with CUDA. Architecture.
[3] Giorgos Vasiliadis, Spiros Antonatos, Michalis Polychronakis, Evangelos P. Markatos and Sotiris Ioannidis (September 2008). "Gnort: High Performance Network Intrusion Detection Using Graphics Processors" (PDF). Proceedings of the 11th International Symposium on Recent Advances in Intrusion Detection (RAID).
[4] Manavski, Svetlin A.; Giorgio Valle (2008). "CUDA compatible GPU cards as efficient hardware accelerators for Smith-Waterman sequence alignment". BMC Bioinformatics 9: S10. doi:10.1186/1471-2105-9-S2-S10. PMC 2323659. PMID 18387198.
[5] Schatz, M.C., Trapnell, C., Delcher, A.L., Varshney, A. (2007). "High-throughput sequence alignment using Graphics Processing Units". BMC Bioinformatics. 8:474: 474. doi:10.1186/1471-2105-8-474. PMC 2222658. PMID 18070356
[6] Syngo-Fastview . http://www.healthcare.siemens.com/medical-imaging-it/syngo-special-topics/syngo-fastview. Accessed 18 Sep 2014.

Fajar Agung Nugroho is lecturer of Dian Nuswantoro University of Semarang City, Indonesia, where he received Bachelor Degree in Computer Science in 2009. In 2010 he went to University of Technical Malaysia Malaka and received Master Degree two years latter.

Erika Devi Udayanti is lecturer of Dian Nuswantoro University of Semarang City, Indonesia, where she received Bachelor Degree in Computer Science in 2009. In 2010 she went to University of Technical Malaysia Malaka and received Master Degree two years latter.

Candra Irawan is lecturer of Dian Nuswantoro University of Semarang City, Indonesia, where he received Bachelor and Master Degree in 1999 and 2004.