A Survey on Parallel Computing Based Improved Segmentation of Medical Images for Tumor Detection

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Abstract : Image segmentation is one of most important and useful approaches of digital image processing. It is widely being used for the specific operation of detecting and measuring tumor in medical images of the human body. Most of all image processing applications require more computing power and hence show high degree of parallelism. Major challenge of parallel computing is not only aim to have high performance but is also to achieve the desired goal in less time with better utilization of resources especially GPU (Graphics Processing Unit).Various classical or sequential segmentation methods, like edge based, thresholding, and region based method would be combined and used with the parallel computing concepts to speed up the system using dedicated GPU. We can also take tumor detection as an application to medical imaging in this context and also can worked with morphological operation. After implementing parallel computing based image segmentation, we also present the comparative study of performance of sequential and parallel image segmentation and in fact, parallel approach always gives better performance.

Index Terms - Image Processing, Parallel Computing, Image Segmentation, GPU, Medical Imaging, Morphological Operation, Tumor Detection.

I. INTRODUCTION

Medical image processing utilization for human tumor diagnoses has been detected by many medical techniques like Computed tomography (CT), Magnetic Resonance imaging (MRI), Positron Emission Tomography (PET), sonography and ultrasound using this different modalities we get 2D, 3D and 4D types of medical images. All these technologies are utilized routinely to identify irregularities in the human body [1]. The big revolution in information technology is to solve the problems and challenges which were generated in medical diagnoses. In information technology such approaches like Segmentations, Registrations and Visualizations have different techniques and algorithms. Using these techniques and algorithm we were overcomes all challenges and problems which were generated in medical images. Image segmentation is an approach of image processing that divides image into contiguous regions, or segments [2]. Segmentation is a crucial step for many applications where it is important to discern objects or boundaries within the image [2]. In medical images different problems were generated, which were solved by using segmentation methods such as: Region Growing, Splitting, Clustering, Thresholding and Edge Detection. These all methods have different algorithms like FCM, K- mean, K- FCM, P- FCM, ROI, etc. but a segmentation algorithm need long execution time. Using Graphical Processing Unit (GPU), processor can be increasing executing time and also achieve performance enhancement. In image segmentation is used to find the region of interest (ROI) by using segmentation algorithm, there implementation is presented in four different ways: Sequential CPU, Parallel CPU, Hybrid GPU and GPU [2]. The process of program instruction by dividing them in multiple processors know as parallel processing, where program is running in less time. In medical image parallel object work on GPU has become very popular in recent years. GPU is a specialized electronic circuit which was work with CPU and gives very efficient and highly parallel structure of GPU implementation depends on how easy it is to make adaptation of a given algorithm [3]. Image processing algorithms are massively parallel by nature, which is simplified by GPU. GPU can solve large data parallel problems to huge medical data then CPU. But all algorithms of segmentation are not accepted by GPU process, because GPU is not suitable for parallel processing with very few slices. This problem was solving by using per-slice threading (PST) with GPU. That time GPU performance become more than 5x times up. For implementation process, we are using software such as MATLAB, Python, C++, CUDA etc. and increases in computing performance by harnessing the power of the GPU [4].

II. IMAGE OVERVIEW OF GPU – CUDA MODEL

A. GPU History

Different GPU versions are available in market. The evolution of the modern graphics processor begins with the introduction of the first 3D add-in cards in 1995, followed by the widespread adoption of the 32-bit operating systems and the affordable personal computer.

The graphics industry that existed before that largely consisted of a more prosaic 2D, non-PC architecture, with graphics boards better known by their chip's alphanumeric naming conventions and their huge price tags. 3D gaming and virtualization PC graphics eventually coalesced from sources as diverse as arcade and console gaming, military, robotics and space simulators, as well as medical imaging.

The early days of 3D consumer graphics were a Wild West of competing ideas. From how to implement the hardware, to the use of different rendering techniques and their application and data interfaces, as well as the persistent naming hyperbole. The early graphics systems featured a fixed function pipeline (FFP), and an architecture following a very rigid processing path utilizing almost as many graphics APIs as there were 3D chip makers.

- Part 1: (1976 - 1995) The Early Days of 3D Consumer Graphics
- Part 2: (1995 - 1999) 3Dfx Voodoo: The Game-changer
- Part 3: (2000 - 2006) The Nvidia vs. ATI Era Begins
- Part 4: (2006 - 2013) The Modern GPU: Stream processing units a.k.a. GPGPU

B. GPU Overview

A graphics processing unit is able to render images more quickly than a central processing unit because of its parallel processing architecture, which allows it to perform multiple calculations at the same time. Here, for computational processes in market verities are GPU models are available [5].

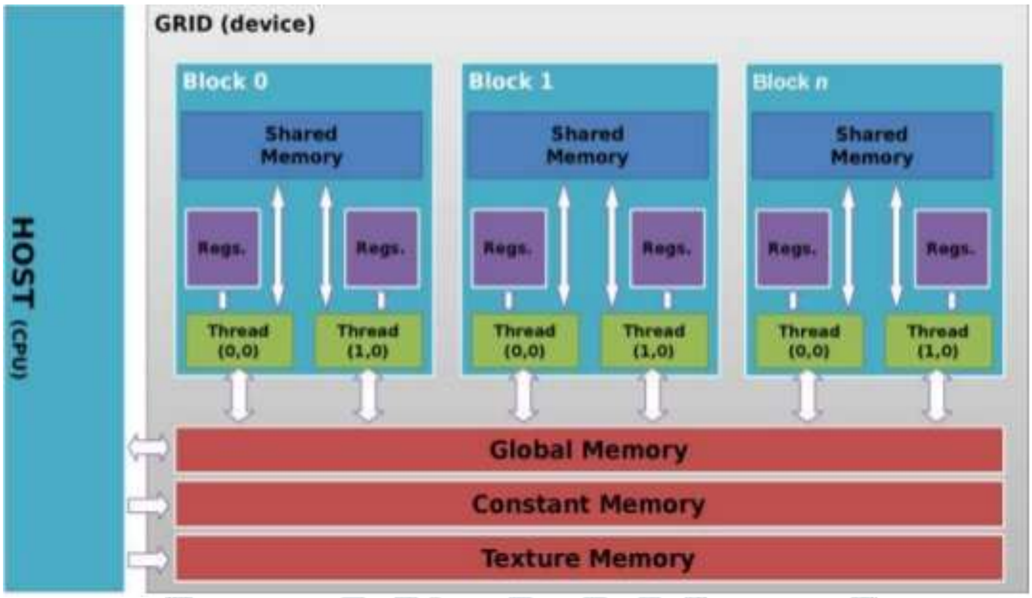

Fig.1 Architecture of GPU [6]

GPU architecture is dividing in three parts:

I. HOST (CPU): Graphics cards take data from the CPU and turn it into pictures. The GPU needs something from the cache memory, even something that the CPU has recently changed, the GPU gets the same data as the CPU, without having go to main memory. They allow the CPU and GPU to share the same memory, which removes the need to copy data between CPU and GPU buffers.

II. Programming Model (GRID): GRID technology can be shared concurrently by multiple users, all tapping into a server from different locations, and not stuck waiting for a turn to sit down at a fixed unit with a single CRT monitor. GPU run on kernel and kernel is executed as a grid of threat blocks. Each kernel has blocks, which are independent group of ALUs. Each block is comprised of threads, which are the level of computation. The treads in each block typically work together to compute value.

III. Memory Model: In GPU for thread execution, they have multiple memories. In Fig we show that cuda has various device memories which are organized in good manner. A GPU has M numbers of streaming memory and N numbers of streaming processor core. Each thread access variable from the local memory and register it. Here, in memory model they work in two different levels.

- Level 1: perform read/write operating
- Level 2: data store by multiprocessor

C. CUDA Architecture

CUDA is NVIDIA's parallel computing architecture that enables dramatic increases in computing performance by harnessing the power of the GPU (graphics processing unit). With millions of CUDA-enabled GPUs sold to date, software developers, scientists and researchers are finding broad-ranging uses for CUDA, including image and video processing, computational biology and chemistry, fluid dynamics simulation, CT image reconstruction, seismic analysis, ray tracing, and much more [4].As you can see on this diagram, CUDA provides two APIs:

- A high-level API: the CUDA Runtime API;
- A low-level API: the CUDA Driver API.

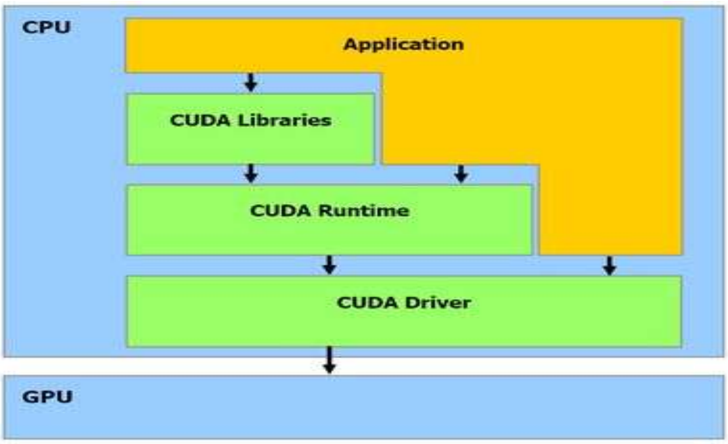

Fig.2 CUDA [7]

CUDA processing flow

- Copy data from main memory to GPU memory

- CPU instructs the process to GPU
- GPU execute parallel in each core
- Copy the result from GPU memory to main memory

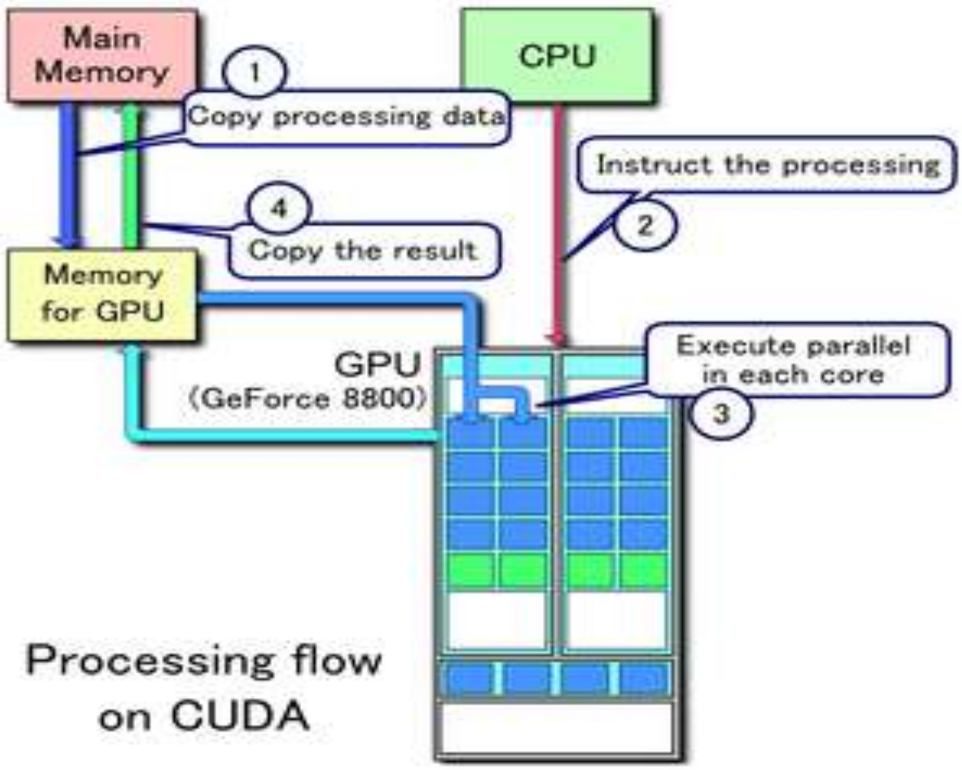

Fig.3 Processing Flow of CUDA [8]

D. GPU Computation for Medical Image Analysis

CUD The modern medical industry produces large quantity of data and processes them with complex algorithm. Generally 2D, 3D and 4D volumes are generated by the medical image modalities to diagnosis. The major techniques involved in medical image analysis which are show in Fig.

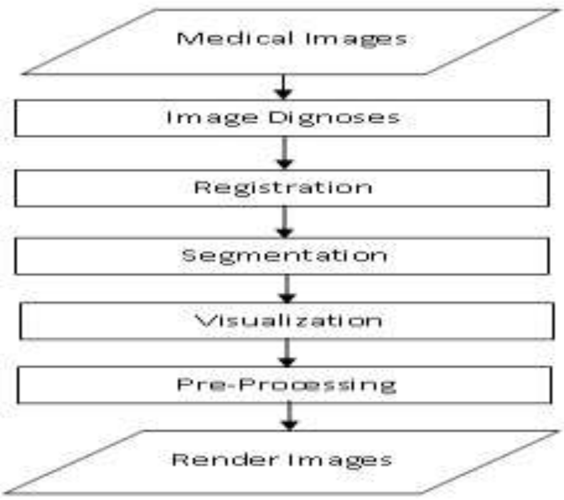

Fig.4 Medical Image Analysis Pipeline [9]

In medical image filtering and registration are famous preprocessing areas. Segmentation is simplify and change the representation of the image, which are more meaningful and easier to analyze and dignosis. Visualization is a post processing method which are represent in medical images.

III. LITERATURE SURVAY

The following table 1 contains study of 14 most important papers on the medical imaging for detecting tumor from human body, by using segmentation different techniques and algorithm with GPU. It also includes the overview of each paper with their positive and negative aspects. Publishers and publication year are also included in the table.

Table 1: Literature Survey

Publication/Year	Title	Overview	Positive Aspects	Disadvantage
IMU (Informatics in medicine unlocked) / 2017	Survey of using GPU CUDA Programming Model in Medical Image Analysis [9].	In this paper, Brief discusses about hardware configuration and optimization.	In medical imaging, growing complexity of image can be increasing by GPU.	CUDA programming is not run in all platform, and also it is little hard to understand and debug the error.
ResearchGate/ 2017	CUDA Model for Accelerating Brain Image Segmentation and Classification [10].	K - Mean algorithm and feature extraction algorithm for MRI images, Volume were implemented and speed up is gain by using GPU.	Using GPU result become 10*-30* time faster than conventional CPU processor in PST model.	When data can transfer between CPU to GPU including in computational time that time GPU parallel processor consider slow process compare with CPU processor.
Springer / 2016	Accelerating 3D Medical Volume Segmentation using GPUs [11].	Segmentation algorithm-FCM, solve time problem using GPUs.	3D model need long process time, using GPU in parallel processing they can decrease time complexity.	When accuracy of image is improved then cost of executing time is increasing.
PLOS ONE/2016	Automatic Region – Based Brain Classification of MRI –T1 Data [12].	Proposed method and other segmentation techniques can improve performance and robustness of result.	Using segmentation different methods processor can increase performance.	The proposed method is more robust in comparison with other techniques.
Springer/2016	Accelerating Computing Intensive Medical Imaging Segmentation Algorithms Using Hybrid CPU – GPU Implementation [13].	Fuzzy c – mean algorithm is used for providing segmentation accuracy. With GPU process, algorithm can accelerate the executing time.	FCM algorithm based image segmentation process is work with CUDA language and gives best performance.	FCM need a long executing time for perform algorithm.
ELSVIER/2016	Parallel Genetic Based Algorithm on Multiple Embedded Graphic Processing Units for Brain magnetic Resonance Imaging [1].	To helping physician for better diagnosis. Fuzzy c-mean clustering algorithm cam embedded multiple images with GPU.	Proposed system can addressing the complexity and challenges can easily show problem in brain.	FCM algorithm is sensitive for the selection of initial cluster center.
IJARCSSE/2016	An Automated System for Brain Tumor Detection and Segmentation [14].	This paper present completely automated way to detect brain tumor using segmentation techniques.	Segmentation and Detection is done by MR image, It is easy and completely automated technique for good accuracy.	Different MR image contained different shapes of tumor.
IJPSI/2016	Brain Tumor Segmentation From MRI images and Volume Calculation of Tumor [15].	The state – of – art methods fail to segment homogeneous tumor against similar background therefore using proposed method content based active contour solve problem.	Using Region Growing method and Edge Detection method, tumor can easily find from human body.	Segmentation method is complex in time.
IEEE/2015	Automatic Brain Tumor Detection and Segmentation from Multi-Modal MRI Images Based on Region Growing and Level Set Evolution [16].	A fully automated method for the segmentation and detection of tumor area from 2D brain MRI slices.	A fully automated technique is developed to detect glioma from multi modal MRI images & segments the tumor region from whole image.	Region-based models is fail to detect exact boundary of tumor.
TROI/2015	Image Segmentation Using GPU [2].	Segmentation algorithm finds the region of interest. Also present four implementations;	Numbers of cluster defined automatically and increase the	Architecture of process becomes complex and differs from one model.

		sequential CPU, parallel CPU, Hybrid GPU, and GPU and also compare their result in MATLAB.	segmentation performance.	
IEEE/2015	Region Growing Segmentation of MRI – A Metric Topological Approach [17].	Region Growing Technology has gained importance in medical imaging segmentation. Growing algorithm can measure entropy, accuracy, PSNR, and MSE.	Segmentation algorithm gives 98% or more quality result.	Segmentation algorithm not gives quality result when image is too blurred or too small size.
ELSEVIER/2013	Medical Image Processing on The GPU Past, Present and Future [3].	This review presents, the past present and future work on GPU accelerated in medical image preprocessing.	Using GPU we can solve wide array of problems in medical imaging.	GPU run only in a NVIDIA platform.
ELSEVIER/2010	A Survey of Medical Image Registration on Graphics [18].	GPU experienced reders with an interest in accelerates image registration as well as registration experts who have interest to use GPUs.	GPU based image registration have high memory throughput.	Implementation on the GPU is potentially limited by the amount of memory available.

IV. RELATED WORK

Image Processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image [18]. The purpose of Image Processing is divided into many groups such as Image Segmentation. In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. Segmentation techniques are either contextual or non-contextual. The latter take no account of spatial relationships between features in an image and group pixels together on the basis of some global attribute, e.g. grey level or colour. Contextual techniques additionally exploit these relationships, e.g. group together pixels with similar grey levels and close spatial locations. There are three general approaches to segmentation, termed thresholding, edge-based methods and region-based methods [19].

A. Methods of Segmentation

I. Thresholding**:** Thresholding is a process to segment each pixel or voxel using one or more threshold values. Thresholding is a simplest technique to implement the data parallelism using voxel per thread in 3D image or pixel per thread in 2D image. The Thresholding method at each pixel or voxel completely indepently [9]. Thresholding using with CUDA gives better performance in 2D images with various size.

II. Region Growing**:** Region Growing is commonly used medical image segmentation technique. Region growing starts with initial seed point from object which is given by either manually or automatically using prior knowledge. The operation starts from the seed point and connects the neighboring pixel, which is similar to the seed point based on some criteria.

III. Edge – Detection: Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp adjustment in intensity at the region boundaries. Edge detection techniques have therefore been used as the base of another segmentation technique.

When an image is acquired by a camera or other imaging system, often the vision system for which it is intended is unable to use it directly. The image may be corrupted by random variations in intensity, variations in illumination, or poor contrast that must be dealt with the vision processing. For filtering purpose some noise removing techniques are also applying on image such as Low-pass, High- pass and min, max and median. These techniques applying on image for de-noising.

Fig. 5 Segmentation Method

B. Morphological Methods

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the process. The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion. This table lists the rules for both dilation and erosion [20].

V. CONCLUSION AND FUTURE WORK

Because of new invention create in information technology; we get different processing approaches like segmentation, classification, registration, denoising etc. These all techniques have different algorithms like FCM, K- mean, K- FCM, P- FCM, ROI, etc. but a segmentation algorithm needs/requires long execution time. Using Graphical Processing Unit (GPU), processor can be increasing executing time and also achieve performance enhancement. In parallel processing process instruction divided in multiple processes, where program is running in less time. In medical image, parallel object work on GPU has become very popular in recent years. But, GPU is not working on single slice. If GPU run with per-slice threading (PST), processor gives five time faster speed up compare to GPU.

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