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Study on Mobile Spatial Service Optimization and Its Application in Forest Intelligent Management System

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Abstract

Recently, because mobile spatial information service is performed in the wireless environment, its application has been limited by disadvantages of mobile intelligent terminal. This paper constructs mobile space data optimization model in order to maximize the advantages of mobile spatial information service, studies deeply the mobile space service optimization method such as spatial data multi-scale representation, compression storage, index optimization and progressive transmission, and applies the mobile space data optimization model into the forest intelligent management system, which has improved the running efficiency, achieved good results.

Keywords: *mobile spatial service; spatial data compression; progressive transmission; forest intelligent management system*

1. Introduction

Recently, with the development of geographic information system, wireless network, and intelligent equipment, mobile spatial information service has gone deeply into every field, which brings great convenience for people's life and production. Mobile spatial information service is in the basis of LBS (Location Based Services), get rid of the bondage of position and cable transmission medium, so that people can acquire, transfer and display spatial data at any time, any place.[1]

However, because mobile spatial information service is performed in the wireless environment, its application has been limited by disadvantages of narrow, unstable wireless network bandwidth, low information processing ability, and small physical memory. This paper constructs mobile space data optimization model, and studies deeply into the mobile space data optimization method, applies the mobile space data optimization model into forest intelligent management system, to enhance the operation efficiency of the system, optimize the utilization of resources, achieve better applied results, make the application of mobile spatial information service fast.

2. Optimization Model of Mobile Spatial Information Service

Mobile spatial information service is the distributed GIS based on the mobile device such as mobile phone, PDA, integrating of GIS, GPS and mobile communication network technology, transferring data with high performance communication network.

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It realizes the mobile information of public information service, makes people enjoy the services provided by GIS system at any time, any place [2].

The processing of mobile spatial information includes spatial information acquisition, storage, index and transmission etc., in order to maximize the advantages of mobile spatial information service, each process of mobile spatial information processing must be optimized. This paper constructs mobile space data optimization model, the model organizes and represents the spatial information based on the thought of the multi-scale representation, optimizes in various stages of compression storage, index and transmission of spatial information, in order to improve the efficiency of mobile spatial information service, break through the Bottleneck of mobile intelligent terminal. The optimization model of mobile spatial information is shown in Figure 1:

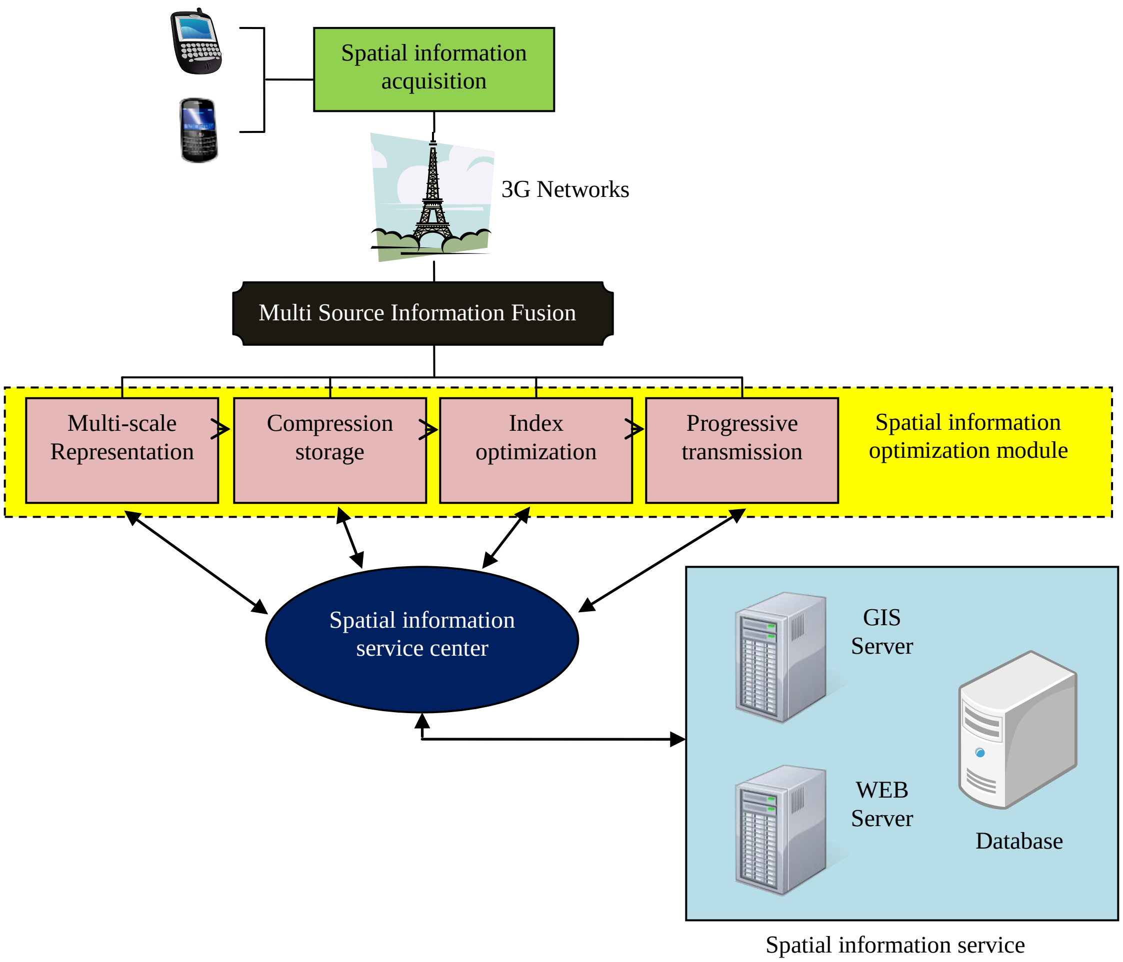

Figure 1. The Optimization Model of Mobile Spatial Information

3. Optimization Method of Mobile Spatial Information Service

In the mobile space information in the optimization model, respectively, the expression, storage, indexing and transmission of mobile spatial information are optimized; the optimization methods and algorithms are adopted in order to maximize the advantages of mobile spatial information service.

3.1. Spatial Information Organization Based on Multi-Scale Expression

In spatial information representation, the thought of the spatial information multi-scale representation is adopted. Multi-scale spatial information expression refers to "with the difference of the objects resolution (scale) which are stored, analyzed and described into the computer, the same space objects arisen and maintained have different digital expression forms in geometry, topology and attributes". The multi-scale expression can use three kinds of basic data model to store: the discontinuous LoD (Level of Detail) model, continuous LoD model and LoD model for node. In the basis of the requirement of progressive transmission for this paper, the thought of the LoD model for node is more suitable for multi-scale expression. Therefore, its database storage method is designed as follows: each scale data corresponds to a table, the same space objects are related with its attributes. But the database stores only the rough map completely in a table, while the other scale map will be storage in increasing way, namely: each layer only stores the increasing or modifying information of spatial data than upper layers; repetitive information will no longer be in storage. [3]

The core of the multi-scale representation of spatial information is the spatial information generalization. Spatial information is process of reducing the complexity of the graphics object expression when the map scale is shrank continuously. After generalization, the roughness of same spatial objects will be different with each other in different scale, and the maps with series of different scale will be obtained. Realization of automatic generalization must have two basic conditions: the data models and the generalization operators. Commonly used generalization operators are as follows: selection/delete, merge, simplified/smoothing, exaggerates etc.

3.2. Research on Compression Storage Algorithms for Vector Data

Vector data compression is extracting a sub set which reflects the original collection as possible from the content, while has the greatest possible compression ratio in the amount of data from the graphic data point set. Specific methods are as follows:

Hypothesis the sequence point set describing a graphic is:

$$A=\{A_1, A_2, A_3, ..., A_{n-1}, A_n\} \qquad n \in Z, n>1$$

The compressed data is a subset which is extracted from the set and reacts to its original as possible, expressed as:

$$A^{'}=\{A_1^{'}, A_2^{'}, A_3^{'}, ..., A_{k-1}^{'}, A_k^{'}\}$$

(In which $k \in Z, 1<k \leq n; \forall A_m^{'} \in A, 1<m \leq k$)

The effect of data compression can be evaluated according to the compression degree of data and reflect degree to the original data, namely the compression ratio and compression error [4~5].

For the compression rate, the evaluation method is relatively simple, namely, computed with the ratio between the compressed points and the points before compressed of the curve. Assume that the point number of a curve is N_f, after compressed, its point number becomes N_b, and the compression rate ε of the curve is shown as in (1):

$$\varepsilon = \frac{N_f - N_b}{N_f} \times 100\% \tag{1}$$

Relatively speaking, the evaluation of vector data compression error will be more complicated than compression ratio. The main indexes are range, deviation and area error. Before the introduction of the three indexes, first assume the abandoned point sets after compressed of set A is $\{V_s, ..., V_t\}$, the line after compressed is L, the representation of the three indicators are as follows:

- Range

The range is the maximum distance from the points $V_s, ..., V_t$ of compressed data to the line L. The range can be used to control the displacement deviation before and after compressed of data, the calculation as shown in formula (2):

$$E_{\max}(V, L) = \max_{u=s,...,t} \Delta(V_u, L) \tag{2}$$

- Deviation

Deviation is the total degree of departure caused by the selection and deletion of points before and after the compressed of the vector data. Generally represented by the sum of distances from each compressed points $V_s, ..., V_t$ to the line L, the calculation as shown in formula (3):

$$\sigma_p = \sum_{u=s,...,t} \Delta(V_u, L) \tag{3}$$

In which: $\Delta(V_u, L)$ is the sum of distances from each compressed points $V_s, ..., V_t$ to the line L

- Area error

Area deviation is the closed graph area consisting of the abandoned points $V_s, ..., V_t$ after compression of curve and the compressed segment. The calculation is shown as formula (4):

$$E(V, L) = Area((V_s, ..., V_t), L) \tag{4}$$

Three above compression error indexes of vector data mainly evaluated from two aspects of displacement and area deviation on the compression effect. Formula (2) and (3) can effectively control the displacement deviation; and formula (4) can effectively control the area deviation.

At present, main vector data compression algorithms are: the vertical distance limit method, angle limit method, Douglas-Peucker algorithm and wavelet compression method. Local data compression algorithm such as Vertical distance limit method and the angle limit method has characteristics such as simple computing and high speed, while emerging distortion as abandon the bend extreme point of the curve sometimes; to the compression algorithm based on wavelet technique, the compressed data will appear deformation at the boundary, and the compression process is complex, with high requirement on the computer. Relatively speaking, the Douglas-Peucker algorithm is a very classic vector data compression algorithm. Relatively speaking, the Douglas-Peucker algorithm is a very classic vector data compression algorithm. It determines the retaining points after compression from whole to part, namely from coarse to fine, with the characteristic of invariance as translation and rotation, also with the advantages of the results consistent after compression given curve tolerance [6].

3.3. Comparison and Analysis of Spatial Information Indexing Methods

The spatial index will directly affect the overall performance of mobile spatial information service. In order to improve the efficiency of spatial index, domestic and foreign experts have done a lot of research. At present, the spatial index algorithms are as K-D tree, R tree and Quadtree.

For the K-D tree, K is the space dimension. Each layer clears the branch direction through detecting different attributes value (keywords). In the two-dimensional space (namely 2-D tree), the values of X coordinates are compared in the even layer (assuming that the root depth is 0), while values of Y coordinates in the odd layer. The structure of K-D tree will appear quite unbalance as the space object element distribution is heterogeneous; the efficient index algorithm will be designed hardly. Therefore, the K-D tree is not suitable for mobile spatial information service which is restricted by mobile terminal. Unlike the K-D tree, R tree is a gravity balance tree. R tree is dynamic tree structures, which can satisfy the requirements of indexing with as little as possible node; just meet the requirements of mobile GIS for efficient spatial indexing structure and indexing. But through the experimental demonstration, the insertion and deletion algorithm complexity of spatial index algorithm with R tree is still too large for current mobile devices. The grid index is a many-to-many space index, namely a space object may occupy multiple grid, while a grid may contain multiple space objects. This many-to-many relationship will lead to data redundancy, because a spatial object may be restored and recorded by multiple grids, the extra repetition exclusion processing need to be carried out in the indexing process. Moreover, the grid is not a dynamic data structure [7~8].

Relatively speaking, the update computation for Quadtree structure is much smaller compared several other indexing algorithms. Moreover, easier achieved by the linear table structure of sequential access, the requirement of storage space is smaller. Therefore, the Quadtree is an effective algorithm of spatial data index for mobile devices [9]. Space division and code graph of Quadtree is shown in Figure 2:

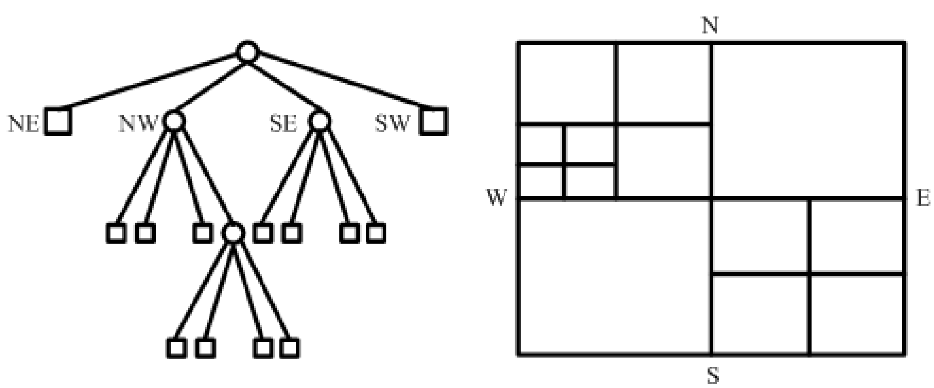

Figure 2. Space Division and Code Graph of Quadtree

But the traditional Quadtree index also has shortcomings, mainly:

- adjustment possibility is relatively poor, the index need be rebuilded while the index range region changes;
- as the level of Quadtree is larger, and the distribution of its node is not uniform, the related node amount in query area is huge, the query efficiency is not high;

- if one graphic logo is associated with plurality of regions, it will cause data redundancy.

The second and the third point defects will affect the retrieval efficiency of Quadtree. The second point is the most prominent. The distribution of vector data is not uniform and the data amount is large, the corresponding Quadtree will appear high unbalanced, which will lead to the big depth of the tree.

For the traversal of non-balanced tree, because of its big depth, the traversal time complexity will increases, thus affecting the efficiency of query. Therefore, how to make the Quadtree tend to balance, is the key to study the Quadtree algorithm.

3.4. Progressive Transmission of Mobile Spatial Information

Mobile spatial information service is restricted by the wireless communication network bandwidth, in order to solve the problem of slow wireless network transmission fundamentally, the thought of progressive transmission for mobile spatial data is proposed. [10]In order to transfer the spatial information from the database server to the mobile client efficiently, it's necessary to choose a good progressive transmission system structure. The system structure is not only to meet the requirement of multi-scale efficient transmission of spatial information, but also with the rapid communication between client and database server. Progressive transmission system structure for this paper is shown in Figure 3:

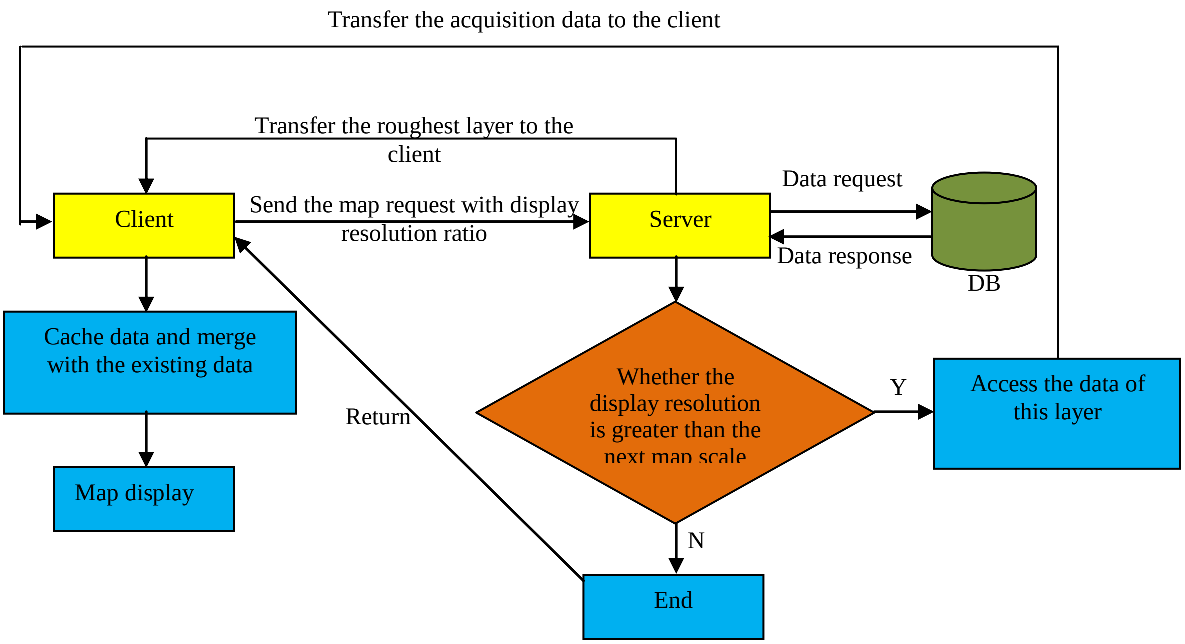

Figure 3. Progressive Transmission System Structure

- The client sends a request with display resolution to the map.
- The server first transfers the most rough layer to the client, then judges the map scale of next transmission, if the scale is not greater than the requested map resolution, the WebServices are called to deal with the request and realize the multi-scale spatial data transmission, the desired data for the user will be

returned to the client, the Plug-in receiver function is called to receive data and cache, and the SVG is used to update data.

- Update data in SVG, Plug-in request function will request the finer layer to the server side according to the need, until the requirements are met.

The effect of progressive transmission is as shown in Figure 4:

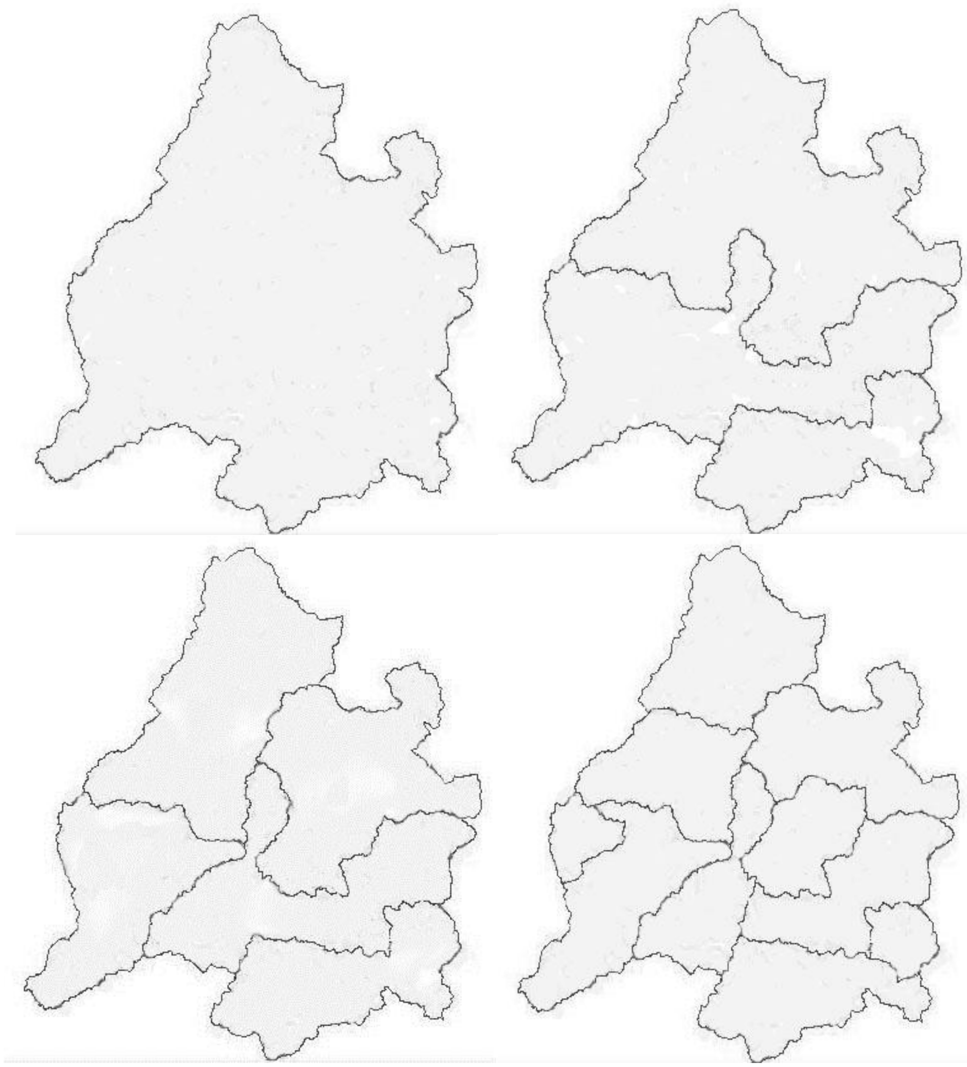

Figure 4. The Effect of Progressive Transmission

3.5. Application of Optimization Model in Forest Intelligent Management System

The forest intelligent management system is based on characteristics of mobile terminals, makes full use of powerful display, query, analysis and navigation functions of mobile space map service system, realizes the collection of position information, task allocation of inspection, real-time monitoring of forest state and spatial data wireless transmission based on integrated GPS technology, wireless network technology and network technology, has the function of LBS.

Forest intelligent management sytem mainly includes several functional modules of the site acquisition, the dispatching of management task, the forest management, uploading and downloading of alarm information, and spatial information query. As the forest management progresses, the map information must be frequently downloaded from the server due to ensure real-time update of inspection coordinate data. This requires the data optimization of the mobile space data to improve the efficiency of management work.

The application of spatial data optimization model in forest intelligent management system improves the utilization efficiency of spatial data, guarantees the real-time management work, and realizes full range tracking management to management staff. The main realization of the system is shown in Figure 5 and Figure 6:

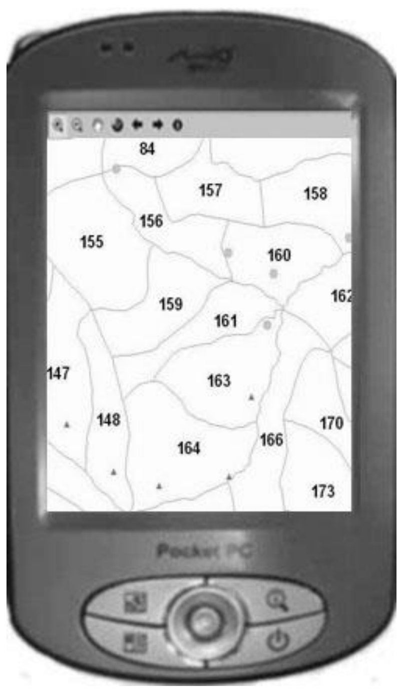

Figure 5. Management Path

Figure 6. Map Display

4. Conclusion

This paper constructs mobile space data optimization model, and studies deeply into the mobile space data optimization method, applies the mobile space data optimization model into forest intelligent management system, to enhance the operation efficiency of the system, optimize the utilization of resources, achieve better applied results, make the application of mobile spatial information service fast.

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