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ORIGINAL RESEARCH ARTICLE

Design of remote sensing-based geographic information system

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ABSTRACT

To deal with problems of traditional geographic information collection, such as low real-time, poor authenticity of the data, and unclear description of detailed areas, a design scheme of remote sensing-based geographic information system is proposed. The system mainly consists of information collection, imaging processing, data storage management, scene control and data transmission module. By use of remote sensing technology, the reflected and radiated electromagnetic waves of the target area are collected from a long distance to form an image, and the hue–intensity–saturation (HIS) transformation method is used to enhance the image definition. Weighted fusion algorithm is adopted to process the details of the image. The spatial database stores and manages the text and image data respectively, and establishes the attribute self-correlation mechanism to render the ground objects in the picture with SketchUp software. Finally, using RS422 protocol to transmit information can achieve the effect of multi-purpose, and enhance the anti-interference of the system. The experimental results show that the practical experience of the proposed system is excellent, the geographic information image presented is clear, and the edge details are clearly visible, which can provide users with effective geographic information data.

Keywords: Weighted Fusion Method; Remote Sensing Technique; Geographic Information; Image Processing; Image Enhancement

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1. Introduction

As a tool to help users control the target location in real time, geographic information system (GIS) not only needs to provide effective location data, but also needs to correspond other attribute information one by one, so that single node information is related to each other, and a perfect data chain is established. The scope of application of GIS is gradually expanded, involving many fields, such as the utilization of urban resources, traffic construction and terrain analysis. The traditional GIS is difficult to meet the practical needs and cannot show users more detailed information.

Sun *et al.*[1] realized the real-time update and transmission of system data by using the global positioning system (GPS) technology of mobile GPS termina under Web to collect geographic information through multi-source users. The system collects information in real time, but the data accuracy is insufficient, and there is false information. Zhang *et al.*[2] used unmanned aerial vehicles (UAV) as the carrier to establish information system through image data, which not only improved the authenticity of information, but also reduced the work intensity of relevant personnel and improved personal safety. However, data information is easy to be ambiguous, making it difficult to get detailed information.

In view of the above problems, this article proposes to use remote sensing technology to establish a geographic information design scheme. Remote sensing technology collects electromagnetic waves radiated and reflected by long-distance targets through electromagnetic wave theory, and finally forms images after analysis and processing. And its main aim is to reduce unnecessary labor costs and continuously improve the clarity of geographical imaging. Compared with traditional survey methods, remote sensing technology has high accuracy and strong flexibility, and it does not need to be in close contact with the destination in the survey, which realizes remote measurement, greatly improving the safety of survey personnel and the accuracy of data, and also improving the efficiency[3], helping information collection departments to save costs.

2. Overall framework of the system under remote sensing technology

The design structure of GIS based on remote sensing technology is shown in **Figure 1**. The system mainly consists of information collection, remote sensing image processing, remote sensing information data storage management, scene control and data transmission modules.

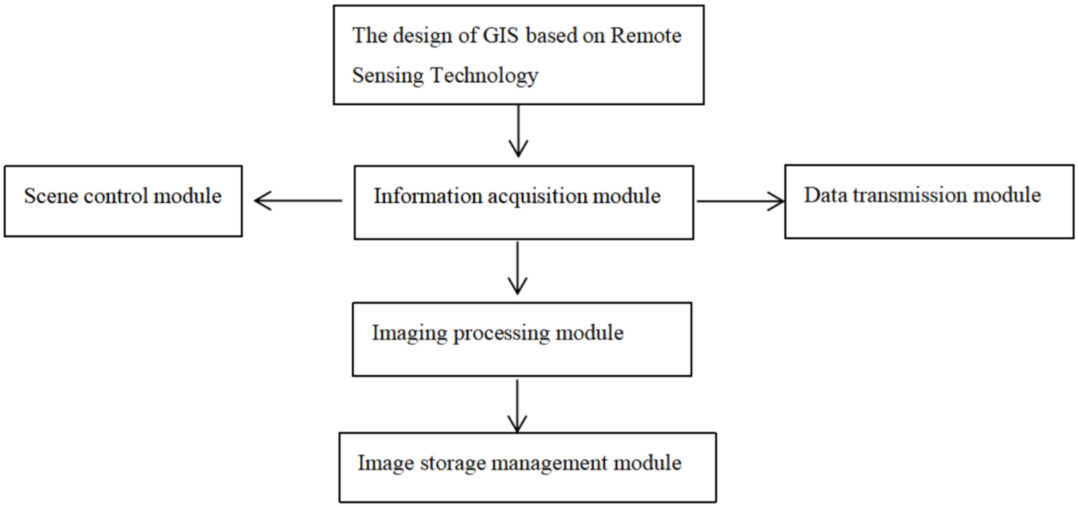

Figure 1. Overall system.

2.1 Information acquisition module

Thematic Mapper(TM) image[4] is the most commonly used image form in remote sensing technology, it has the advantages of high resolution and small spatial proportion. So the author takes TM image as the carrier to collect geographic information.

The system network system takes the integrated construction as the goal[5], and the purpose is to provide an open sharing for the majority of users, rich resources, flexible internet platform to meet the network needs of various applications. The system setup consists of two networks. People join the wireless network in the external server, collect geographic information in several sub devices, collect large-capacity data about geographic information, and download it to the client through the wireless network[6]. Considering the difficulties in detecting areas without signals and other factors, at this time, the remote sensing acquisition mode is non real-time data acquisition. The obtained data is stored in the carrier hard disk first, and then transmitted until it is within the scope of the network. The client has a set of perfect program mode, and can also switch freely between programs. This technology is mainly carried out in the LAN environment.

The functions of data collection and information exchange need to be carried out on the network through web (global wide area network) technology, which mainly realizes the remote exchange of data between the total client and each remote sensing detector. The system network structure is shown in **Figure 2**.

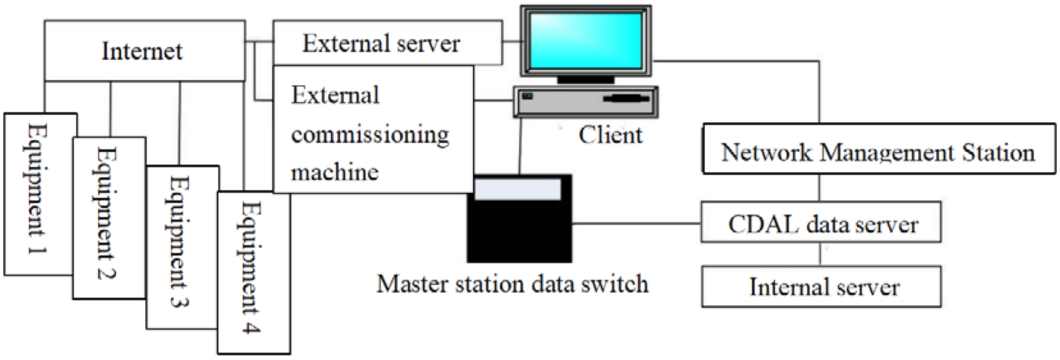

Figure 2. System network structure.

2.2 Remote sensing technology imaging processing module

2.2.1 Image cache

Remote sensing imaging preservation can be designed ROM, single Port RAM and Dual Port RAM by using on-chip distributed resources. So, before caching in the ROM, read the image sub block to FPGA (Field Programmable Gate Array) chip first, and then carry out subsequent operations, which has the following advantages: FPGA[7] can reduce the data reading delay, and the speed of reading on-chip ROM in FPGA is faster than the off-chip memory[8].

2.2.2 Image processing

Image geometric deformation and radiation deformation are the key problems in remote sensing image processing. The author improves the above problems and strengthens image processing and geometric correction at the same time. The process is as follows.

(1) ERDAS 9.1 system is used for image band fusion processing.

(2) Compare the remote sensing topographic map image of the author. TM image fusion is carried out before image correction. When there is root mean square error in the correction process, 0.4 pixels is the best error control value[9].

2.2.3 Image fusion

Among remote sensing image fusion algorithms, HIS (Hue-Intensity-Saturation) transformation method is the most commonly used algorithm, which uses *S* component to replace the highest single frame rate, and the final fused image is obtained through his inverse transformation.

HIS transformation method is usually used to improve brightness, enhance color, improve the image segmentation value, adjust the fusion data and other image quality problems. Usually, the color cardinality is not adjusted in the transformation process, and the highest single frame image is directly used instead, resulting in excessive distortion of the original image due to exposure, which is not conducive to correct recognition and classification. To this end, the module uses the spherical coordinate system method to improve HIS transformation (**Figure 3**), which improves the standard deviation of the fusion algorithm, reduces the correlation coefficient of high-resolution images, and optimizes the mean value compared with the previous one.

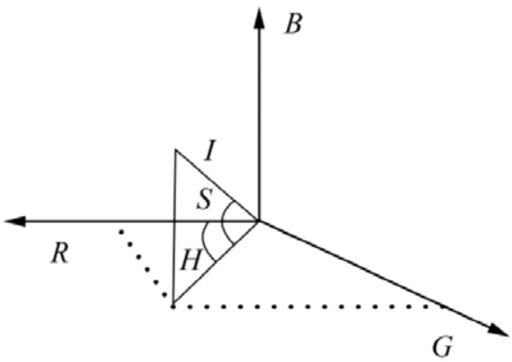

Figure 3. Relationship between spherical coordinates and RGB space.

Finally, through the combination of the feature joint optimal fusion method and the remote sensing image with the statistical characteristics of wavelet rate, the problem of low single frame resolution of the fused image is solved to the greatest extent by using this method[10], and the imaging processing and image quality processing are optimized.

When HIS and TM weighted fusion based on image, the weighted fusion process of image pair redundancy is as follows:

$$FTS = RTFT + RSFS \quad (1)$$

Where R_T, F_T is the weighting coefficient, F_S is the sink redundancy value of TM, and R_S is the sink redundancy value of HIS. Then the channel weighting process of color synthesis is:

$$R^r = a_1 R + a_2 P_{am} \quad (2)$$

$$G^r = b_1 G + b_2 P_{am} \quad (3)$$

$$B^r = c_1 B + c_2 P_{am} \quad (4)$$

Accurate weight coefficients (a_1, a_2, b_1, b_2, c_1, c_2) can be applied to enhance the weight of image fusion to reduce redundancy. However, for TM and HIS, the accuracy of coefficients should be emphasized to reduce redundancy. Because the subdivision band of HIS is more stable than the 2nd and 3rd bands of TM, but lower than the 4th, 5th, and 7th subdivision bands of TM, so the band calculation formula is:

$$r_{xy} = \frac{\sum (x_1 - x)(y_1 - y)}{\sqrt{\sum (x_1 - \bar{x})^2 \sum (y_1 - \bar{y})^2}} \quad (5)$$

Taking the correlation coefficient obtained from HIS image and TM image as an example, if a_1 and b_1 are reduced correspondingly, it needs to be determined by equation (6).

$$a_1 = |r_{xy}| \times 0.5 + 0.5, \qquad b_1 = 1 - a_1 \quad (6)$$

HIS method not only reduces the image exposure, but also does not affect the original color level, but retains the high-resolution information in the original TM image, and the method is simple and easy to calculate the data. **Figure 4** and **Figure 5** are the comparison before and after weighted fusion processing.

After weighted fusion processing (**Figure 5**), in the TM remote sensing image, the low-frequency part represents the background information, and the high-frequency part represents the target individual. Through the above operations, the integrity of geographic information can be improved, and the fuzzy details and image target structure features can be optimized. After the weighted fusion algorithm, the image is very easy to distinguish ground objects, and the degree of image structure restoration is high, which minimizes the noise in the overall high wave frequency of the image, while retaining the characteristics of the image to the greatest extent[11].

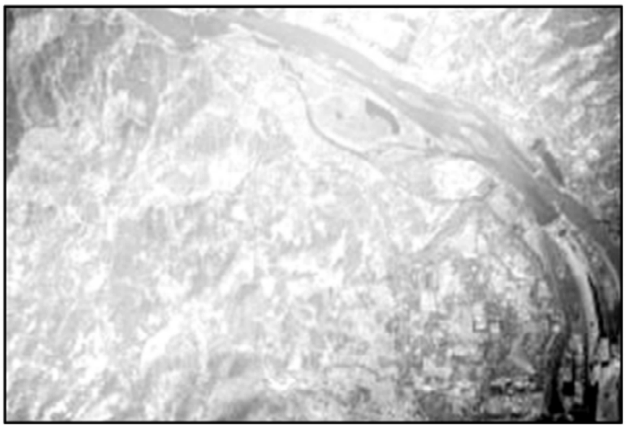

Figure 4. Before the weighted fusion.

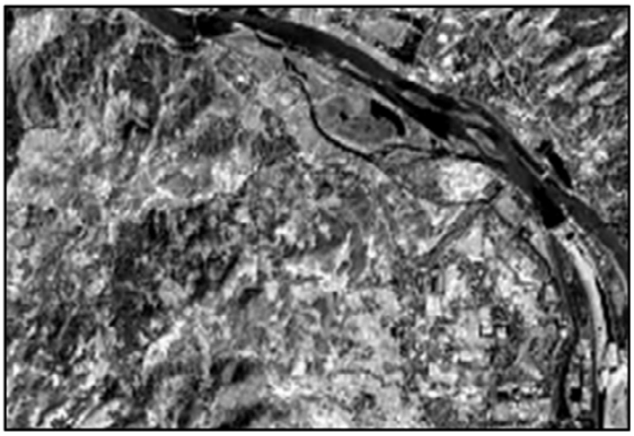

Figure 5. After a weighted fusion.

2.3 Data storage management module

Geographic information system contains not only image information, but also some text information to explain the details of the image and help the system provide better services. Therefore, in the process of data storage, it is necessary to judge the stored individual. If it is image data, it is saved using image compression technology to reduce the loss of image details; if it is text format information, it is stored in binary format. This bidirectional storage format allows researchers to more accurately obtain the information they want; each text and images should be treated very strictly. In the subsequent query process, the program can automatically obtain data information by inputting the corresponding key information to the corresponding image or text data storage area according to individual requirements.

If the individual to be stored contains both image and text data information, the traditional database has no corresponding storage format, so it is difficult to store effectively. If the text is stored separately, it is difficult to retain the maximized information. Therefore, the author uses grid geographic data storage to synthesize the Chinese digital wealth database (CDAL: Chinese Digital Assets Library) text database, through which data can be input and output. Through the conversion and processing of grid format, the data can maximize the open source and cross platform orientation of data. It can realize the grid data of multiple server platforms supported by the client in a single data mode, realize the effective integration of data resources, and jointly describe the geographic band information within the coverage area of remote sensing images through image information and text information[12].

In order to meet the rapid retrieval and query function of geographic information system, it is necessary to preview the archived remote sensing image information in advance, with corresponding text interpretation, so as to facilitate subsequent queries to save time. At the same time, it can effectively clarify the spatial extraction range of remote sensing images, eliminate duplicate data, and check whether there are uncollected geographical areas. The traditional image storage module is difficult to match with the CDAL text database. Therefore, the author proposes to use SDO-GEOMETRY in Oracspatial as the storage format of remote sensing images. The integrated management of data is carried out through Oracspatial[13], in which the functions of image indexing and query are completed on the SDO-GEOMETRY mechanism. This method realizes the discrimination of remote sensing image types, and designs the relevant data extraction interface according to the standard definition for each target object, so as to realize the standardization of the original data in various servers to the computer and systematic data storage enables intelligent management of resources. The process is shown in **Figure 6**.

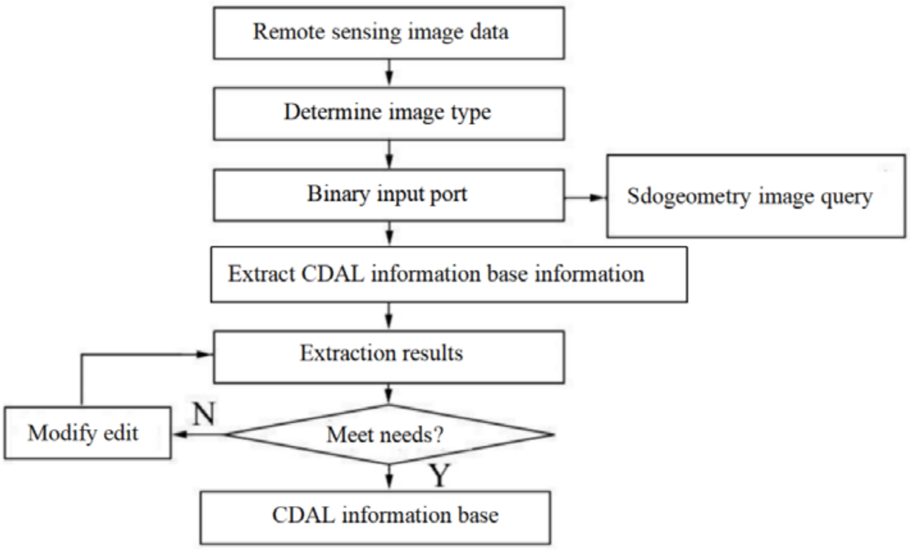

Figure 6. The flow diagram of the data store management module.

2.4 Scene control module

In the scene control module, the scene is judged according to the information extracted in the CDAL database and the display content. After restoring the virtual objects in the image with the real scene, the three-dimensional object conversion is carried out. The scene control module needs to carry out real-time control on the attribute data and virtual objects in the visual state, so as to ensure the stability of the data source during the data operation of the remote sensing system[14].

The data control module established by the author can make full use of the image and text information in the data management module, and combine them organically, and use Sketchup sketch master software to render the image into the environmental atmosphere, so as to make the geographic information system more perfect. The flow chart of the scene control module is shown in **Figure 7**.

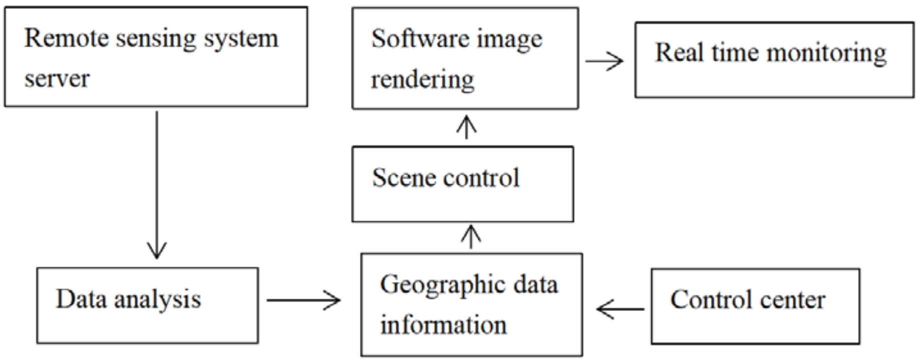

Figure 7. Flow chart of the scene control module.

2.5 Data transmission module

The data transmission information is based on the server and client of the wireless LAN connection system, and supports multiple computer devices in the wireless LAN, so as to achieve single machine transmission and multi machine reception. The detailed structure is shown in **Figure 8**.

The data transmission module combines the requirements between the server and the client, and transmits the data synchronously in real time through RS422 serial port protocol: one machine to many machine serial port protocol, so as to ensure the accuracy and stability of the data in the transmission process and improve the overall performance of the system[15].

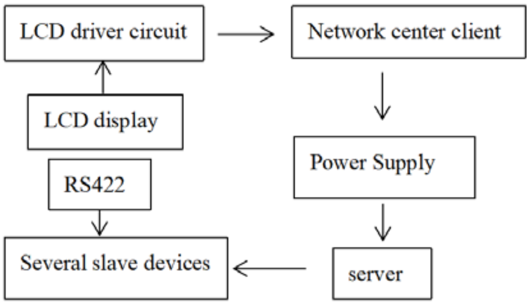

Figure 8. Flow chart of the data transmission module.

RS422 serial port protocol can connect up to 10 receivers, that is, one master device and multiple sub devices. Several sub devices cannot transmit information independently, but all of them can receive the information transmitted by the master device. RS422 balanced transmission and differential reception, with very strong anti-interference, and it uses two signal lines to complete information transmission, with separate reception. Transmission channel can effectively improve system stability and work efficiency. In addition, the data transmission module also includes a liquid crystal display (LCD) drive circuit, power supply, etc., forming a circuit structure. Among them, the error report and operation status report of the computer can be displayed on the computer display screen using LCD driver circuit.

3. Simulation experiment

In order to verify the effectiveness of the geographic information system based on remote sensing technology designed by the author, many related experimental analyses were carried out. The experiment is based on literature [1]. Literature [2] is used as a comparative sample for verification and analysis. The experimental environment is shown in **Table 1**.

Table 1. Experimental environmental parameters

To configure	Data type library	R & D environment	System settings	Running memory/GByte	CPU/GHz
Specifications	Oracle 13g	Matlab 9.0	Windows7.5	DDR2.0	Intelp42.4

Table 2. Method experience rating results

Number	Author system	Literature [1]	Literature [2]	Number	Author system	Literature [1]	Literature [2]
1	4.30	3.16	3.69	6	4.41	4.23	4.12
2	4.62	4.15	2.85	7	3.95	2.23	3.21
3	4.73	2.05	1.25	8	3.88	3.89	3.22
4	4.15	3.92	2.39	Average	4.34	3.42	2.89
5	4.66	3.72	2.36				

The experiment invited 8 people to participate in the subjective test of the author system, literature [1] and Literature [2] system, with an overall score of 5 points. 1 point means that the operation cannot be understood and the process is too troublesome; 2 points means that it is slightly unsuitable and the operation is difficult to understand; 3 points means reluctantly accepted, and the operation is complex; 4 points means no feeling, and the difficulty of experience and control is general; 5 points means simple and easy operation, full score for experience. The scoring data of the three methods are given in **Table 2**.

As can be seen from **Table 2**, the user experience score obtained by the author's system is the highest, which is due to the image and text information can be connected with each other and have a unified storage module and scene control module, which improves the applicability of the system.

The comparison of geographic information imaging in the author system, the literature [1] and literature [2] system is shown in **Figure 9**. We can see the resolution, clarity and exposure of the author system imaging quality are better than the literature results. This is because remote sensing technology is not easy to be affected by the changes of natural environment through the electromagnetic wave imaging reflected or radiated by the target, so the imaging effect is more stable and clearer, which proves that the system has high performance and a wide range of applications.

a Literature [1] b Literature [2] c Author system

Figure 9. The geographic information imaging picture of the three methods.

4. Conclusion

The author designs a geographic information system based on remote sensing technology, which is on the client side through wireless local area network. The server remotely monitors geographic information, collects information, takes pictures and stores them. The weighted fusion method is used to improve the image definition, and the image and text formats are stored and managed separately, so that the data can be output quickly when needed. At the same time, the corresponding scene rendering is designed to enhance the authenticity of geographic information, and the anti-interference transmission of data is realized by using one machine to multi machine serial port protocol. The experimental results prove the effectiveness and robustness of the system.

Conflict of interest

The authors declared no conflict of interest.

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