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RESEARCH ARTICLE

SATELLITE IMAGE PROCESSING ON A GRID BASED COMPUTING ENVIRONMENT

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Abstract— Providence of remotely sensed data promotes the challenges of how to process the data and how to analyze it as soon as possible. With accordance to Grid conformity heterogeneous computing sources, a Grid environment is built for the processing of remotely sensed images. In this study, CSF4 is taken as meta-scheduler in the collective layer in such a network environment. The message transmission is implemented by a protocol defined by a Grid middleware GRAM (Globus Resource Allocation Manager). SGE, LSF, and OpenPBS are used in the fabric layer of the Grid environment. As an example of remotely sensed image processing in the application layer, image smooth processing is achieved under the MPICH-G2 programming model. The relationship between the node number and time-consuming are analyzed. And the efficiency is shown by comparison between the parallel and serial processing under different node numbers and image sizes. These instructions give you basic guidelines for preparing papers for conference proceedings.

1. INTRODUCTION

Satellite image processing plays a vital role for research developments in Astronomy, Remote Sensing, GIS, Agriculture Monitoring, Disaster Management and many other fields of study. However, processing those satellite images requires a large amount of computation time due to its complex and large processing criteria. This seems a barrier for real time decision making. To switch the job faster, distributed computing can be a suitable solution. Recently, Cluster and Grid are two most familiar and powerful distributed systems to serve for high performance parallel applications.

During the last decades, the imaging satellite sensors have acquired huge quantities of data with satellites collecting and transmitting to Earth receiving stations in excess of 3 TB of data a day. For examples, Landsat data alone comprises 434 TB of archive (31 years of Landsat 1-5, 165 TB; four years of Landsat 7, 269 TB). However, the state-of-the-art systems for accessing remote sensing data and images, in particular, allow only queries by geographical coordinates, time of acquisition, and sensor types. This information is often less relevant to the content of the scene, including image structures, patterns, objects, and radiation properties. It was estimated that less than 10% of these data have been effectively utilized. One of the challenging problems is how to process these huge remote sensing data and extract the valuable information timely to meet the needs of applications.

For many years, efforts have been made to exploit the remote sensing data and images easily and timely by developing new techniques. The use of clusters and Grids for high-performance applications has become widespread lately. High-performance computing could afford the significantly expensive supercomputers of the time. More than 70% of the top 500 computing systems in the world are clusters of workstations. Computational Grids-also mostly composed of PC workstations-have become prominent in recent years. As one of the best solutions, Grid computing can integrate distributed and heterogeneous computing resources from such large-scale computing applications. The volume of remote sensing data is so enormous but it needs to be processed or shared on the internet every day. Some Grid environment has been built for application to satellite images processing. Image processing Grid (ImageGrid) is one of five important Grid application projects supported by ChinaGrid from China Ministry of Education, aiming to creating a Grid platform for image practitioners and researchers to solve large-scale and complicated scientific problems of image processing. A Grid based image processing system was designed and implemented with respect to the technology of middleware. And the results confirm the feasibility of the application of computational Grids to digital image processing. Different architectures have been presented for application on image processing. A distributed algorithm, able to run in a Grid system, was presented for change detection from MODIS spectral bands. A distributed Grid computation based platform and corresponding middleware for Grid computation was developed and a constrained power spectrum equalization algorithm and effective block processing measures were applied during the processing Satellite image processing plays a vital role for research developments in Astronomy, Remote Sensing, GIS, Agriculture Monitoring, Disaster Management and many other fields of study. However, processing those satellite images requires a large amount of computation time due to its complex and large processing criteria. This seems a barrier for real time decision making. To switch the job faster, distributed computing can be a suitable solution. Recently, Cluster and Grid are two most familiar and powerful distributed systems to serve for high performance parallel applications.

The wealth of satellite imagery available in web mapping service applications such as Google Maps1, which now provides high-resolution satellite images from many locations around the Earth, has opened the appealing perspective of performing classification and retrieval tasks via programming libraries such as SwingX-WS2. In fact, the introduction of Google's mapping engine prompted a worldwide interest in satellite imagery exploitation. The combination of an easily pannable and searchable mapping and satellite imagery tool such as Google Maps with advanced image classification and retrieval features has the potential to significantly expand the functionalities of the tool and also to allow end-users to extract relevant information from a massive and widely available database of satellite images.

2. LITERATURE REVIEW

2.1 A Remote Sensing Image Process Method of Supervised Classification under Grid Environment

On the base of studying and analyzing the Globus Toolkit2.4 platform and remote sensing technology, this article uses the grid platform Globus Toolkit2.4 and the Bayesian classification to build a remote sensing image process method of supervised classification under the grid environment. This method can provide a preferred approach for the classification of remote sensing image.

Remote sensing technology was put forward in the 1960s, but the aviation remote sensing technology was used in military reconnaissance in the early 20th century. It has been used in geology civil engineering and other civilian areas since the beginning of 1920.The remote sensing technology got a wide range of applications at present, but the remote sensing data is huge and complex, with the development of information technology and sensor technology, spatial resolution, spectral resolution and temporal resolution of remote sensing image increased greatly, so the amount of computing will also be increased. How to deal with this data quickly has become an important issue in the remote sensing area. Traditionally, the remote sensing image processing systems are stand-alone systems, the main model is centralized model, and both of the data and processing are disposed in a single machine. Obviously this processing mode is not in conformity with the opening, distributed and network requirements. But the grid provides a distributed environment for remote sensing image processing.

The grid united the internet as a super computer whose core is “the internet is a computer”. Due to the full use of the network resources, when dealing with the remote sensing data, parallel processing can save more time. IT not only can achieve the arithmetic parallel, but data parallel.

This paper combined with the classification of remote sensing data and Grid computing technology, introduced a remote sensing data processing method based on Grid environment that can greatly improve the processing speed .But the Grid technology is still in the stage of research, with the development of research, and it will be widely used in remote sensing data process.

2.2 Satellite Image Processing on Distributed Computing Environments

Satellite image processing plays a vital role for research developments in Astronomy, Remote Sensing, GIS, Agriculture Monitoring, Disaster Management and many other fields of study. However, processing those satellite images requires a large amount of computation time due to its complex and large processing criteria. This seems a barrier for real time decision making. To switch the job faster, distributed computing can be a suitable solution. Recently, Cluster and Grid are two most familiar and powerful distributed systems to serve for high performance parallel applications. GRASS GIS (Geographical Resources Analysis Support System) is an open source software/tool, which has been used to process the satellite images. Inside GRASS, different modules have been developed for processing satellite images. GRASS module “r.vi” is developed by Kamble and Chemin, and is used as a test example for this study. Developing the methodology, which enables to run GRASS GIS environment for satellite images processing on distributed computing systems, is the main concerning issue of this paper. Additionally, two different implementation methodologies for distributed r.vi are discussed for two different programming platforms.

The GRASS module r.vi, is used to process 13 different vegetation indexes for the satellite images. Vegetation Index (VI) is the major set of indicators for vegetation. NDVI (Normalized Difference Vegetation Index) is one of them. Where, RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions, respectively. Other vegetation indexes are derived using various methods of differentiations and contrast.

The GRASS module (r.vi) is parallelized by using the master-worker model. The master process run in the GRASS environment, and decomposes the target images in rows and dispatches the computation of rows to multiple worker processes. Worker processes are free from GRASS, they just run the computation and send back the row wise result to master process. The example module (r.vi) will be implemented using MPI on a PC cluster system (r.vi.mpi) and Ninf-G on a Grid system (r.vi.grid).

The major objective of this research is to provide the Remote Sensing user a compact example for Grid and MPI programming as GRASS GIS distributed processing. Additionally, these types of research will merge the Remote Sensing or GIS with High Performance Computing communities. In near future, a comparative study on r.vi, r.vi.mpi and r.vi.grid will be developed.

2.3 A New Tool for Classification of Satellite Images Available from Google Maps: Efficient Implementation in Graphics Processing Units

It develop a new parallel implementation of the k-means unsupervised clustering algorithm for commodity graphic processing units (GPUs), and further evaluate the performance of this newly developed algorithm in the task of classifying (in unsupervised fashion) satellite imagery available from Google Maps engine. With the ultimate goal of evaluating the classification precision of the newly developed algorithm, we have analyzed the consensus or agreement in the classification achieved by our implementation and an alternative implementation of the algorithm available in commercial software. Our experimental results, conducted using satellite images obtained from Google Maps engine over different locations around the Earth, indicate that the classification agreement between our parallel version and the k-means algorithm available in commercial software is very high. In addition, the GPU version (developed using the CUDA language available from NVidiaTM) is much faster that the serial one (speedup above 30), thus indicating that our proposed implementation allows for larger scale processing of high-dimensional image databases such as those available in the Google Maps engine.

The paper describe a new tool which allows an inexperienced user to perform unsupervised classification of satellite images obtained via Google

Maps by means of the well-known k-means clustering algorithm, which can be followed by spatial postprocessing based on majority voting. The classification stage has been implemented in parallel using commodity graphic processing units (GPUs), which are specialized hardware cards that are nowadays widely available in standard PCs. The parallel version of the k-means algorithm–implemented in NVidiaTM GPUs using the compute unified device architecture (CUDA)4– is shown to be more than 30 times faster than the serial version. This opens the way for exciting new developments and potentials in efficient processing of large databases of satellite images, such as those available from Google Maps engine and used in this work for demonstration

In the work, it developed a new parallel implementation of the k-means clustering algorithm in the context of satellite image processing using NVIDIATM GPUs. The algorithm has been implemented using CUDA, and tested using a recently developed system for information extraction and analysis of image data sets from Google Maps engine. The algorithm has been evaluated in terms of its agreement with commercial software in the same context, and also analyzing the speedup with regards to the (optimized) serial implementation of the same code.

The main contributions of this study can be summarized as follows:

• The proposed method succeeded in obtaining a good agreement in classification with regards to commercial software.

• The GPU implementation obtained a significant speedup over the optimized serial version, thus supporting large scale tests in the Google Maps engine.

2.4 Contribution of Satellite imagery and DEMs to the Detection of Neolithic Settlements in Thessaly, Greece

Thessaly is a region of low relief in Greece where hundreds of Neolithic settlements/tells called magoules were established from Early Neolithic period until Bronze Age. Multi sensor remote sensing was applied to the study area in order to evaluate its potential to detect Neolithic settlements.

Moreover, different kinds of digital elevation models were used such as SRTM, DEM constructed by interpolation of contours from topographic maps, DEM constructed by aerial photos and DEM constructed by Aster images, where tells can be identified as small contrasting spots within the elevation pattern of the natural variation of the land surface.

A range of image processing techniques such as colour composite, principal components analysis, decorrelation stretch, followed by visual interpretation, were originally applied to the hyperspectral imagery in order to detect the settlements and validate the results of GPS surveying. The next step was to collect spectral signatures of these tell sites, to correlate them within the same spectral range of the different sensor systems and finally to proceed with their statistical analysis. Various filters were applied to all images to explore the high spectral and spatial variability of the settlement patterns, such as Sobel 3*3 right diagonal and Laplace filter. Classification of all the images using different hard and soft classifiers and application of vegetation index NDVI was followed.

To cope with the difficulties of pixel based methods, object–oriented classification techniques were also applied to Ikonos imagery to classify tells according to their shape and geometry.

In addition, sophisticated filters were applied to each DEM in order to detect the settlements. After validating the results with real altitude data, we concluded which of them are more reliable either for general topographic studies of the area or more specifically for the detection of the settlements. The final step was the application of fuzzy algorithms for the classification of the possibility of settlement existence. Although there are specific difficulties encountered in the classification of archaeological features composed by a similar parent material with the surrounding landscape, the results of the research suggested a different response of each sensor to the detection of the Neolithic settlements, according to its spectral and spatial resolution. Moreover, the integrated use of remote sensing imagery and the digital elevation models produced an important enhancement to the design of a predictive model of the Neolithic settlements of Thessaly by combining the spectral, spatial and topographic attributes of the tells.

ASTER images proved to be the most reliable and efficient for the detection of Neolithic settlements. In contrast, Landsat images did not produced satisfactory results, mainly due to the summer acquisition date of it. The high spectral abilities of HYPERION, especially after merging it with the high resolution images of Ikonos, seem to have an increased potential not only for detecting but also for outlining the particular features. The image processes that proved to be more effective were the spatial filtering, the process of de-correlation stretch and the radiometric enhancement. In addition the results of the analysis of DEMs, especially the application of the three different filters to SRTM DEM, proved to be very promising.

3. CONCLUSION

From this paper we perform literature survey on satellite image processing in a grid based environment. However, Providence of remotely sensed data promotes the challenges of how to process the data and how to analyse it as soon as possible. With accordance to Grid conformity heterogeneous computing sources, a Grid environment is built for the processing of remotely sensed images.

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