Research on Remote Sensing Image Template Processing Based on Global Subdivision Theory

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Abstract

Aiming at the questions of vast data, complex operation, and time consuming processing for remote sensing image, subdivision template was proposed based on global subdivision theory, which can set up high level of abstraction and generalization for remote sensing image. The paper emphatically discussed the model and structure of subdivision template, and put forward some new ideas for remote sensing image template processing, key technology and quickly applied demonstration. The research has very important significance for improving remote sensing image processing speed, reducing repeated handling of huge amounts of image data, and expanding practical application of remote sensing.

Keywords: Global Subdivision Theory (GST), remote sensing image, subdivision template, template processing

1. Introduction

Remote sensing is a certain science and technology which can measure, analyze and determine a target without contact with the object directly utilizing some sort of sensor devices [1]. The data acquired by remote sensing techniques has some advantages of high real-time, wide range and rich information, which has been widely used in many military and civilian areas such as military reconnaissance, disaster forecasting, environmental monitoring, and resource exploration and so on.

With the development of sensors, remote sensing platforms, and data communication technology, the amount of data obtained by remote sensing expands rapidly, resulting in such a situation that the spatial data production and transmission capacity is far greater than the space data analysis capabilities [2]. At the same time, many application fields have constantly increase requirements about real-time, accuracy and reliability of remote sensing images. The speed has become the bottleneck of the application of remote sensing image.

Aiming at the questions such as vast data, complex operation and time consuming processing for remote sensing image, a new concept of subdivision template was proposed based on global subdivision theory. Subdivision template can set up high level of abstraction and generalization for remote sensing image, and provide convenience for quickly and simply use of remote sensing data resources. This paper emphatically discussed the model and structure of subdivision template, and put forward some new ideas for remote sensing image template processing, key technology and fast demonstrate application. The research would provide cornerstone and feasible solution for template-based change detection and parallel processing. So it has important significance.

2. Global Subdivision Theory

The Global Subdivision Theory (GST) [3] is a lager-scale hierarchical open spatial data management framework. It researches on how to subdivide the Earth (or spherical) into a series of cells with same area and similar shape. It has many advantages such as global scale, continuity, stability, multi-level, uniformity, and so on. So GST may avoid data redundancy effectively and express the levels of the data, which takes advantages over the planar grid system when dealing with the global multi-scale spatial data. With the development of Digital Earth (DE), the expression and management of the global multi-scale spatial information make the limitations of traditional planar grid system become more obviously. To establish a new model for the global multi-scale spatial information is a common concern for most domestic and foreign scholars.

So far, many kinds of subdivision theories were put forward by scholars from various countries. They can be summarized into three kinds: polyhedral subdivision, experience subdivision and wavelet division [4]. The typical subdivision models are Quaternary Triangular Mesh (QTM) by Duttn, Spherical Quaternary Triangle (SQT) by Fekete, Equal Angle Ratio Projection (EARP) by Yuan and so on[5]. The Extended Model Based on the Mapping Division model (EMD) was proposed in paper [6] by Cheng. It made the hierarchical subdivision by longitude and latitude interval, based on traditional mapping division way to achieve the objectives of direct storage and index for existing spatial data. So EMD can

effectively implement management, organization and use of huge spatial data.

GST has been applied in many fields of global spatial information, which can effectively implement storage, extraction and analysis of global scale mass data. It can solve those question that traditional data model limit to manage huge amounts of data on a global scale, multi-scale and hierarchical organization. It can ensure the global spatial data expressing in a global, continuous, hierarchical and dynamic way [7]. But many studies are at the initial stage, most of researches are about theoretical study of subdivision methods, coding model and storage mechanism, but less specific practical application of the results are in shown at present.

3. Subdivision Templates of Remote Sensing Image

3.1 Basic Concepts

GST divide the Earth into cells with regular shape, different coverage area using a certain different division method. The cells have the advantages of hierarchical organization, the uniqueness of the spatial location encoding, storage location and high search efficiency. Subdivision template is structure data set for remote sensing image and matches along with subdivision cell. It contains the data of spatial characteristics set, geographical features set, and control points set of cell. It inherits the advantage of cell, so it is easy to organize and manage to achieve efficient processing applications. Each subdivision template is a comprehensive data set basing on the baseline remote sensing image. It has basic information of image, and combines high-level features and semantic information of remote sensing images in a higher level abstraction and generalization. So it would be more conducive, storage and application for remote sensing images. Here, baseline remote sensing image is a kind of orthogonal projected remote sensing image for some scale.

According to different requirements about spatial location, covering range, resolution of cell in different level, select appropriate orthogonal projected remote sensing image, and convert into a formal, normative image format through a standardized processing step. Then, baseline remote sensing image were gotten. In the procedure of remote sensing image processing, the important task is to set up association with different information and store them in certain way. These information are underlying data and parameters of remote sensing images (such as sensor type,

produced time, resolution), contents of covering region (such as regional names, object names), advanced features of the image (such as texture features, color features) and characteristics of cells (such as cell code, division level, cell control points).

3.2 Logical Contents

Through above analysis, we can sure subdivision template is comprehensive information collection of remote sensing image on certain subdivision cell. From a logical point of view, the subdivision template includes the following contents:

Basic Information: contains two aspect information, one is underlying data and relevant parameters of remote sensing images, such as image number, sensor type, resolution, band value, the image source and so on. The other is cell basic information such as cell level, cell code, and cell basic control points data.

Feature Information: including the features and characteristic information of the remote sensing image and cell, such as the image number, image area names, image object names, significant texture features, shape features and cell elevation characteristics, regional characteristics and so on.

Knowledge Comments Information: description and annotation of the subdivision template and cell for some important information, coding style and other related items, such as the template description, regional introduction, image object introduction, and features descriptions.

3.3 Physical Contents

Database management is the mainstream form of remote sensing image data storage and management [8]. High performance cluster-based processing technology based on parallel data processing and grid computing technology based on large-scale distributed processing are the main method for remote sensing image using high-performance processing [9-10]. Therefore, subdivision template can adopt distributed storage management based on relational database. On the whole, the different levels of subdivision template and the remote sensing image are stored in multiple parallel processing units. They can be unified managed using a suitable index structure. In a special storage unit, subdivision template and image are organized, managed and retrieved in a relational database mode, which technology are already quite mature, and many functions can be carried out by structure query language (SQL). According to template contents and image data,

several databases and data tables are created. They can be associated and mapping through primary key, foreign key and other convert operations.

In addition, in order to improve the efficiency of image access, image segment method is adopted, which can divide a huge remote sensing image into a number of smaller physical data block. This way is good to store and manage the huge image. And the data block size will directly affect the system performance, and be considered as an important factor in remote sensing image data storage management. Usually, the size is power of 2. The block size of 256×256 pixels or 512×512 pixels is often used and was proved better in major environment [11].

4. Subdivision Templates Processing of Remote Sensing Image

4.1 Processing Flow

The processing flow of remote sensing image template based on GST can be described by figure 1.

According to specific subdivision method to determine the size and scope of certain level cells, select a number of continuous levels of cells as research object.

Aiming at different application requirements, initially select the orthogonal projected remote sensing image of typical hot area. And establish subdivision template through standardized processing.

Using some remote sensing image processing software such as Erdas, Envi to extract image features, created knowledge annotation by manual.

In mainstream computer systems developing parallel computing platform for subdivision template, complete image segmentation, feature extraction, manual annotation and other high tasks.
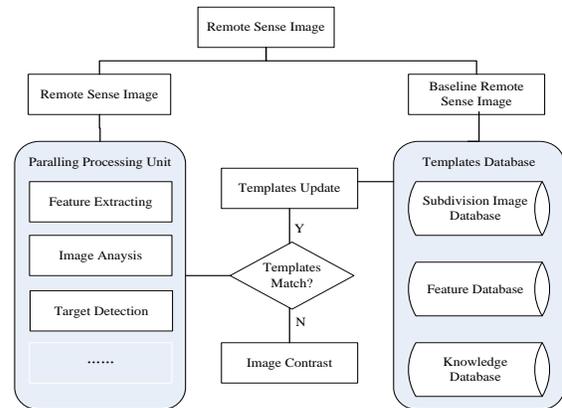

Figure 1.   Subdivision template processing framework

4.2 Key Technology

The key technology of subdivision template processing for remote sensing image are template quickly generation, automatic update, parallel processing and rapidly apply demo.

Templates quickly generation: For cells without establish subdivision template, select appropriate remote sensing images, and develop some automatic processing algorithms for image normalization, feature extraction, feature vector to organize and store, construction association with cell, template automation coding.

Template automatic updates: Automatic update is the key way to ensure uniqueness, independence and timeliness of subdivision template. Templates automatic update can timely detect changes of same region from remote sensing image, and convert new image into templates, and update relate information.

Subdivision templates parallel processing: Research on parallel processing strategy on template-based parallel processing mechanisms, including image preprocessing, image segmentation, feature extraction and similarity measure. Design parallel scheduling algorithm, and analyze its performance.

Rapidly applied demo for subdivision template: utilize subdivision template for image analysis, image region recognition, change detection, target recognition and tracking, object classification, and form some typical application demonstration.

4.3 Preliminary Application

Based on EMD model, we research on shape, feature and coding of cell in certain level, and construct the corresponding subdivision template of remote sensing image. An initial prototype system for subdivision template of remote sensing image processing system was developed. The system was developed in Windows Server 2003, using SQL Server 2005 to manage remote sensing data, and using VC++ to design and develop user interface. Preliminarily, we selected several high-resolution remote sensing images of tourist attractions, and create subdivision template manually. At present, basic functions such as image browsing, template view and feature retrieval according to the specified conditions were completed. In figure 1, if you select some kind of retrieve mode (subject information of image contents), and input some keywords (Henan AND tourism AND spa), the search results will be shown in bottom. You can get main information of image and template, and query detail information by clicking the related buttons.
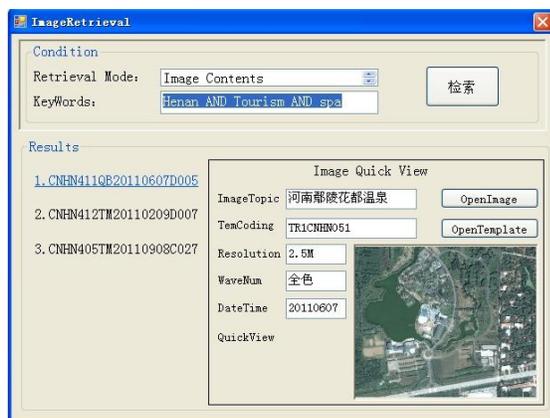
Figure 2.   Subdivision template and image retrieve interface.

At present, the system has only completed a test of basic functions of in single computer environment. Preliminary tests showed that the system have highly-targeted, high practicability, high retrieval efficiency and good expandability. More functions would be further developed.

5. Conclusions

Remote sensing images have been widely used in various fields. With the increasing of data amount and expanding of application requirement, the collection, organization, management and sharing of remote sensing data are becoming the most prominent problem to be solved for data producers and users. The global subdivision theory divides the Earth into cells in level with same area and shape, which has advantages of global, multi-resolution, well-proportioned spatial location. It provides a new way to solve the effective organization and management of massive remote sensing data. Combining the features and advantages of subdivision cell, the paper put forward the concept of subdivision template and proposes to set up subdivision template of remote sensing image gradually by level, by batches, and by cell region. Template quickly generation and automatic update would be deeply researched to ensure template uniqueness. With increasing of subdivision template, parallel processing technique would be adopted to improve processing efficiency and sharing service. This study will have a very important strategic significance for extending application fields of remote sensing image, opening practical applications of GST, and enhance the value of spatial data.

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