Parallel Processing Research on Subdivision Template of Remote Sensing Image

Delan XIONG, Genyuan DU
International School of Education, Xuchang University, Xuchang Henan 461000, China
Tel.: (86)0374-2968725, fax: (86)0374-2968938
E-mail: xiongdelan@aliyun.com

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Abstract: In order to solve some problems in managing and parallel processing of global expanding remote sensing data, introduces the spatial subdivision organization framework. Firstly, analyzes the spatial properties of subdivision cell and its significant advantages in parallel processing. Then, discusses subdivision template and template parallel processing mode for remote sensing image. And a template-based parallel processing flow of subdivision remote sensing image is proposed. The special application example is carried out to extract crop planting area. The initial experiment of extracting wheat planting area in Xuchang shows: compared to the common ERDAS or ENVI software, this method can improve the extraction accuracy and processing speed to some extent. Copyright © 2013 IFSA.

Keywords: Spatial subdivision organization, Remote sensing image, Subdivision template, Parallel processing, Planting area extraction.

1. Introduction

Since the remote sensing technology, computer and communications technology are developing rapidly, the human capacity for getting spatial information is more and more strong. The types and quantities of data are increasing, and its cycle is shorter and shorter, its precision is higher and higher. The explosive growth of spatial information provides a favorable precondition for automatically, intelligently and real-time application services. Meanwhile, the rapidly increasing spatial data brings serious challenges for organization and management of spatial information [1].

Remote sensing is considered as high real-time, widely covering and rich information resources. At present, high performance cluster technology based parallel processing and grid computing technology based large-scale distributed processing are the main methods of remote sensing image high-performance processing [2, 3]. Ref. [4] proposed a general parallel processing framework for remote sensing images. Ref. [5] adopted block processing method to achieve dynamic load-balance in remote sensing image parallel processing. And its processing time and efficiency have improved to a great extent. Usually, the results and improvements in references are obtained in theory and special experimental conditions. Since the effective data organization mechanisms is lack, the cluster computing nodes inevitably exist some questions such as size segmentation, data access overhead, image location dependent. Some theoretical algorithms of remote sensing image parallel processing still have some difficulties, or real efficiencies are low in fact.
Spatial information subdivision organization provides a new efficient storage and organization method for global massive growing spatial data. It achieves integrated organizing, open sharing, inter-operating and rapid distributing for multi-sources, multi-scales and multi-temporal spatial information. So it can solve series of bottlenecks that constrain spatial information for fast retrieval, efficient integrating and sharing. To process remote sensing image using subdivision organization can easily implement multi-scale transformation, centralized services, and inter-regional distributed services. So it provides the new solution ideas to quickly process global massive remote sensing data. Currently, many researches were done about theoretical system, coding model and storage mechanisms of subdivision organization. While specific application results are relatively small, especially for fast processing strategies is under the support of subdivision theoretical. So it is necessary to research data model of subdivision cell, parallel processing mechanism of templates, parallel processing software platform, etc.

Subdivision template parallel processing for remote sensing image is making use of the advantages and characteristics of subdivision data in parallel processing, to realize organization and management of multi-scales remote sensing images by subdivision templates, and complete massive data quickly parallel process. From the beginning of spatial information subdivision organization, this paper deeply analyses subdivision organization framework, spatial features of subdivision and its unique advantages in parallel processing. Combining the concept of subdivision template, the template-based parallel processing of subdivision remote sensing image is proposed. Some application tests in field of planting area extraction are done.

2. Spatial Information Subdivision Organization

The basic idea of spatial information subdivision organization is: to establish discrete cell structure systems according to the Earth space subdivision framework; to achieve a unified code for global information and construct sharing and inter-operability foundation for spatial data; to design geospatial subdivision data model and form sphere-plane uniform expression for spatial information; to construct geospatial information index system from centimeter accuracy to the entire planet. So it can achieve time-space storage organization and rapid retrieval for massive spatial data, easy to rational allocation and scheduling for spatial storage resources, computing resources and services resources.

2.1. Subdivision Organization Framework

Subdivision organization framework divides the Earth’s surface into continuous discrete cells set with similar shape, regular size and seamless space. The cells are encoded following certain sequences and rules. And it provides space dividing structural basis for coding, storing, indexing, computing, expressing and severing of remote sensing image data.

Subdivision cell is a geospatial divided unit defined by spatial subdivision framework. It corresponds to an objective existence geographic area, and it is the base for indexing, storing, scheduling and expressing of spatial data applying global subdivision theory. The main parameters of cell are code, subdividing level, corner coordinates, location coordinates, area, side-length, position, curvature, projection area, conversion accuracy and so on. The subdivision cell has regular geometric shape and accurate geospatial position range. Many levels of cells have nested relationship, and continuously cover the entire surface of the Earth. Therefore, subdivision cell becomes the basis of multi-scale awareness, communication and description for any global position.

Subdivision code is a global unique code given to certain cell. It also corresponds to a special area using geospatial expression in different level. Generally, we consequentially code the cells using certain coding curve, and establish cells index mechanism combining corresponding algorithm. So subdivision code is the basis of cell identification and cell index. It reflects inheritance and adjacent relationship among multi-scale cells, and provides a convenient way for spatial relation computing and template processing of subdivision region.

2.2. EMD Subdivision Model

The Extended Model Based on Mapping Division (EMD model) is proposed by CHENG Chengqi in Peking University. The main idea of EMD model is: using regular polyhedra and triangles subdivision method for high latitudes, and to realize spatial data organization for polar regions; using a map-based and equal latitude and longitude grid subdivision method for middle a low latitudes, to inherit and expand good subdivision properties of mapping division. The specific method of subdividing and coding method can see in [10].

The subdivision model determines the structure and layout in same level, and also determines the nest or subordinate relationship in different levels. At the same time, the level and size of subdivision cell have natural link with the spatial scale and map scale, and so with the resolution of remote sensing image. In EMD model, the geometric features of subdivision cell and its corresponding relationship with map scale are shown in [7].

2.3. Subdivision Organization Advantages in Parallel Processing

According storage and organization methods of spatial information subdivision theory, the spatial
data in different region stores in corresponding storage node of storage cluster through subdivision processing. So it provides organizational basis for inter-regional spatial data multiple parallel computing [7]. Remote sensing parallel computing using subdivision organization has the following distinct advantages:

1) Facilitate to realize multi-source remote sensing images quickly match. The global multi-source remote sensing images are unified organized according subdivision cells’ region. So all remote sensing images of the same region can be quickly obtained just by cell codes. Using distributed storage can directly parallel process remote sensing image, and greatly save overhead and improve overall efficiency.

2) Favor to multi-scale freedom granular partition spatial image data. Since there are nested hierarchies among levels of subdivision cells in subdivision organization, the remote sensing images can partition into different levels of subdata corresponding to subdivision cell. So remote sensing images’ multi-scale freedom granular dividing is completed.

3) Realize efficient geographical location and access of subdivision data. The subdivision data is stored according to a certain level and sequence. You can quickly access any location subdivision data blocks using the association of code, storage location and actual region. And if using distributed parallel storage will greatly improve retrieval efficiency.

3. Template-based Parallel Processing for Subdivision Remote Sensing Image

3.1. Subdivision Template

Subdivision cell template for remote sensing image is abbreviated for subdivision template. It is spatial features set of subdivision cell, and extracted from high-resolution remote sensing image. It may be other spatial data associated with subdivision cell [12]. Subdivision template is data sample of remote sensing image in special region corresponding subdivision cell. Usually, it is orthophoto remote sensing image with obvious characteristics. It includes spatial features set, geographical features set and control point data of the subdivision cell. So it inherits all advantages of subdivision cell, and is useful to establish association between abstract subdivision model and special remote sensing images. Using it can quickly identify an unknown remote sensing image belongs to which subdivision cell. According to different application requirements in data processing, there exist many kinds of subdivision templates. One type of template corresponds to a special data processing algorithm.

3.2. Parallel Processing Mode for Subdivision Template

The main idea of parallel processing mode for subdivision template is: considering template as basic unit of subdivision cell computing, to construct baseline image in the unit of cell in appropriate level and range, to create subdivision template according cell information, image information and application requirements. When process data in any region, the image template is extracted from template database and use to compute. So it realizes image quickly subdivision parallel processing, and provides support for related application [13]. Each pixel in remote sensing image has each pixel has definite spatial meaning. And there are special relationships among pixels, and their features distribution has spatial continuously. So it is easy to adopt parallel processing. Subdivision template merges common characteristics of subdivision cell and remote sensing image, and provide a unique advantage for remote sensing image concurrent computing. Because the spatial continuity and distributed storage of subdivision cells provide good condition for parallel processing among different computing nodes. And the data format and organization method of subdivision template can implement parallel processing within the same computer node. Template-based computing mode of subdivision cell is shown in Fig. 1.

4. Application Examples

4.1. Processing Flow

Crop planting area extraction is one of the basic researches in remote sense agriculture. It need use the comprehensive reflection of multi-sources remote sensing images to extract. Large area of crop planting extraction may exist some problems such as heavy workload, long time, so it likely cause operational errors and data management chaos [14, 15]. Extracting crop acreage by subdivision template of remote sensing image has theoretical feasibility. It can achieve dynamic conversion of multi-scales remote sensing data, and facilitate ‘s’crop extraction more accurate and quickly. It also can achieve
analysis and comparison of historical data in time and space.

Planting area extraction by subdivision template of remote sensing images can be described as following flowcharts in Fig. 2. It is similar to the process of subdivision template-based remote sensing images [16]. Firstly, establish the corresponding relationship between remote sensing images and subdivision cells. And then extract the feature information of crop planting area and store into template database. To the region without establishing subdivision template of remote sensing image, this process can be seen as gathering remote sensing images, extraction crop acreage and establishing subdivision templates. To the region already established subdivision template of remote sensing image, this process can extract current planting area, analyze and compare with existing template data.

![Flowchart of crop planting area extraction using subdivision cell template.](image)

**Fig. 2.** Crop planting area extraction using subdivision cell template.

### 4.2. Wheat Planting Extraction Experiment

According to EMD subdivision model, the size of subdivision cell is similar to the scope of certain geospatial. So it can establish subdivision template through choosing regular remote sensing images correspond to certain region. Based on the relationship of cell’s features in EMD model and maps’ scales, we can choose some remote sensing images as data source. For example, the regions of city or country can correspond to the seventh or eighth level, and remote sensing images with resolution of 17m or 8m. The chosen multi-scales remote sensing images are referred the following standard in Table 1. Here, the resolutions are the reference values according to subdivision cells in certain level, they are not limited to which kind of satellite remote sensing images.

![Table 1](image)

**Table 1.** Reference values in choosing images in different scopes.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Subdivision level</th>
<th>Map’s scales</th>
<th>Image’s resolution</th>
<th>Cover scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>seventh</td>
<td>1:50000</td>
<td>17.0</td>
<td>province</td>
</tr>
<tr>
<td>2</td>
<td>eighth</td>
<td>1:25000</td>
<td>8.0</td>
<td>city</td>
</tr>
<tr>
<td>3</td>
<td>ninth</td>
<td>1:10000</td>
<td>3.8</td>
<td>country</td>
</tr>
<tr>
<td>4</td>
<td>tenth</td>
<td>1:5000</td>
<td>2.15</td>
<td>town</td>
</tr>
<tr>
<td>5</td>
<td>eleventh</td>
<td>1:2500</td>
<td>1.07</td>
<td>village</td>
</tr>
<tr>
<td>6</td>
<td>twelfth</td>
<td>1:1250</td>
<td>0.54</td>
<td>field</td>
</tr>
</tbody>
</table>

As the process flow shown in Fig. 2, we carried out some confirmatory experiment to extract wheat planting area in Xuchang of Henan province. Wheat is our main food crop, and is the main crop of planting area extraction. Henan is the main wheat’s production province in China, and the wheat’s planting area, yield and total output are usually in the first place in our nation. In the experiment, we mainly extracted wheat’s planting area in Xuchang, and chosen four high-resolution remote sensing images with three bands. Firstly, the original images are preprocessed using ERDAS 9.2, such as image enhancement, geometric correction, division cutting. The size of processed image is 32.5 M on average. The parallel processing cluster consists of six parallel processing nodes, each one is configured as CPU of Core (TM) 2 E7300 2.66 GHz, RAM of 4 GB. The operating system is Ubuntu 10.04, and the program is developed by C++ and MPI technology.

### 4.3. Results Analysis

In the experiment, we extracted wheat’s planting area in the year of 2011 in five countries of Xuchang city. The accuracy is extraction results compared to historical survey records of Xuchang Agriculture Bureau. The speed is extraction time. They are compared with other remote sensing software in Table 2. In it, Acc represents accuracy, Sp represents speed.

![Table 2](image)

**Table 2.** The results comparison of wheat planting area extraction.

<table>
<thead>
<tr>
<th>Country</th>
<th>ERDAS Acc (%)</th>
<th>Sp (s)</th>
<th>ENVI Acc (%)</th>
<th>Sp (s)</th>
<th>Our method Acc (%)</th>
<th>Sp (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xuchang</td>
<td>79.7</td>
<td>2.31</td>
<td>79.6</td>
<td>2.65</td>
<td>82.8</td>
<td>1.71</td>
</tr>
<tr>
<td>Yuzhou</td>
<td>85.7</td>
<td>4.59</td>
<td>88.4</td>
<td>4.23</td>
<td>86.8</td>
<td>3.53</td>
</tr>
<tr>
<td>Changge</td>
<td>78.9</td>
<td>4.23</td>
<td>67.9</td>
<td>4.43</td>
<td>92.8</td>
<td>2.53</td>
</tr>
<tr>
<td>Yanling</td>
<td>89.1</td>
<td>3.15</td>
<td>92.9</td>
<td>3.45</td>
<td>94.3</td>
<td>3.00</td>
</tr>
<tr>
<td>Xianceng</td>
<td>66.3</td>
<td>3.63</td>
<td>75.8</td>
<td>3.13</td>
<td>89.2</td>
<td>3.03</td>
</tr>
</tbody>
</table>

The results show that using subdivision template of remote sensing images can extract crop planting area with high accuracy and speed on the whole.
compared to common software such as ERDAS, ENVI. The extraction accuracy is obviously better than them, and extraction speed is also have some improvement. As subdivision template of remote sensing image has main advantages of parallel processing, the present experiment is only a simple application attempt of this research approach. If using proper parallel processing clusters and developing corresponding application platform, it will greatly improve processing speed, and better achieve the integrated schedule and information extraction of multi-scales images. And this will be our further research direction.

5. Conclusion

Remote Sensing images have increasingly widely application in many military and civilian fields. Spatial information subdivision organization divides the earth into discrete cells with regular shape and clear layer. It provides new way to store, extract and analyze the global massive data, and ensures quickly integration and application service for multi-sources remote sensing images data. So it can make use of subdivision template of remote sensing images to extract crop planting area. And it is easy to form a complete process flow, simplify processing steps. It makes planting area extraction and subdivision template creation unite, and form subdivision templates database of crop information in certain region. It will have very important significance to the implementation and supervision of agricultural remote sensing. In the future, the studies will focus on the template-based parallel processing strategies and algorithms, aiming to improve the classification speed and expand new application demonstration.

References


[7]. Chengqi Cheng, Fuhu Ren, Guoliang Pu et al., Introduction to spatial information subdivision organization, Science Press, Beijing, 2012.


