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Port resources monitoring and management based on remote sensing and geographic information sharing

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Abstract: With rapid expansion of port scale and changes of land usage, it is very difficult to keep up-to-date with the usage of port resources accurately by traditional measures. Therefore, in this paper, a novel monitoring and management method is proposed, which takes full use of remote sensing images and geographic information sharing technologies. To recognize the elements of a port, a new method is first proposed based on typical port layout pattern and port feature spectrum. Then a port resources monitoring and management system is also implemented based on the proposed recognition method. Finally, the application proves that the proposed method has a great improvement in accuracy and efficiency compared with traditional methods, which helps a lot to monitor and manage the precious resources of port and coastline.

Keywords: Port monitoring, GIS sharing, feature spectrum, port layout pattern

1 Introduction

Port is the tie and traffic hinge between land and sea. It is of great importance to make sure that port resources can be utilized highly. With the rapid development of economy, the scales of port are enormously expanded. Therefore, it is very hard to follow the quick change of port resources usage, especially with traditional methods. Generally, two categories of traditional methods are used, including down-top data driven strategy and top-down hypothesis driven strategy. The former one is used widely, but is featured with heavy work and complicated algorithm. The later one possesses high accuracy based on feature acknowledgements, but with worse replaceability and compatibility.

As an important military and civil facility, the port has its own spatial features which are different with other facilities. Therefore, how to extract port resources precisely and efficiently from remote sensing images is a research hotspot in field of image processing. And this will also provide great help for port motoring and management. In practice, we can identify port from satellite images using our eyes easily, but it is time-consuming and difficult to identify the subtle changes in port layout. But as for the computers, they can extract port elements automatically and efficiently, and save a lot of time greatly, although it's difficult to extract port elements precisely with no errors. Therefore, this study adopts typical port layouts as template and feature spectrum to identify and extract port elements. It proves to be more efficient than traditional detection measures. Based on the results, port resources monitoring and management system is designed.

2 Proposed port elements recognition method

Via the analysis of satellite images, port elements have the similar features with lands in gray level and texture, and the big difference is its shape [1]. However, there are too many kinds of shapes in a port, which makes it difficult to take one general geometric model to describe the shape of different port. Therefore, a new method to recognize the elements of a port is proposed based on typical port layout pattern and port feature spectrum.

2.1 Typical port layout pattern

Generally, the port linked by roads and cities, can be regarded as large concrete building area which is close to water body [2], and the shape of port differs from each other. To berth ships, the apron of a port possesses linear characteristics, the breakwater is constructed to avoid strong currents and waves, and at least two standing-out jetties are built to serve berthed ships. Therefore, the typical port layout pattern is determined as shown in Fig. 1 based on the mentioned assumption.

As illustrated in Fig.2, the typical port is located between sea and land, has some closure like basin, and contains a certain number of jetties with linear apron, general rectangle shape and special length-width ratio.

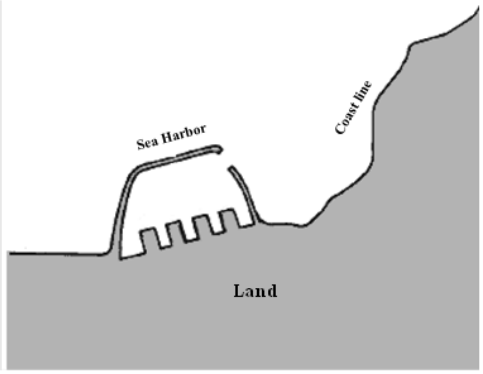

Figure 1 Typical port layout pattern

2.2 Port feature spectrum

Spectrogram is a traditional analysis method and derived lots of application on matching, segmentation and clustering [3-5]. This paper proposed a new method to implement the detection and identification of port elements based on spectrogram theory and the characteristic of port closure. The computing process is described as Fig. 2. It is concluded that the extraction of coastline feature is the key to detecting the elements of a port.

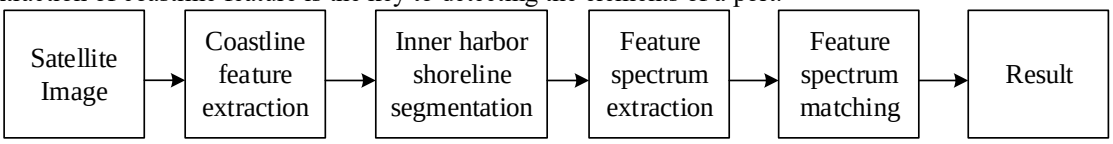

Figure 2 feature spectrum algorithm

To extract the coastline feature, the initial satellite images are first resampled to depress image resolution. Then DWT (Discrete Walsh Transform) texture feature and FCM clustering algorithm are utilized to achieve sea area segmentation, and the preliminary coastline will be extracted. Finally, ACM (Active Contour Model) is used on higher resolution image to get more accurate coastline.

The coastline is extracted as follows,

$$\text{Coastline}=\{P_i,\ i=1,2,\ldots,n\}$$

Where P_1 and P_n means the starting point and end point, n means number of extraction pixels.

During the computing, we assume sea area segmentation result as s (x, y), which comprises sea area and land area showed as following formula.

$$\text{Sea}=\{(x,y)\mid s(x,y)=1\}$$
$$\text{Land}=\{(x,y)\mid s(x,y)=0\}$$

And the closure of coastline is defined as followings,

$$C_{ij}=\begin{cases}|R_{ij}|/|L_{ij}|\ -1, & \text{if } L_{ij}\subset \text{Sea}\\ 0, & \text{if } L_{ij}\not\subset \text{Sea}\\ 0, & \text{if } i=j\end{cases}$$

R_{ij} means the coast line length between feature point F_i and F_j, R_{ij} is measured with pixel number. L_{ij} means the line length between two feature points, which is Euclidean distance and represented by pixel number.

3 Geographic information sharing

3.1 Concept

With the development of information technology and network, geographic information sharing means that digital information can be obtained, queried, explored, exchanged, utilized and reprocessed conveniently, swift, accurately and safely. Geographic information sharing puts more emphasis on accessing geographic spatial datasets [6],so that the users have free access to datasets. And geographic information sharing aims to distinguish the difference of description method on spatial datasets and realizes the universal description and expression of geographic information.

Data format conversion, direct access and data sharing based on network service standards are main methods to fulfill the geographic sharing [7,8]. As for different technology, quantity of process data with different formats will be generated. Therefore, format conversion method will generate lots of mid-format data. Direct access GIS system must have the ability to open datasets from various data source. Network standard method will be compatible with relevant standards, criterions and definition worked out by different geo-standard organization.

3.2 Geographic information sharing based on Web service

With the developing of web service, Internet is not only platform for data transmission, but also the platform for service sharing [9]. Geographic information sharing does not only rely on file management and database, but also puts

more attention on internet service quality [10]. This paper adopts combination of database and web service to realize port resources monitoring and management seamlessly.

4 Port resources monitoring and management system

4.1 System framework

As illustrated in Fig. 3, the port resources monitoring and management system is consisted of three layers, respectively hardware layer, data layer and application layer.

(1) Hardware layer. The hardware supports port resources monitoring and management system, which consists two parts: (a) Data storage and management facilities includes data management servers, web application servers, data storage hardware, server switches, and work station switches; (b) Terminal machines are composed of workstation computers with high performance, portable terminals, precision instruments like scanner and mapper, etc.

(2) Data layer. This layer is used to store data, and the types of data includes the geographic information data and business data. Geographic information data, in the forms of vector data and raster data, include port shoreline digital line graphics, planning graph, terrain map and navigation digital map and satellite images of kinds of resolution and DEM data. And business data cover resources data, planning data, construction project data and relevant data of other ports.

(3) Application layer. This layer is mainly implemented by different software, which are divided into two categories. (a) Professional tools, including image information analysis software, remote sensing images management software, 3D model building software, port planning simulation software, Oracle database software and image processed software. (b) Business application software, including port resource monitoring, port coastline resource management, port planning information management, port planning supporting, port infrastructure information management and geo information sharing platform.

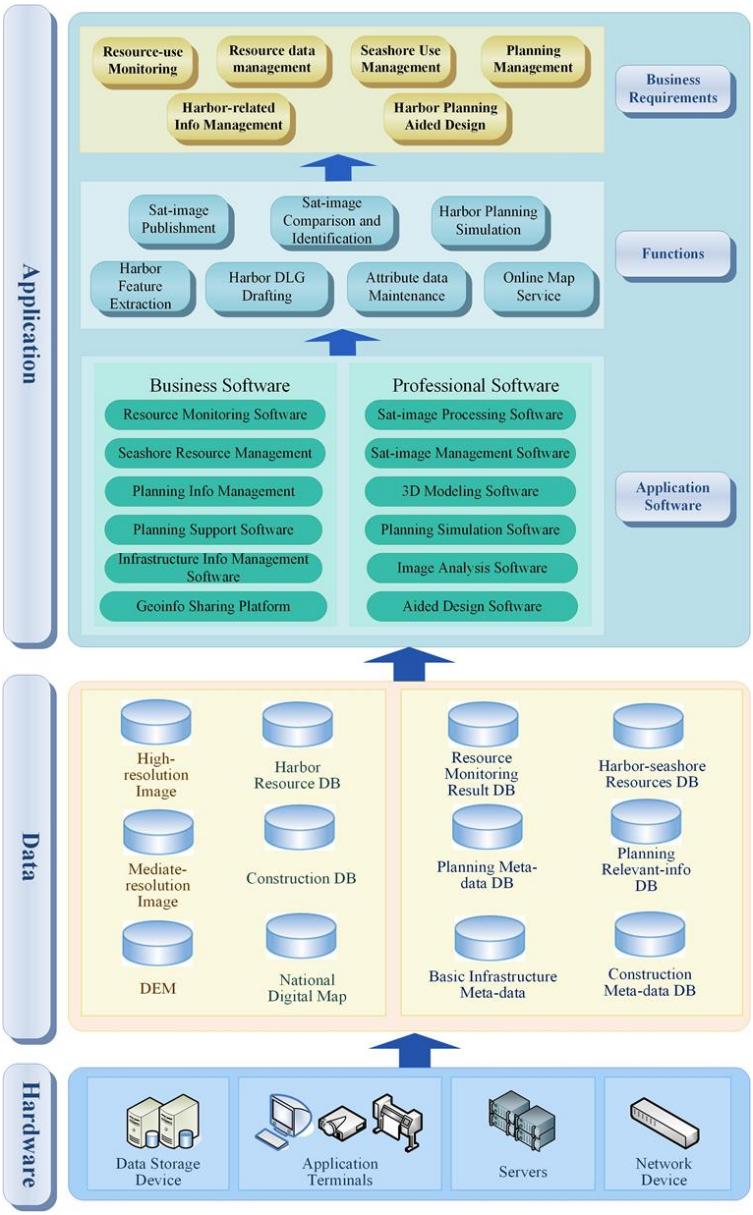

Figure 3 System Overall Framework

4.2 System function modules

(1) Port Resource Monitoring. This module is used to monitor the changes of port elements. Based on port layout pattern and feature spectrum, relevant geographic objects are extracted, and the change of different time is computed and marked in the satellite images by comparing the satellite images of the same region in different years [11,12].

(2) Port Coastline Resources Management. This module includes port project information input, query, aided examination and approval, and coastline use permit management. We can obtain details of each port construction project such as starting date, end date, responsible manager, construction area, etc. This module is built on the basis of construction project database and port coastline use permit database. All relevant can access coastline resources management module via internet, or through web service.

(3) Port Planning Information Management. This module provides macro-management of port planning information. It is specially developed based on MIS (Management Information Management), which makes it very convenient to manage port planning information via web. Planning information management module comprises planning information input, information query and planning proposal approval, and provides port planning query, information fuzzy query, spatial query, port planning information export and aided analysis, etc.

(4) Port Planning Decision Support. To provide additional help for port planning, a customized sub-system is designed for port planning supporting data. Planning relevant information can be made full use of and managed efficiently.

(5) Port Infrastructure Management. In this module, port infrastructure and construction projects can be monitored and managed dynamically, including waterway, breakwater, anchorages, wharves, berths and port traffic.

4.3 System application

Fig. 4 is an example of system application to monitor the changes of usage of port resources. As illustrated in Fig. 4, the elements of port in the year of 2010 and 2012 are first recognized and relevant geographic objects (seen in Fig. 4(a) and 4(b)) are extracted based on port layout pattern and feature spectrum. Then the system compares the satellite images as shown in Fig. 4(c), and the changes in port elements are marked in the satellite image in Fig. 4(d). Therefore, it is concluded that the proposed system has a great improvement in accuracy and efficiency compared with traditional methods, which helps to monitor and manage the precious resources of port and coastline.

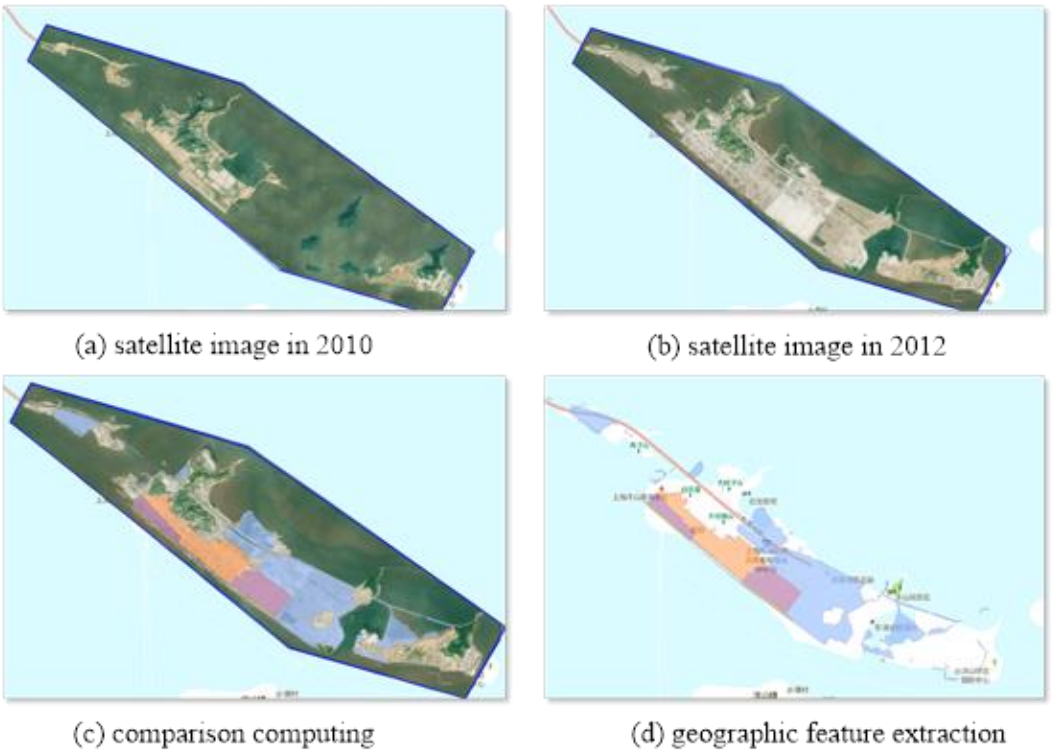

Figure 4 The application of monitoring the port resources

5 Conclusion

In this paper, general questions are summarized, especially in resources management. Compared with traditional method, remote sensing images are utilized to detect and identify port elements. Typical port model and feature spectrum are combined to approach port feature extraction, which is proved to be more efficient and accurate than using single method. This is mainly used for land change monitoring from macro-scale, not for other resource dynamic changes. As for detailed change of port resources, port resources monitoring and management system based on remote sensing technology and geographic information sharing is built. All details of port resources dynamic change can be obtained and

monitored, such as construction project information (start date, end date, process), infrastructures, and so on. The system can also provide great help for port planning and planning information management. And it is proved to be most effective tool for port resources management through system business operation.

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