RESEARCH ON THE KEY TECHNIQUES OF REMOTE SENSING INFORMATION MOBILE SERVICES

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KEY WORDS: GIS, LBS, Mobile, Service, Image, Application

ABSTRACT:

The remote sensing information can present many good features when used in mobile location-based service. It has a vast application and market prospect, but it is not easy to implement because of technique limitation and other problems. In this paper, we would first picture an application prospect of remote sensing information mobile service, including some examples in travel service, disaster emergencies, and military application; then we construct a basic Architecture, and mainly discuss some key techniques such as image dividing, image pyramid, image compression and mobile device based fast visualization; finally we give out a prototype system based on .NET Framework Compact.

1. INTRODUCTION

When used in the area of location-based service (LBS), remote sensing images could present many good features, such as rich contents, intuitive to the users, short cycle of updating, etc. However, they may not be easy to store, manage, transfer or display because of their large data quantity. As a result, there are few LBS products which supply remote sensing images. Digital vector maps still take high proportion of accessible image information. The great success of Google Earth, which is based on the internet, indicates the huge attraction of remote sensing images to the users. Different information can be revealed from remote sensing images according to the need of different users, which is exactly the disadvantage of traditional digital vector maps. Hence, we may expect remote sensing images will be applied widely in the area of LBS in the coming future.

Mobile service has a large proportion of LBS, and it is also the main trend of LBS development, which makes it necessary to develop the mobile service of remote sensing information. We may face more restrictions and difficulties if providing service of remote sensing information to mobile devices like PDA. Narrow bandwidth of wireless communication network and weak capacities of mobile devices is the prior problem for the moment. Nevertheless, we can discover the potential of remote sensing information applied in mobile LBS, such as personal positioning navigation, fire fighting and rescue job, emergencies and military needs.

As for the existing improvements, researchers have proposed projects to distribute mass quantity of image data when facing mobile equipments (Xu, 2006), and some combine remote sensing image displaying function into the design of mobile terminal (Li, 2006). But when it comes to commercial products in the market, Google Maps Mobile Version is the only one that realizes the display function of satellite images.

This paper is trying to picture the prospect for application of remote sensing information on mobile LBS. We will also try to construct a general architecture for remote sensing information mobile service, whose goal is to realize the remote sensing images' real-time query, transfer and viewing function of mobile equipments such as PDA. The following will discuss some involved key techniques. Last, a prototype system based on .NET technology will be displayed.

2. APPLICATION EXPECTATIONS

Most mobile LBS provide digital vector map to users so far. On the contrary, remote sensing images can be found to be better at many aspects. First of all, normal digital vector maps tend to be displayed in monotone ways because of beforehand abstraction and simplification. They are capable of meeting primary needs of usage until users need to access those simplified detail information. Meanwhile, the displaying content of remote sensing images is in abundance. In particular, high-resolution images have abundant structures and texture information, which provide users with intuitive and expressive experiences and are more attractive to users than normal images. What's more, remote sensing images are able to provide infrared and radar images for professional users. Second, the updating type of common digital maps is regular full update and the updating process usually takes several months, which reveals its low adaptability under circumstances of partial emergences. On the opposite, the acquirement of remote sensing information is relatively flexible. The normal re-visit cycle of earth observation remote sensing satellite is several days or more, and fresh remote sensing information can be acquired through scroll of the satellite or aviation remote sensing when emergencies happen.

Therefore, if we can provide remote sensing information in mobile LBS, the functions of LBS will be largely expanded and consequently wider application prospect can be seen in personal travel service, disaster emergencies, as well as military applications. We will try to show the application prospect of remote sensing information in mobile LBS, taking some concrete applications as examples.

2.1 Travel Service

Current mobile LBS mainly provide location query, public transportation query, route calculation and driving navigation, etc to traveling users. But for those passengers who travel on foot, line graphs of road trends, buildings and geographical names won't provide enough information. Remote sensing information, on the other side, especially high-resolution images, is capable of expressing more detailed information about roads and buildings. For instance, only basic road trends and building outlines can be observed in Figure 1(a), while users may acquire the information of sidewalk trends, positions to park their cars and specific figure and color of nearby buildings in Figure 1(b). Figure 1(c) is partial amplification of Figure 1(b).

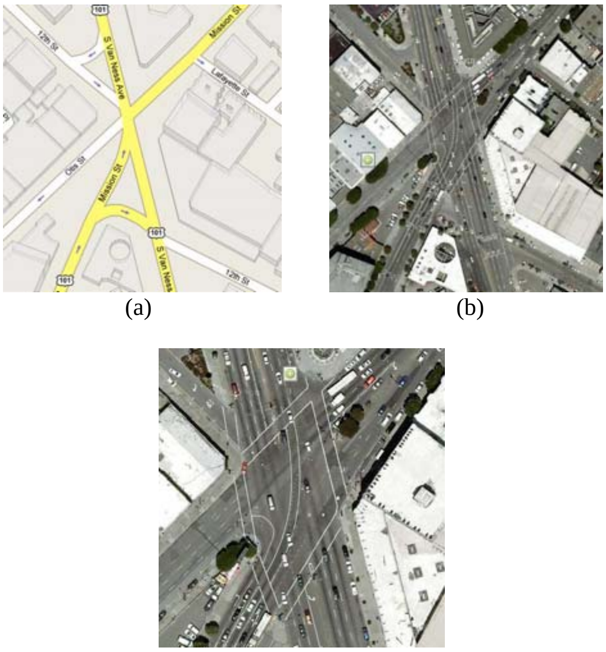

Figure 1. Comparison of vector map and remote sensing image

2.2 Disaster Emergencies

When disasters happen, it will be much more efficient for the rescue team to implement emergent actions if they can acquire real-time remote sensing information through handheld mobile equipment. Take city fire as an example, firemen can get to know the road situation and building structure near the fire through remote sensing information, which will benefit the organization of fire fighting, entry of ambulances and evacuation. And for situation of forest fire, field commanders can also acquire information of terrain, physiognomy and road traffic through remote sensing information by mobile equipments. While serious disaster or accident happens, partial images can be updated by aerial photograph or scroll of a satellite, etc, to ensure that outdoor relevant personnel are able to have the latest remote sensing information. Besides true color images, infrared and radar images can also be provided for the professionals.

2.3 Military Application

When it comes to application on the military aspect, single soldier or vehicle on the frontline can acquire the latest spying images by satellite or aerial reconnaissance to get more detailed and specific comprehension of the battlefield or his mission. For instance, a scout will be able to know the characteristics of the terrain and physiognomy on his route through remote sensing images by handheld equipment, which will benefit his action. As for the spying target, comparison can be made between remote sensing images and information from the real field to discover the disguise of enemy facilities or changes of deployment. In addition, when facing a city battle with unfamiliar and complex terrain situations, individual soldier and commander of the grass-roots level can get to know the road trend and distribution of buildings through real-time high resolution remote sensing information, which will be the base for the organization of an attack or defence.

3. KEY TECHNIQUES

3.1 Introduction of Architecture

When used in LBS, remote sensing information is mainly obtained by mobile devices (e.g. PDA), combining with positioning information and users' interactive operation with the server. So remote sensing mobile service should have some good features, mainly as follows: 1) mobility, mobile device is the carrier of the client, it needs to interact with the server through wireless communication network; 2) real-time performance, the server must process requests and transfer images in time, so that users can browse and operate real-time; 3) location relativity, different positioning techniques could be used to provide location information to both users and the server; 4) scalability, the carriers of the client may be different, and the demands of various user groups would also be different, so system must adapt to the differences.

According to these features, the architecture of remote sensing information mobile service is roughly designed as follows (as showed in Figure 2). It is mainly constructed with client, Web server, application server and data sources.

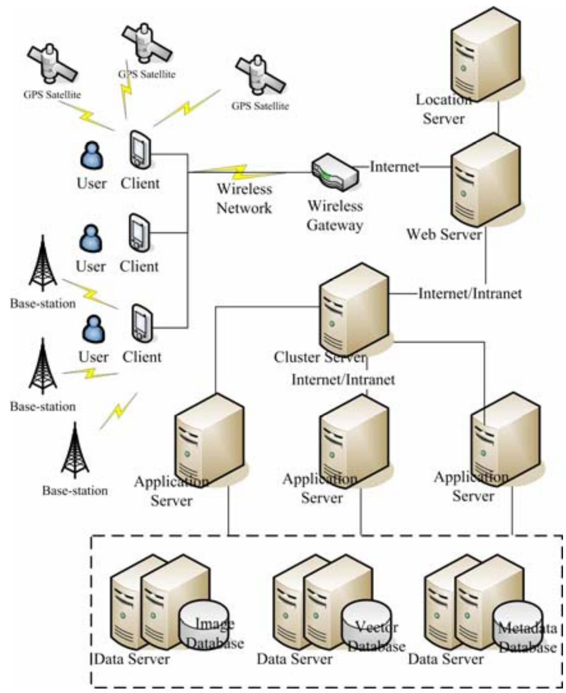

Figure 2. Architecture of remote sensing mobile service

Client: running in PDA, smart phone, or other mobile devices. Usually, they should be able to access wireless network and have location function. For the restriction of these terminal equipments, the client would not undertake complex computing, and should reduce the amount of local data. Its main functions would be interacting with the server, sending requests, downloading and displaying remote sensing images. It requires concise and friendly operating interface.

Web server: would deal with http requests from clients, parse and forward them to application server; on the other hand, receive the processing results from application server, and inform the client to download remote sensing images and other data.

Application server: deal with users' requests sent by Web server, process and compute, get image and other data from the data sources, and deal with load-balance problem.

Data source: include remote sensing databases, metadata databases, etc. Always be ready for upper servers to get data real-time. Data may be distributed in several servers, depending on the scale of the system. In addition, it should deal with data security and backup.

3.2 Remote Sensing Image Database Oriented to Mobile Services

We need to store remote sensing images in databases to organize and manage the images with various resolution and sources. Generally, images need pre-processing (e.g. ortho-rectification, image mosaic, resampling) before storage. For better adaption to mobile service, remote sensing image databases needs some key techniques as follows.

3.2.1 Image Dividing: The screen resolution of the mobile devices is usually low. By comparison, remote sensing images usually have a much larger size. When we want to display a part of an image, we needn't to download the whole sheet. The bandwidth of wireless network and the storage capacity of terminal devices also prevent us to do so. We could divide a large image into regular rectangle blocks in the same size, in order to reduce data transmission. The client only downloads the image blocks it needs. Besides, image dividing also facilitates image compressing, organizing and management, especially for database storage.

The sizes of image blocks could affect their distribution and transmission. Generally, the width and height of a block is better to be a power of two, so that they could be convenient for computing. The size of a block would be 32×32 or 64×64 pixels, considering the screen size and resolution of PDA and other mobile devices.

Suppose the size of an image block is w×h, and the size of the display window is W×H, then the maximum and minimum number of blocks on which the window overlays are computed as:

$$N_{\max} = \left(\lceil W / w \rceil + 1\right) \times \left(\lceil H / h \rceil + 1\right) \quad (1)$$

$$N_{\min} = \lceil W / w \rceil \times \lceil H / h \rceil \quad (2)$$

Where $\lceil x \rceil$ = the integer not less than x

N_{max} = maximum number of image blocks
N_{min} = minimum number of image blocks

3.2.2 Image Pyramid: Zoom is a common operation of the users. In this situation, clients often display the image of a large area in lower resolution. If we download the images in original resolution then zoom out, the redundant data will be times of what we need. This will badly affect the transfer efficiency and waste memory space of the terminal device. An effective solution is, the server stores the images in different resolutions, and only send images in a suitable resolution to client according to the request. To help management, we can organize the series of images to a regular structure just like a pyramid (as shown in Figure 3), namely so called "image pyramid" (Yu, 2006).

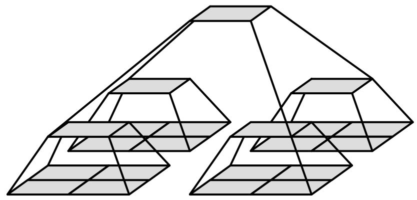

Figure 3. Structure of an image pyramid

Each level of the image pyramid stores the images of a certain resolution version. For convenience, the resolution of each level is half of that of the lower level (except the lowest level). Currently, the image pyramid could be generated bottom-up. If there are images in a suitable resolution for a certain level, they can be used directly; otherwise, images of the level should be generated from those of the lower level by resampling. Images of every level should be divided, as discussed in 3.2.1, before storing in database.

Table name: PYRAMID_LV**		
Field name	Type	Description
ImgBlk_ID	Char	Image blocks' ID, based on row and column number
Width	Int	Width of a block, in pixels units
Height	Int	Height of a block, in pixels units
Left_X	Float	X coordinate of left border of a block
Right_X	Float	X coordinate of right border of a block
Top_Y	Float	Y coordinate of top border of a block
Bottom_Y	Float	Y coordinate of bottom border of a block
Row	Bigint	Row number of a block
Column	Bigint	Column number of a block
ImgBlk_Data	Image	Image data of a block

Table name: PYRAMIDS		
Field name	Type	Description
Pyramid_Lvl	Int	Level of the pyramid
Resolution	Int	Spatial resolution of the level
Block_Size	Int	Size of a block, in pixels units
Row_Num	Bigint	Number of rows
Col_Num	Bigint	Number of columns
Left_X	Float	X coordinate of left border
Right_X	Float	X coordinate of right border
Top_Y	Float	Y coordinate of top border
Bottom_Y	Float	Y coordinate of bottom border

Table 1. Basic datasheet of an image pyramid

In the image database, an image block is the basic storage unit. We could organize the image blocks according to rows, columns and levels. Besides the basic information, we should also store some relative information and metadata, such as geographical coordinates and range, resolution of each level, image sources, imaging date and time, compressing method, etc. A basic datasheet is designed as shown in Table 1.

3.3 Remote Sensing Image Compression

When used in LBS, remote sensing images usually need compression. This is necessary in order to reduce storage space and improve the efficiency of transmission. Nowadays, there are many mature image compression formats, such as JPEG, TIFF, PNG, etc. Considering the usage of these images, we can use either lossy or lossless methods. Mostly, they are used for displaying to users, but not for scientific analysis. So the compression ratio could be as high as possible, under the premise not to affect the subjective image quality.

JPEG (Joint Photographic Experts Group) is the most popular image format in internet at present. The standard of this format includes several algorithms. The most commonly used one is the lossy algorithm based on DCT (Discrete Cosine Transform) (Taubman, 2002). It has a high and regulable compression rate, can effectively control the file size. The most important is that, this format is board supported and platform-independent. But JPEG has some inherent defects: first, because of the DCT algorithm, image quality will badly decline (blocking artifacts appears) at low bit rates; second, its storage and transfer are linear, and the image can only be displayed from top to bottom; finally, it has bad error resilience, if data dropout, the whole image could be destroyed. So JPEG may not perform perfectly when used in mobile LBS, especially in the narrow-bandwidth environment.

JPEG-2000 receives much attention these years as a new image compression standard. Its compression algorithm is mainly based on DWT (Discrete Wavelet Transform) (Adams, 2001; Taubman, 2002). This image format has many good features, and some of them are very beneficial for mobile obtained remote sensing image compression, including: 1) high compression ratio, at the same image quality, its compression rate can be 30% higher than that of JPEG. Image can keep smooth when the bit rate is low (without blocking artifacts); 2) progressive recovery of an image by fidelity or resolution, instead of waiting for downloading the whole image file, users can quickly browse the image in a lower quality, and the quality will be enhanced with more data transfered; 3) region of interest region, different parts of an image can be coded with differing fidelity, so we can set higher bit rates for important features; 4) good error resilience, some redundant information is retained after encoding, in order to resist bit errors and frame dropping during transmission, even if the code stream is incomplete, the whole image could be represented in a lower quality.

At present, development platforms support JPEG-2000 far less than JPEG. Because of its complex algorithm, the development would be difficult, and the decoding would give much pressure to terminal devices. In fact, when we use JPEG-2000 format in above-mentioned image database, we don't need implement the standard completely. Because the sizes, bit rates, progressive modes and many other parameters of the image blocks are the same, the decode program could be well simplified. If the sizes and compression modes of these image blocks are the same, their file heads will be the same, too. These file heads are redundant, thus could be stored as metadata uniformly, in order to reduce the data amount of each image block.

3.4 Mobile Device Based Fast Visualization

Because of the limited resource of mobile device, there will be delay if the images are directly drawn on the screen real-time, especially when the users are doing view operations. Usually, we use off-screen drawing. That is, set a background image (not smaller than the display area) in the memory, and draw the downloaded image blocks on background image in the suitable positions, then update the display area by the static background image at suitable times. It is much faster to draw images in memory and to display a static image than to display the blocks dynamically. The client only needs to adjust the background image after view operations.

Another effective measure to improve the speed of browsing is to set an image buffer. The client can download the images which would be possibly displayed, using the spare network bandwidth. Commonly, the client caches the image blocks near the displaying area. So we can directly use the background image as the image buffer, by setting its size up to several times (e.g. 9 times) of the display area. When the user is browsing the remote sensing images, the client would first download the image blocks for displaying and draw them on the centre area of the background image. Then the client could download and draw the image blocks near the displaying area with background mode. If the user drags the image, the client only needs to move the downloaded image blocks to the suitable position on the background image, and then continues to download other needed blocks; if the user zooms in/out the image, the client could fist zoom and display the background image, and then downloads image blocks of a new resolution level. This can shorten users' waiting time.

Besides, we could also take other measures. The numerical parameters in the client program had better be quantified to integers, in order to reduce computing expense. The operating interface could be as concise as possible, and could solidify some of the operation flows. If the image compression format is very complex, we should simplify the decoding process to improve the browsing speed.

4. PROTOTYPE SYSTEM RESEARCH AND IMPLEMENT

On the basis of the key techniques discussed above, the authors implemented a simplified prototype system. Its general architecture is shown as Figure 4. The server of the system runs on a Microsoft IIS 5.0 server, and is actually a website based on ASP.NET 2.0. The server communicates with the database using ADO.NET, and the image data store in Microsoft SQL Server 2000 database. The database organizes the image data using image pyramid as discussed above. The size of every image block is 32×32 pixels. Every image block is stored without file head after compression, and occupies about 250 bytes.

The client runs on a PDA whose operating system is Windows Mobile 5.0. It is developed by C# language, based on .NET Framework Compact 2.0. The client communicates with the server by wireless network in http mode. It sends URI (Uniform Resource Identifier) as request to the server, waits for processing, and downloads the image blocks. The size of the display area is 192×192 pixels, and the image buffer is 9 times of that. Its caching and displaying strategies are as discussed above.

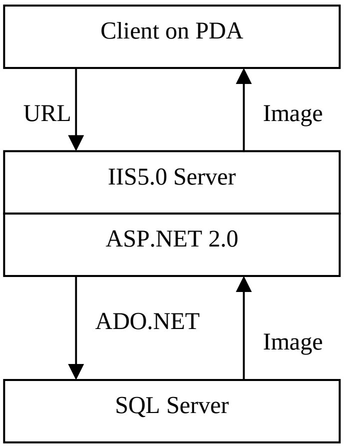

Figure 4. Structure of the prototype system

Figure 5. Client of the prototype system

In the prototype system, remote sensing images real-time downloading and displaying, and the basic view operations such as zoom and dragging, can be realized. Figure 5 shows an example of the client. The image is displayed just after zoom in operation, and we can see the upper half of the image is newly downloaded and clearer, but the lower half is fuzzier and is directly stretched from the background image.

5. CONCLUSIONS

The remote sensing information mobile service has a vast application and market prospect, but it is not easy to implement because of technique limitation and other problems. In this paper, the authors gave a prospect of remote sensing information mobile service, constructed a basic Architecture, and then mainly discussed some key techniques such as image dividing, image pyramid, image compression and mobile device based fast visualization, and finally gave out a prototype system. If we want the system more improved, besides keeping on research the techniques discussed above and expecting the improvement of wireless network and mobile device, we also need to research other related technologies, such as concurrent access of multiple users, load-balancing of servers, multi-buffer caching, image query, etc.

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