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A COMPARATIVE STUDY – MEDICAL IMAGING TECHNIQUES: GPU-BASED OR PARALLELIZED?

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Abstract— Medical Imaging is a way of developing visual illustrations of a human body and as a result, helps in the proper diagnosis and treatment of a particular disease. Medical imaging has proved to be a boon for medical science. Numerous approaches and algorithms are there to implement different medical imaging techniques. This paper compares the different approaches and algorithms used in the medical imaging techniques. The different techniques are compared on the basis of whether they are implemented with the help of GPU or a parallelization based technique has been used.
Keywords— Distributed Processing, GPU, Loosely Coupled, Medical Imaging techniques, Parallel Processing.

I. INTRODUCTION

The process as well as the technique of developing visual illustrations of a body's interior for medical treatment as well as clinical evaluation, and also for the representing visually physiology i.e. the human organs' function, is known as medical imaging. Medical imaging is helpful in revealing the internal body structures as well as in diagnosing them and the treatment of the diseases related to them. The standard which is used almost everywhere for storing, exchanging as well as transmitting medical images is DICOM (Digital Imaging and Communication in Medicine). The DICOM Standard incorporates All the necessary protocols that are made use of in imaging techniques like computed tomography (CT), radiography, ultrasonography, radiation therapy as well as magnetic resonance imaging (MRI) are incorporated in the DICOM standard may be provided to understand easily about the paper.

1.1 Medical Imaging Techniques

1.1.1Radiography
The imaging technique which makes use of the electromagnetic radiation; especially, X-rays is known as radiography. An X-ray generator produces a heterogenous beam of X-rays. The projection of this beam is done towards the object for the creation of required image.

1.1.2 Computed Tomography
The diagnostic imaging test which is used for the creation of precise illustrations or images related to body organs, soft tissue, bones, soft tissue as well as blood vessels; is known as CT or Computed Tomography. CT scanning is usually the most effective means for the detection of various cancers as these images make the confirmation of tumor very clear to the doctor and help in determining the location and size of the tumor.

1.1.3Magnetic Resonance Imaging(MRI)
The test which makes use of pulses of radio wave energy and magnetic field for creating images of structures and organs within the human body is called Magnetic Resonance Imaging or precisely MRI. The pictures that are obtained from an MRI scan are in the form of digital images, which in turn makes their storage and processing easier on a computer.

1.1.4Ultrasonography
Ultrasonography makes use of ultrasound waves for producing the images related to internal body organs as well as other tissues. The goal of ultrasonography is usually finding the source of the disease which the patient is suffering from. The most common form of ultrasonography is obstetric ultrasound which is widely used in the examination of pregnant women. X-rays are not used in the technique of ultrasonography.

II. RELATED WORK

Doel et al 2017[1] have proposed GIFT-Cloud which is a data sharing as well as collaboration platform designed for carrying out research in medical imaging. Mingliang et al 2016[2] have improved the NLM algorithm which now involves noise weighting function as well as parallelizing to denoise medical images. Guo et al 2016[3] have developed an enhanced iterative algorithm, thus combining TVM (Total variation minimization) and RSF (Region scalable fitting) model. This improved algorithm can be used for inspecting defects in large-sized objects as well as for a unilateral off-centered scanning trajectory. Nguyen et al 2016[4] have proposed the existing parallel hybrid architecture in a

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distributed version for solving computation time problem . The authors have also proposed a new method for computing the coefficients of filters' by enhancing filters' parameters by considering the current voxel's neighbourhod more accurately. Bychkovsky et al 2016 [5] have surveyed imaging in early and adavanced breast cancer. The authors have discussed thoroughly the optimal use of staging imaging in both early as well as locally advanced breast cancer, surveillance imaging's role in detecting recurrent disease in Stage 0-III breast cancer as well as the authos have discussed how patients with metastatic breast cancer should be followed with advanced imaging. Feng et al 2016[6] have proposed a scalable 3-dimensional hybrid MPI+Threads parallel Delaunay image-to-mesh conversion algorithm which has its scalability on a distributed memory-clusters. Schwerter et al 2016[7] have proposed an approach for performing a 3D CT data registration to a single interventional native fluoroscopic frame. Nasirudin et al 2015[8] have presented a Monte Carlo-based simulation of a SCT which has been equipped with a PCD. Yiu et al 2015[9] have proposed a new pixel-based, high-speed MV beamforming framework intended for performing synthetic aperture imaging for the formation of whole frames of adaptively apodized images at real-time throughputs. The proposed framework is primarily centered upon parallel computing principles. Strakos et al 2015[10] have presented the speedup of the k-means algorithm which is used for image segmentation. The authors have achieved this speedup with the help of effective parallelization using MIC architecture Intel Xeon Phi coprocessor. The authors used segmentation of CT images of the abdominal body part for demonstrating parallel capabilities of k-means algorithm. Kulak et al 2015[11] have developed the fuzzy axiomatic design also having the RFAD(risk factors) approach. The authors are the first to use this approach in comparing multi attributes of medical imaging systems. Hofmann et al 2014[12] have examined the Xeon Phi for its appropriateness in running the FDK algorithm. XeonPhi is centered upon Intel's MIC(Many Integrated Cores) architecture. FDK is the most frequently used algorithm for performing the 3D image reconstruction in the field of cone-beam computed tomography. Karonis et al 2013[13] have proposed the use of distributed and hardware-accelerated computing methods for achieving fast image reconstruction using pCT(proton computed tomography). Steuwer et al 2013[14] have presented SkelCL. SkelCL is a high-level programming model for the computing systems which are having multiple GPUs. The authors have implemented it as a library on top of OpenCL. Zhu et al 2012[15] have presented the implementation of a deconvolution algorithm for brain perfusion quantification on GPGPU (General Purpose Graphics Processor Units). The authors have made use of the CUDA programming model for the implementation. The authors have also evaluated the performance gains of such algorithms using GPUs and presenting both sequential as well as parallel implementations of those algorithms. Heckel et al 2011[16] have presented an interactive segmentation method for 3D medical images which is used for reconstruction of an object's surface by making use of implicit, smooth and energy-minimizing functions. Benquassmi et al 2011[17] have presented the parallelization of Katsevich CT image reconstruction method by making use of OpenMP. Then the authors have compared the results obtained with the CUDA results on 3 different GPGPUs. Fluck et al 2011[18] have presented a survey giving an overview of GPU accelerated image registration. The authors have addressed have surveyed programming models as well as interfaces, thus analyzing the different approaches for programming on GPU. Crane at al 2006[19] have proposed the integration of MR (Magnetic Resonance) scanners with HPC (high-performance computing) grid. The authors' objective has been to improve patient care by enabling near real-time, computationally intensive medical image processing, directly at an MR scanner. The authors have also described a graphical software tool, developed for running on the MR scanners. Warfield et al 1998[20] have developed an automatic registration algorithm to align the medical imaging data. The proposed algorithm works by measuring alignment by comparing dense feature sets (tissue labels).

III. COMPARISON TABLE

Author Name	Year	Paper Title	Technique Used	Parameters		
					Parallelization	
				GPU based	HPC	Loosely Coupled Distributed Computing
Doel et al [1]	2017	GIFT-Cloud: A data sharing and collaboration platform for medical imaging research[1]	Cross-platform technology used	×	✓	×
Mingliang et al [2]	2016	Medical image denoising by parallel non-local means[2]	Improved version of NLM algorithm	✓	✓	×
Guo et al [3]	2016	Improved iterative image reconstruction algorithm for the exterior problem of computed tomography[3]	Improved iterative algorithm combining TVM and RSF	×	✓	×
Nguyen et al [4]	2016	Medical image denoising via optimal implementation of non-local means on hybrid parallel architecture[4]	Computation of filters' coefficients	✓	✓	×

Feng et al [6]	2016	A Hybrid Parallel Delaunay Image-to-Mesh Conversion Algorithm Scalable on Distributed-Memory Clusters[6]	3-Dl hybrid MPI+Threads parallel Delaunay image-to-mesh conversion algorithm	×	✓	×
Yiu et al [9]	2015	GPU-Based Minimum Variance Beamformer for Synthetic Aperture Imaging of the Eye[9]	Minimum Variance Beamforming on GPUs	✓	✓	×
Strakos et al [10]	2015	Parallelization of the image segmentation algorithm for Intel Xeon Phi with application in medical imaging[10]	k-means algorithm	×	✓	×
Hofmann et al [12]	2014	Performance Engineering for a Medical Imaging Application on the Intel Xeon Phi Accelerator[12]	FDK algorithm on XeonPhi	✓	. ×	×
Karonis et al [13]	2013	Distributed and hardware accelerated computing for clinical medical Imaging using proton computed tomography (pCT)[13]	Combining MPI with GPUs	✓	✓	×
Steuwer et al [14]	2013	High-level programming for medical imaging on multi-GPU systems using the SkelCL library[14]	SkelCL implemented as a library on top of OpenCL	✓	✓	×
Zhu et al [15]	2012	Parallel perfusion imaging processing using GPGPU [15]	Deconvultion algorithm implemented on GPGPU	✓	✓	×
Heckel et al [16]	2011	Interactive 3D medical image segmentation with energy-minimizing implicit functions[16]	Interactive segmentation method having energy - minimizing functions	✓	×	×
Benquassmi et al [17]	2011	Parallelization of Katsevich CT image reconstruction algorithm on generic multi-core processors and GPGPU.[17]	Katsevich CT image reconstruction method	✓	✓	×
Crane et al [19]	2006	Grid enabled magnetic resonance scanners for near real-time medical image processing[19]	Combining MR scanners with HPC grid	×	✓	×
Warfield et al [20]	1998	A high performance computing approach to the registration of medical imaging data[20]	automatic registration algorithm for aligning medical imaging data	×	✓	×

IV. CONCLUSION

Most of the Medical Imaging techniques need to be parallelized and the state-of-art techniques either require High Performance Computing (HPC) or GPUs for their processing. Implementing different techniques by making use of HPCs or GPUs result in increased cost of hardware. In this paper, the comparison of various approaches and algorithms used in medical imaging has been done. The comparison is done on the basis of whether they are implemented with the help of GPU or a parallelization based technique has been used. In the comparison, it is seen that, the state-of-art techniques are not effective for the distributed loosely coupled systems. This issue has not been considered by the existing literature so far. In near future, we will propose the implementation of k-means algorithm for computed tomography image segmentation on a framework consisting of distributed loosely coupled systems. For this implementation, the available hardware will be made use of and hence the hardware cost will be reduced manifold.

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