Research of Illegal Building Monitoring System Construction With 3S Integration Technology

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***Abstract*—The problem of illegal buildings has developed as an obstacle to the economy and the act of constructing harmonious society in China, and its monitoring has been an important task of urban planning department. In this essay, the remote sensing dynamic monitoring technique was applied to the research of illegal building monitoring using the multi-temporal and high spatial resolution satellite images with the auxiliary of the Geographic Information System (GIS) and the Global Position System (GPS). Meanwhile, the illegal building monitoring system was constructed based on C/S and B/S model, through which the comprehensive analysis can be done automatically or semi-automatically combining numerous historic and field information. The system has been applied in local urban planning department and improved its availability and efficiency.**

Keywords-illegal building, system construction, 3S, change analysis

I. INTRODUCTION

China is now facing the tough problem of illegal buildings, which has developed as an obvious obstacle to the economy and the act of constructing harmonious society. Illegal buildings, the so-called tumor of city, threaten to not only city planning, but also resources saving and public safety [1]. Besides, with the substantial increase of new town construction and old city transformation, the need for illegal building monitoring system to monitor, discover and curb the illegitimacy in the bud has been gaining more significance.

As the technique of remote sensing(RS) has the properties of short period, low cost, good actual effect, etc, it plays an effective role in illegal buildings dismantling, pattern of city layout, city updating and reconstruction, transportation and environment, etc [2]. And the technique of Geographic Information System (GIS) can provide useful auxiliary information and analysis means for the application of RS for being an effective way of spatial management and analysis. Moreover, Global Position System (GPS), one technique that wildly used in navigation and field data acquisition, is a useful complement of data source to spatial information application. Therefore, the integration of 3S Technology is an efficient way to monitor, manage, and analyze illegal building in city, which has been used in the city of Beijing, Wuhan, and Tianjin.

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II. CONTENT OF ILLEGAL BUILDING MONITORING

A. Different types of illegal buildings

Generally speaking, there are six types of illegal building as following [1], 1) violate plan type, the building that gets no permission of any plans, or goes beyond the scope of plan permission; 2) illegal land occupation type, the building that has not obtained state-owned land access, or in violation of the land administrative law; 3) improper construction type, the building that has not obtained construction license, or constructed outside the license; 4) construction without permission type, including accessorial house and the building whose textures is changed without permission; 5) temporary building that is not demolished beyond the approved period of time for their uses; 6) other illegal types. All types of illegal building can be detected with the help of the data of planning examination and approval, combining RS images or building thematic maps, which reveal the geometric plan of building.

In urban planning bureaus of different cities, the illegal building can be classified into different types according to specific business requirements. Therefore, the data of illegal building types could be stored in data dictionary in the process of system construction, so that the types could be modified flexibly by administrator users via visual interface.

B. Spatial data of illegal building monitoring

Using the technology of 3S integration to monitor illegal building, the following three kinds of spatial data are needed.

- High spatial resolution RS images

Remote sensing provides a new means of earth observation to obtain cities' present condition and land use change. The precondition of illegal building monitoring is timely and effectively obtaining multi-temporal and high spatial resolution RS images. In the suburbs, the 2m to 5m

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resolution RS data, such as SPOT5, and CBERS-02B, etc, are sufficient to meet demands; in the urban areas, the 1m and below RS data are preferred, such as data of IKONOS, QuickBird, and WorldView, etc; especially in the key areas, the data of stratospheric airship and unmanned aircraft with the spatial resolution of up to 0.1m or 0.2m, are effective in data partial updating.

Rotation, translation and scale transformation existing between images of two periods for the differences of imaging condition is apt to cause greater error. Thus, once the high spatial resolution RS images are obtained, the most important step of image preprocessing is multi-temporal image registration. The accuracy of image registration influences the accuracy of change detection [3].

- Building thematic map

The creation of building thematic map has two sections, graphic data producing and attributes data entry, which could be operated by use of software platform of ArcGIS, Erdas, MapGIS, etc [4-5]. In actual production of graphic data, the most common way is to create the latest building thematic map manually by updating the extant thematic map overlapped the latest RS image after registration. It should be noted that the outlines of buildings should be drawn according to the base rather than roof because of the deflection angle existing in imaging that makes building askew in images. And there are two methods to entry attributes data, direct approach and indirect approach. The direct approach is to add fields and input data directly in the attribute table of spatial data. The indirect approach is to establish an external data table by other software tools, such as Access, and then related the table to graphic data using the linkage key character [4].

According to the Data Classification Standard of National 2rd Survey of Land Use in China, building land use can be divided into 5 categories and 22 sub-categories. The category of each patch in building thematic map should be determined by visual interpretation of RS images combining field data. In order to meet the requirements of illegal building monitoring and change analysis, Table 1 shows the attributes that should be contained in thematic map.

TABLE I. IMPORTANT FIELDS OF BUILDING THEMATIC MAP

Field Name	Field Alias	Field Type
CC	Building Category Code	String
CN	Building Category Name	String
HS	Housing Structure	String
BN	Building Name	String
DA	Detailed Address	String
OS	Ownership	String
BA	Building Age	Date
LP	Linkage Picture	String
SN	Storey Number	Int
PA	Building Plan Area	Double

- Building change thematic map

Generally speaking, there are two methods of building change thematic map creation. One is to contrast the former building thematic map with the latest RS images after registration to make change thematic map manually. The other one is to do spatial operation of two building thematic map to create change thematic map, which can be automatically done by using the published web service tool developed in Visual Studio platform.

Building change thematic map can be orderly organized by metadata base, with the essential fields like started time, end time, file directory. Users can query and count the change between any two times. If the change thematic map has existed in the period, the data could be utilized directly. Otherwise, it's necessary to be created by invoking the web service tool of change detection.

III. DESIGN OF ILLEGAL BUILDING MONITORING SYSTEM

A. Structure of illegal building monitoring system

According to the business requirements of the urban planning bureau of Tianjin, the illegal building monitoring system is composed of GIS analysis and monitoring subsystem, data management subsystem, GPS investigation subsystem, WebGIS application subsystem. Moreover, the system is interconnected to urban planning platform. The structure of illegal building monitoring system is shown in Figure 1.

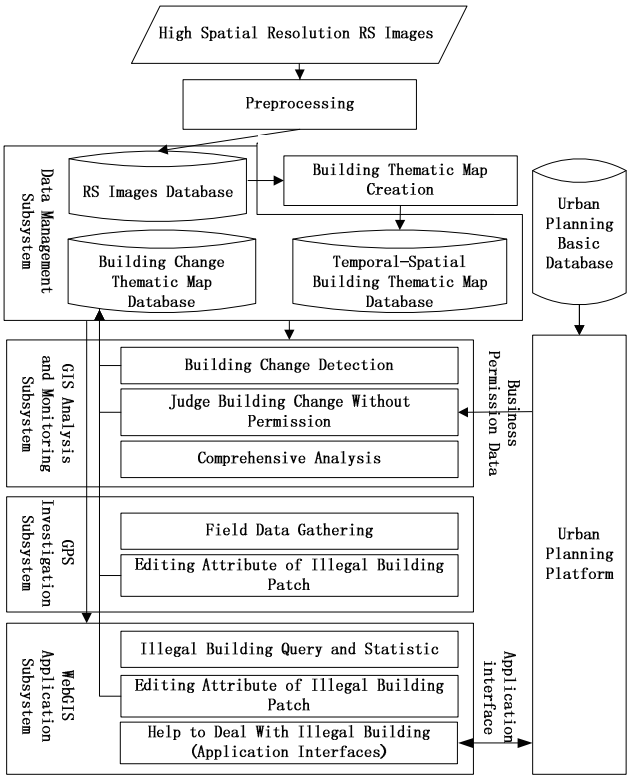

Figure 1. Illegal building monitoring system structure diagram

- Data management subsystem

Data management subsystem is built on the base of web server and database server, which takes charge of the storage

and query of data, including RS images, building thematic maps, building change thematic maps, etc, and enhances the management of users' authority and data access controlling. In the procedure of subsystem construction, Oracle and ArcSDE software platforms can be used. The main function of this subsystem including data input, data storage, data communications, data display, data query and data update, etc.

- GIS analysis and monitoring subsystem

GIS analysis and monitoring subsystem is designed as an interactive system that can achieve human-computer interaction through a series of menus, dialog box, etc. Users can manipulate the data of RS images, building thematic map, building change thematic map, etc. Besides, other data from urban planning database like the building permission data, building construction plan data, can be integrated to make comprehensive analysis automatically or semi-automatically, such as illegal change discovery, illegal data storage, etc. The function of this system mainly includes change detection, illegal change discovery, historic contrast analysis, information query and statistic, reports output, etc.

- GPS Investigation subsystem

Field investigation is an essential step of illegal building monitoring, which is important to ensure the accuracy of judgment of illegal buildings. GPS investigation subsystem is developed in hand-hold terminal, used by field inspectors to confirm the category of illegal building, obtain details of progressions, and collect evidences by photographing. Users can modify the attributes of change patches and transmit the field photos wirelessly to servers via the clients' visual interfaces.

- WebGIS application subsystem

WebGIS application subsystem is built for users of districts and countries' urban planning departments. The authorized users can view, query, analyze, and update local districts' building data within their authorities while logging on. Besides, this subsystem is interconnected to urban planning platform, not only punish the related units of illegal building together with other departments under the unified administrative system, but also submit the data of illegal building and the results of penalty to e-government system as references of administration.

B. Operation procedure of illegal building monitoring

The overall operation procedure of illegal building monitoring includes following steps as shown in Figure 2.

a) Data preparation. The city level users obtain high spatial resolution RS images, do multi-temporal images registration, and then create building thematic map based on latest image data.

b) Data Management. The registration data and building thematic map are stored and managed by city level users under with the usage of ORACLE and ARCSDE software platform.

c) Building change detection and illegality judgment. The city level users produce building change thematic map in GIS analysis and monitoring subsystem, then obtain the illegal building data by contrast of building permission data, and make comprehensive analysis based on building data to produce analysis documents. Finally the illegal and change data are published into web services.

d) Field investigation. After the district and country level users get the tasks of illegal building monitoring, they should first do field investigation with the GPS investigation subsystem, and submit field data to servers.

*e) Result confirmation.*The district and country level users check and confirm the illegal building data, and make penalty decision.

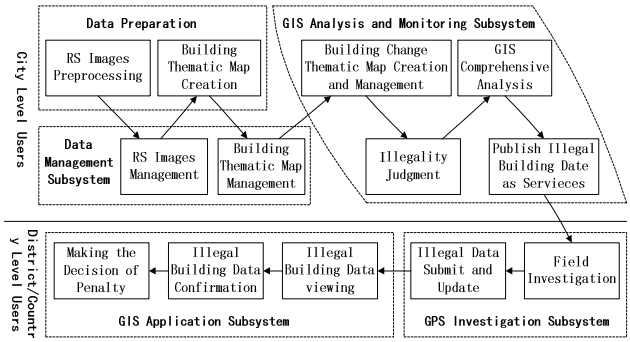

Figure 2. Illegal building monitoring operation procedure diagram

IV. KEY TECHNOLOGIES OF SYSTEM CONSTRUCTION

A. Multi-temporal images registration technology

Multi-temporal images registration technology is to make the same coordinates in different images represents the same positions in real geographical environments. It is common to make geometry registration between two images of same geographic covering but different scanning time by several unchangeable controlling points. Nowadays, the registration methods based on feature point and feature line [6-10] are the most usual.

In order to get credible results of change detection, the precision of registration should be achieved sub-pixel level [3, 11]. Experiences reveal that the precision of registration should smaller than 1/5 pixel if the precision of change detection is required to be no more than 10% [2].

B. Automatic change detection based on thematic map

Building thematic map is very necessary in urban planning, because it is not only useful in building change detection, but also in similar business such as building plan, site selection, etc. Therefore an automatic change detection of building based on existing thematic map is proposed.

It provides two ways of change detection, the approach based on building geometric change and the approach based on building category change. The former approach is to get change patches by using the spatial operation named

SymetricDifference, which is an operation on a multi-set of sets giving the set of elements that are in an odd number of sets [12]. The later one is to be realized by using the spatial operation of Union, and then delete the unchanged patches that the building category codes of two periods' data are equal.

C. Spatial-temporal database management technology

According to needs of the information management and characteristics of data, an amendment model of spatial-temporal database would be chosen. The contents of database can be divided into two parts: current data and change data, which can be organized through relevant analysis to get data in one historical period. The amendment model only needs to save current data once and whenever it changes, only small amounts of change data need to be recorded, so that it not only effectively in preventing data redundancy but also can manage change data more effectively. The technique of ESRI's ArcSDE, geodatabase data model, massive data storage, version management, historical archiving, and multi-user concurrent access are used to build spatial-temporal database.

D. Data service and publishing technology

In order to achieve dynamic, open, scalable, independent spatial data pattern map-visualization, and to be good to spatial data interoperability, all the spatial data of building monitoring should be published into services according to the unified standard of OGC.

The two kinds of geographic data managed in this system should be published into two different kinds of services. To raster data, it's apt to adopt technology of seamless image library that build image pyramid to create cache data and then publish data into WMS service. And vector data are published into WFS service, which can be queried and return querying dataset in the form of GML according to HTTP request that constructed based on the spatial relationship and attributes information in accordance with OGC Filter XML.

V. IMPLEMENTATION OF SYSTEM

According to the software environment, hardware configuration and business requirements, the system was built with the control, COM component of ArcGIS Engine 9.3 enterprise edition, and the web GIS system platform of ArcGIS Server 9.3 based on C/S and B/S model. Besides, it used the ArcSDE with the database of Oracle 10g to save and manage spatial data. The system has been applied in urban planning department of Tianjin city, and improved its availability and efficiency. Practical experience shows that the system has the ability to support simultaneous access and concurrence transaction of the data covering the whole city by multiple users, and interacts with the urban planning platform well. The main interface of the system is shown in Figure 3.

VI. CONCLUSION

This paper started with elaborating the different types of illegal building and three kinds of essential spatial data in monitoring, and carried out researches of system design and construction, during which, an idea of monitoring system based on C/S and B/S model is brought forward combining technologies of 3S integration and database, etc. Finally, the system has run into operation and been playing an important role in illegal building monitoring of Tianjin, which greatly improved the working efficiency of local government.

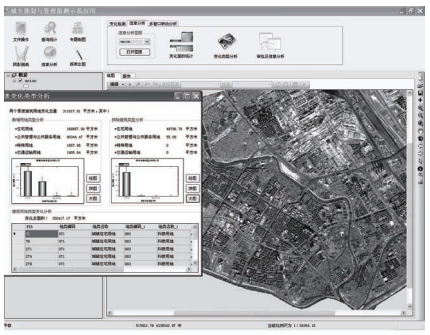

Figure 3. The interface of illegal building monitoring system

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