Grid Enabled Environment for Image Processing Applications: A Review

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ABSTRACT
Image processing and Grid computing are finding its applications in almost all promising areas of research. Image manipulation tasks involve large data store and computational power. The Grid infrastructure is a suitable computing platform to meet the computational requirement for the analysis of real time image processing applications. This paper aims to present a review on the emerging applications and tools using Grid computing technology in the field of image processing.

General Terms
Image Processing, Grid Computing

Keywords
Grid computing, remote sensing images, medical images, image retrieval.

1. INTRODUCTION
Grid computing is an emerging technology which is finding its importance in handling large volumes of data. It is used to share and coordinate the distributed processing resources to achieve super computing capability. A high end computing facility and mass data storage is needed for any image processing applications which are not feasible with the help of a single computing resource. Grid computing tries to make all the resources shared, including computing resources, storage resources, communicating resources, software resources, Information resources, knowledge resources, etc, [16]. At present, grid technology is implemented in many famous Grid projects such as Information power Grid (IPG) of NASA-USA, Euro Grid, Data Grid, etc,. [17].

Grid computing is broadly classified into Computational Grids and Data Grids. Computational Grids provide computationally intensive problem solving algorithms in any image manipulation tasks. Data Grids involves data store and management in a distributed networked environment. If the Data Grid uses any special equipment to control and analyze, it is referred as an instrument Grid. The emerging third type of Grid known as a Service Grid provides an infrastructure based on web service concepts and technologies. [1].

Ian Foster suggests that there are three definite characteristics of grid computing. : (1) It should coordinate computing resources and users that exist within a variety of control domains, which differs markedly from a local-area network. (2) It must coordinate such resources with ‘‘standard, open, general-purpose protocols and interfaces’’. (3) It must deliver non trivial qualities of service that provide users with access to computing resources that are greater than the sum of the system’s non-integrated parts, such stringent definitions classify the so-called grid middleware that is used to enable grid systems[18]. Open Grid Service Architecture (OGSA) is a grid architecture which adopts existing and emerging standards of web services [18, 24].

Grid infrastructure is build with a software Toolkit called “Globus”. It is an open source software toolkit that facilitates construction of computational grids and grid based applications [5]. ALiCE, developed at the National University of Singapore, is a Java-based grid computing middleware that supports the development and execution of generic Grid applications over a geographically distributed, heterogeneous collection of resources [22].

MedIGrid is a distributed application for the management, processing and visualization of biomedical images that integrates a set of software and hardware components and more specifically, a set of grid collaborative applications useful for nuclear doctors [23, 26].

The rest of the paper is organized as follows, Section 2 gives the overview of image processing in Grid environment followed by Grid computing for satellite images in section 3 and Grid based medical image processing in section 4. In Section 5, the importance of Grid in image retrieval is discussed and finally in section 5 it is concluded followed by References.

2. IMAGE PROCESSING AND GRID
Image processing algorithms are complex and difficult to apply when it involves massive image data. In order to decrease the execution time and increase the response time of any image processing algorithms, a Grid infrastructure can be used in real time applications. A decentralized algorithm for parallel computation of multiple images in a cluster or Gird is presented in [14]. In Cluster or Grid environment, the image processing applications are submitted in the application layer and the middleware lies in the collective layer. The resource layer is responsible for allocating and managing the appropriate resources for the execution of jobs. Then the jobs are distributed to various nodes in the cluster to achieve parallel computation. A novel distributed genetic algorithm architecture implemented on grid computing using the G-Lite middleware is presented [28].

Genetic algorithms(GA) are used in the distributed Grid because of its capability to solve a wide range of optimization problems to accomplish structural parallelism. The super-resolution (SR) imaging is to overcome the inherent limitations of the image acquisition systems to produce high-resolution images from their low-resolution counterparts. The framework which is discussed in [30] gives the algorithm for converting the low resolution images to high resolution images by grid computing, which splits the computationally-intensive Markov chain MonteCarlo Super- resolution Imaging(MCMC SR) task into a set of independent and small sub-tasks dispatched for parallel processing. The figure-1 shows the diagrammatic representation of the Grid framework for any image processing application.

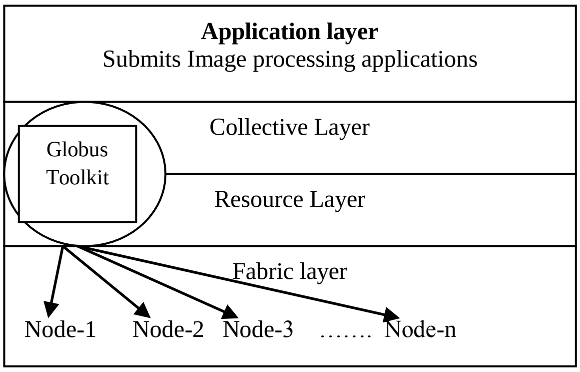

Fig. 1: A Grid framework for image processing applications

3. GRID AND REMOTE SENSING IMAGES

In remote sensing applications, many satellites are collecting enormous images periodically. It is very difficult to handle those data effectively in a single computing environment. In this scenario, Grid computing plays a vital role in handling and processing the image data. Computational grids and the spatial information processing technology are combined to form a new technology known as spatial information grids.

A Grid middleware for remote sensing image processing to meet the real time requirement has been discussed in [2]. It is a middleware based on Condor system that supports the execution of remote sensing image processing over a geographically distributed, heterogeneous collection of resources. In paper [3], a Grid environment for processing and analyzing the remotely sensed images is presented. Under such Grid environment, image smooth processing is performed by using meta-scheduler CSF4 (Community Scheduler Framework4). GRAM (Globus Resource Allocation Manager) protocol is used for message transmission in the layered architecture [3]. A Toolkit for edge detection, image enhancement, frequency domain analysis, segmentation etc. on high resolution images in Grid computing platform is designed in [4]. Various researches are available in the literature that demonstrates the use of grid computing in remote sensing images. Some of the system which is implemented for remote sensing images has been discussed below

MedioGrid, a real-time satellite image processing system for extracting relevant environmental and meteorological parameters on a Grid system is presented in [5]. It has been designed to rely mainly on the service Grid. In paper [17], the architecture of Grid GIS (Geographical Information System) based on LAN is described. It uses distributed middleware architecture based on Grid Markup Language (GML) to solve the problem of sharing resources through the internet to improve efficiency. In paper [20], a Grid enabled parallel strategies for the image registration process based on wavelet has been discussed and the parallel algorithms proposed have been integrated into related service system of ChinaGrid.

The computational intensive-satellite image geo- rectification problem on a cluster grid is presented in [22]. Geo-rectification is a process of bringing the raw satellite images into a correct spatial location and orientation. The architecture of service oriented remote sensing data processing grid is proposed in [24] and a grid prototype system is implemented on Globus Toolkit 4.2(GT4). Grid architecture for providing different kind of services and also an algorithm to fuse remote sensing images is suggested in [25]. This architecture gives the optimal parallel execution plan suitable for the parallel image fusion according to the resource changes on the Grid.

The applications and architecture of computational grids to digital image processing of remotely sensed images is discussed in [29]. The implementation of distributed computing and processing model based on the theory of grid computing for processing the remotely sensed images is presented in [32]. A distributed, grid computation-based platform as well as a corresponding middleware for grid computation for the deblurring problem in remote sensing images is addressed in [36]. Grid based satellite imagery processing application is designed using Environment oriented Satellite Data Processing Platform (ESIP) for observing the earth [40].

The registry service is an essential component in RSDPS-G(Remote sensing data processing software based on Grid computing) for sharing and interoperating huge volume of distributed remote sensing data, as well as publishing and querying services. The registry service is also a key component for workflow-based virtual remote sensing data products. A registry service based on Monitoring & Discovery System (MDS4) which is a module of Globus Toolkit (GT4) is proposed in [31].The tools using grid infrastructure for remote sensing images has been summarized in Table-1.

Table-1: Grid tools for Remote Sensing Images

#	Tool	Method Used	Purpose
1	Grid-based image processing testbed	Condor-based computing	Real time processing
2	Layered architecture for remotes sensing images	CSF4, GRAM	Processing and analysis
3	Toolkit using Grid infrastructure	Globus Toolkit, Metadata server	edge detection, image enhancement, frequency domain analysis, segmentation etc
4	GRID infrastructure in MedioGRID	Medio Grid	extracting relevant environmental and meteorological parameters
5	Architecture of Grid GIS (Geographical Information System) based on LAN	Grid Markup Language	Shares resources through the internet to improve efficiency
6	parallel strategies of wavelet-based	ChinaGrid , wavelet, Hybrid and	Image registration process

	automatic image registration	group parallel – Grid optimization method	
7	Distributed Geo rectification	ALiCE Grid	Digital alignment of a satellite image
8	architecture of RS data processing grid	Global Toolkit 4.2	Heterogeneous image fusion service
9	Service-Oriented Software Architecture	distributed image data services and image processing services,	Fusion of remote sensing images
10	Architecture for digital image processing	Computational Grid	Digital image processing
11	Distributed computing and processing model	Distributed Computing using web service and COM technology	Data and resource distributed processing
12	Grid computing middle-ware	constrained power spectrum equalizer, an effective partition method and the Neumann boundary condition	Deblurring Problem
13	Environment oriented Satellite Data Processing Platform (ESIP)	gProcess Architecture	Satellite imagery based processing applications in Earth Observation (EO) domain.
14	RSDPS-G	MDS4	Sharing and interoperating huge volume of remote sensing data

4. GRID AND MEDICAL IMAGES

The significance of medical imaging is growing day by day. It is very much necessary for the diagnosis and treatment of diseases. The storage and analysis of medical images is very vital and intensive. Data Grid and computational Grid solves the problem of managing the huge data involved in medical analysis. The laboratory model to demonstrate the fault-tolerance features of the Data Grid and computational services in the Data Grid for DICOM (Digital Imaging and Communications in Medicine) store and the manipulations are illustrated in [6]. A grid enabled medical image analysis which describes Grid middleware through core Grid medical services for medical data processing applications has been discussed in paper [7]. A framework for the assessment of image registration algorithms based on Grid computing and its workflow are described in [8]. The main goal of the European DataGrid IST project was to develop a middleware capable of addressing different application requirements in various fields. In paper [9], the data related requirements like data security, data semantics and traceability and the computation related requirements like pipelining computation, parallel computations and interactive applications for the medical image processing applications were identified and summarized. A Grid enabled environment for image processing applications is given in fig. 2.

A design and implementation of toolkit for segmentation, registration and visualization of biomedical images in the distributed environment has been studied in [15]. The middleware Image Processing for the Grid (IP4G) enables the rapid and efficient implementation of image analysis methods. An application of a component- based Grid middleware system for processing extremely large images obtained from digital microscopy devices is presented in [19].

The development of a medical imaging Problem Solving Environment (PSE) for advanced and grid computing environments has been discussed in [23]. A graphical software tool is described and developed to run on the MR scanners for submitting processing jobs to the Departmental grid [34]. The purpose of the work discussed in [35] is to create a software tools to enable a large database of images to be available to a research network for the purpose of validating and comparing a variety of different image processing procedures.

Medical applications on a Grid infrastructure, the MAGIC-5 Project, is presented and discussed in [37]. The MAGIC-5 project develops algorithms for the analysis of mammographies for breast cancer detection, Computed-Tomography (CT) images for lung cancer detection and Positron Emission Tomography (PET) images for the early diagnosis of Alzheimer Disease (AD). A Virtual Organization (VO) has been deployed, so that authorized users can share data and resources. A PACS (Picture Archiving and Communications System) based on data grids and MIFAS (Medical Image File Accessing System) to perform querying and retrieving medical images from the co-allocation of data grid is proposed in [38]. The challenges of using the PACS are a) PACS are limited to certain bandwidths and locations, b) high cost of maintaining Web PACS and the difficult management of Web PACS servers.

A review of current backup solutions will be presented along with a brief introduction to grid technology is presented in [39]. The focus of this paper is centered on applying a grid computing architecture to a DICOM environment since DICOM has become the standard for clinical image data and PACS utilizes this standard. A grid workflow for the medical image processing applications has been described in [33]. This workflow management system is able to execute all tasks related to grid communication, such as authorization, scheduling and monitoring.

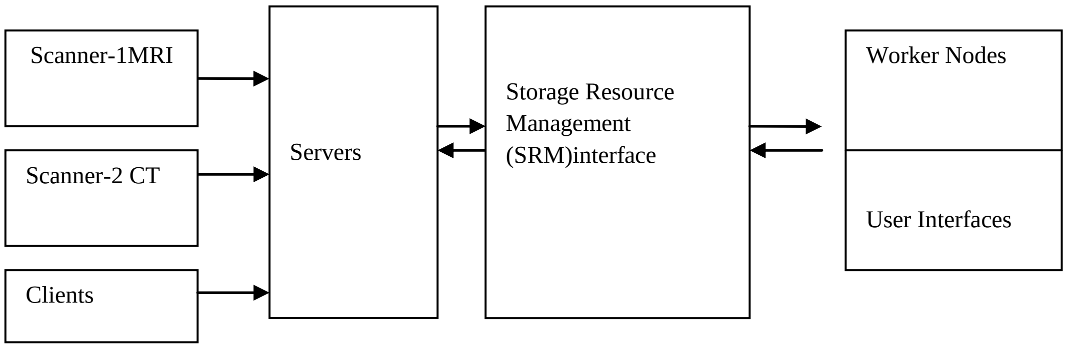

Fig. 2: A Grid enabled environment for image processing applications

A Global Imaging Laboratory established by European Consortium based on Grid/Cloud computing facilitates to develop drugs for Alzheimer's disease. The Consortium has developed the core e-Infrastructure (neuGRID) required to develop disease markers on extra large brain imaging datasets [41].Table-2 summarizes the grid tools for medical images.

Table 2. Grid Tools for Medical Imaging

#	Tool	Method Used	Purpose
1	Data Grid for DICOM	Data Grid	Store and the manipulations
2	Grid middleware	Core Grid medical service	Medical data processing
3	Generic and grid-enabled workflow framework	Bronze standard workflow gridification	Image registration assessment
4	Distributed Medical Data Manager (DM2)	EDG middleware and testbed	Data security, data semantics, computation related requirements
5	Insight Segmentation and Registration Toolkit (ITK) and Visualization Toolkit (VTK)	component-based framework	Segmentation, registration and visualization of biomedical images distributed environment
6	IP4G	Middleware	Image analysis methods
7	Graphical software tool	Departmental grid	MR scanners for submitting processing jobs
8	MAGIC-5 Project	Grid infrastructure	Analysis of mammographies for breast cancer detection
9	PACS &MIFAS	Data Grid	Perform querying and retrieving medical images
10	neuGRID	Grid/Cloud computing facilitates	Facilitates to develop drugs for Alzheimer's disease

5. GRID AND IMAGE RETRIEVAL

Image retrieval is a technique in which the digital images are searched and retrieved from a huge database. A hierarchical grid-based indexing method for content-based image retrieval (CBIR) is proposed in [10] to improve the retrieval performance. CBIR system represents the images as feature attributes which is generated from the low level contents. This method works efficiently and effectively to access the image data with very low computational complexity for larger image database. A Grid approach for large distributed processing is presented in [11] to apply a range of CBIR methods on a substantial number of images. The need for Gird computing and the performance evaluation in the complex processing stages like Image Segmentation, Region Classification, Scene Classification, Object Detection and Recognition and Index Generation are discussed in [11]. The influence of Grids to address the computation requirements of content based medical image retrieval based on texture features in larger databases is presented in [12]. Texture features are used in the similarity searches, Texture based indexing and retrieval, correlations to image variation, etc. The grid computing environment for image retrieval is given in Table-3.

Table 3. Grid Tools for Image retrieval

#	Tool	Method Used	Purpose
1	Hierarchical grid-based indexing	DCT and hierarchical grid-based indexing	Improve the retrieval performance.
2	GridSim	CBIR methods	Distributing the required computational task across some Grid nodes
3	IM GRID	Image Mining	Access and extract knowledge from the data store in a parallel way

A Grid simulator called GridSim to apply a range of CBIR methods using the combination of color and texture is presented in paper [13]. A very high throughput with relatively low overheads is achieved by massively distributing the required computational task across some Grid nodes. IM GRID, a grid computing environment is an extension of the Image Mining (IM) software is used in paper [21] to access and extract knowledge from the data store in a parallel way. The IM GRID reduces the image processing and analysis time of cell biological images for drug discovery within High Throughput-High Content Screening (HT-HCS) context. The work in the paper [27] discusses about the basic principles of a content-based image retrieval (CBIR) system and identifies the computationally challenging tasks in the system. A grid computing infrastructure for searching medical images is proposed to achieve high computational speed.

6. CONCLUSION

This paper gives a review of the classical and recent trends in Grid Computing for the image processing applications. The role of Grid computing technique in the medical images, satellite images and also in the image retrieval technique are discussed and summarized. This study gives insight to some of the software tools which is used in the imaging environment based on Grid architecture. Therefore, the Grid Computing enables the software developers and researchers in image processing to develop the algorithms for storing and manipulating enormous image datasets effectively.

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