Research on application mode of monitoring the illegal constructions for sale based on multi-source data and 3S technology—a case study in Shenzhen, China

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Abstract. Although there are lots of researches on illegal constructions monitoring and some cities in China have been carried out operational monitoring, there are few researches on monitoring ones for sale. It is hard to monitoring the illegal constructions for sale through the traditional ways from one kind of data, multi-source data are used in the research, including remote sensing data, aerial images, street map data, media and network monitoring data and regular field data. Application mode is done by combining 3S technology, and monitoring standards and processes are defined in the paper. The principles of using 3S technology for illegal constructions for sale is obtained location information in large area through RS, get exact coordinates from field survey using GPS and combining link the two and other data into various query and analysis to complete the monitoring process In monitoring the illegal constructions for sale in Shenzhen, the proposed method has made some achievements and it will provide valuable experience for other district in monitoring the illegal constructions

1 Introduction

A large number of illegal constructions are existed in China, especially in the first class cities, and the transactions in private are already a matter of face. Due to the limit of policy and traditional technical methods, the underground market of the illegal causes not only the severe constructions obstruction in scientific decision-making of urban social and economic development, but also restricted the planning of urban real estate construction, the regulation of the market, the services of the resident population management.

The traditional ways of monitoring the illegal constructions mainly rely on the public report and regular surveys which is time cost and low efficiency. With urban development, illegal constructions are more and more difficult to find, the traditional ways are hard to meet the monitoring need. In recent years, 3S technology is widely used in urban planning, especially in monitoring the illegal constructions, such as Beijing, Hangzhou, Wuhan [1-4].

According to statistics, the area of Shenzhen construction land is 917 square kilometres, of which the area of illegal constructions accounting for up to 42%. The number of the illegal construction is large, the distribution is wide and the impact of the social and economic is deep. Both the purpose and the means of monitoring share the similarities and differences with other cities.

Unlike previous studies for all kinds of illegal constructions, we focused on the particular class—the illegal constructions which are on sale. In the paper, application mode of monitoring is explored with multi-sources data and 3S technology, and some achievement is made. Research on the model and relative experiences will not only promote the researches on social and economic impact in Shenzhen, but also have good reference to other cities monitoring works.

2 Introduction of 3S technology and multi-source data

2.1 3S technology

3S is an abbreviation for geographic information system (GIS), remote sensing (RS) and global positioning system (GPS). These three technologies are both independent and closely related.

2.1.1 Geographic information system (GIS)

Geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data. In a general sense, the term describes any information system that integrates, stores, edits, analyses, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyse spatial information, edit data in maps, and present the results of all these operations.

In illegal constructions monitoring, GIS can be used for spatial analysis, data storage and thematic mapping.

2.1.2 Remote sensing (RS)

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Various sensors can be used to detect reflected radiation of the object. After transform, image enhancement and recognition, features of large area can be extracted from remote sensing data

Remote sensing data provide base map during the investigation and through multi-temporal data change information about illegal buildings can be found easily.

2.1.3 Global positioning system (GPS)

The Global Positioning System (GPS) is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

The GPS data provide the location information of the illegal buildings.

3S technology is the support technology in monitoring illegal constructions, but there are some disadvantages while using these three technologies alone. Geographic information about illegal constructions can be obtained rapidly through remote sensing, but detail information cannot be obtained. GPS can provide the exact coordinates, but is unable to provide geographical attributes. GIS has abilities to space retrieval and analysis capabilities, but data acquisition becomes the bottleneck [5].

The principles of using 3S technology for illegal constructions for sale is obtained location information in large area through RS, get exact coordinates from field survey using GPS and combining link the two and other data into various query and analysis to complete the monitoring process.

2.2 Multi-source data

Compared to legal real estate sale market, the data of illegal constructions are hard to obtain. Relying on one single data collection way cannot get reliable, comprehensive and authenticable data. So besides using traditional survey data and remote sensing data and GIS data, a variety of new and readily available data sources, such as Internet communication soft wares, website information, web map, street view data are introduced into the monitoring process.

There are disadvantages in using survey data, remote sensing media etc. Using survey data lack of valid evidence to support the need of verification work, which is low efficiency. Although it is wide coverage and high efficiency using remote sensing data, the identification ability in high dense building area is poor and is easy to find error in field survey.

The main sources of data used in the paper and their usage are shown in the following table:

Table 1. Multi-Source Data and Their Usages.

No	Data name	Usages
1	Multi-temporal remote sensing data	In order to obtain illegal constructions information such as location and status, new illegal constructions can be found and existing ones can be seen by comparing multi-temporal remote sensing images.
2	Routine survey data	Routine patrol routes are planned by the government in order to find the new illegal constructions on sale.
3	Media and network data	Due to the large number and long history of illegal constructions, a variety of sale channels are used on Internet besides traditional publicity leaflets, such as QQ, WeChat, blog and etc. Some sale information can be obtained by this way.
4	Street view data	Street view data are introduced into the monitoring process in order to improve the efficiency of the sale market investigation of illegal constructions.
5	Investigation data	To suspected polygons or missing property polygons, it is inevitable to do some field work to obtain detail information about structure, price, etc.
6	Aerial images	Aerial data are used to get information about building appearance and surrounding environment when field survey cannot easily enter.

3 Application mode of monitoring the illegal constructions for sale

Although there are lots of researches on illegal constructions monitoring and some cities in China have been carried out operational monitoring, there are few researches on monitoring ones for sale. Multi-source data and 3S technology are used in the process of monitoring in the paper in order to get the location information and transaction information. The application mode provides solid foundation on data of social and economic impact.

3.1. Monitoring standards

Firstly, all aspects of monitoring using multi-source data and 3S technology are discussed in-depth, and the monitoring standard is established which is divided into three parts-elements, requirements and results. It is showed in Figure 1.

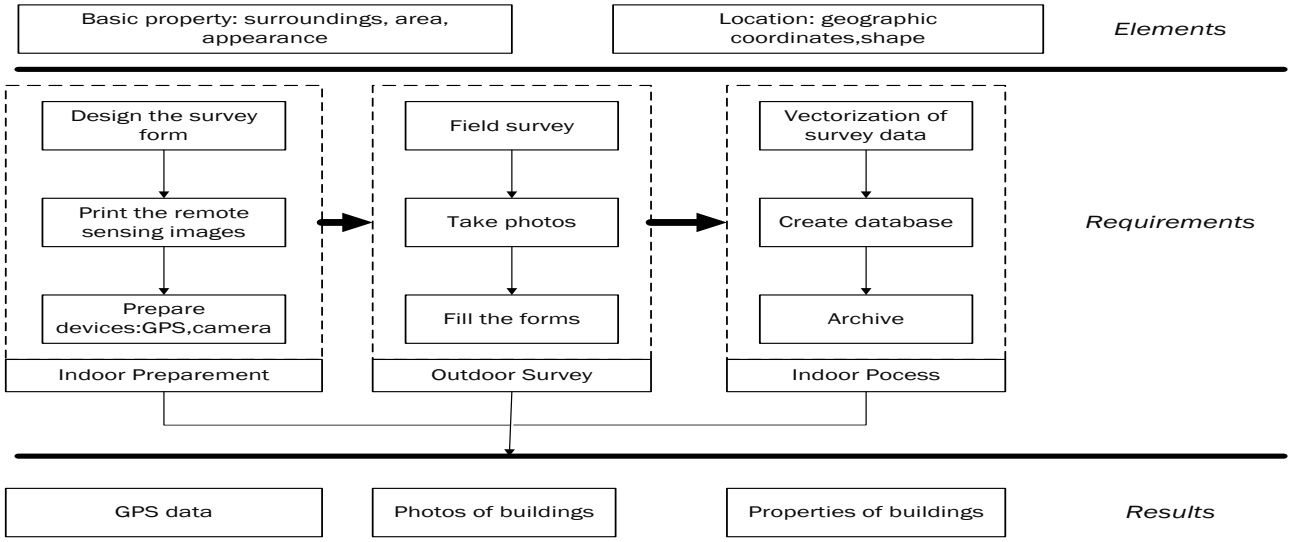

Figure 1. Monitoring Standards

Monitoring elements are provided in the standard, including basic properties and location information such as area, appearance, surrounding environment.

Secondly, monitoring requirements are provided in the standard. They are divided into three sections: indoor preparation, outdoor survey, indoor process and the operational standards in each section are provided too. In the first section, the survey objects are determined by multi-source data, survey forms are designed and printed out with other relative documents. In this section, street view data are introduced into the process which is different from relying on field investigators' photos and is greatly reducing the workload of investigators. In the second section, it is mainly relying on field survey to fill in the form. When it is hard to enter the field to survey, aerial data are used. In the last section, after vectorising the investigate data, database of the illegal constructions is built to manager their properties, shapefiles and photos.

Finally, the results of the monitoring are provided including GPS location, photos of the buildings and the investigation forms.

3.2 Monitoring process

The monitoring process is divided into six steps, shown in Figure 2:

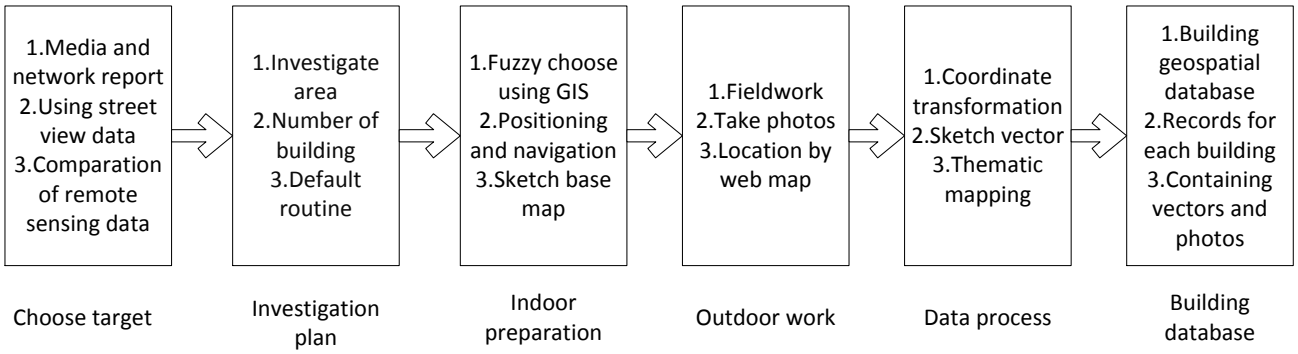

Figure 2. Workflow of Monitoring Process

3.2.1 Choose target

The illegal constructions are divided into two categories: the stock ones and the new ones. For the stock ones, routine inspection, media and network data and street view are used to collect relative information. Addresses are matched with existing data to locate the final ones that are needed to do field survey. For the new ones, multi-temporal remote sensing data are used to discover the location of them and judge the building type with other data.

3.2.2 Investigation plan

First the approximate locations of the illegal constructions for sale are found. survey schedule, personnel tasks and investigation contents are arranged in order to ensure the tasks are completed on time.

3.2.3 Indoor preparation

Indoor workers choose areas where the illegal buildings lays using GIS technology, make identification on the base map and develop the best survey lines according to the areas, distributions of the buildings and the road conditions.

3.2.4 Outdoor work

(1) Fieldwork
According to the existing images to locate the illegal building for sale, building names, shape, floor number, usage and construction time are verified. Identifications are made in the images and the latitudes and longitudes are record by the handheld GPS device. Property information is confirmed by the actual situation and the outdoor survey forms are filled, such as addresses and number of floors, etc.

(2) Take photos
Building architectural, entrance doors, building number and surrounding environment must be record fully and clearly. If the investigators were unable to enter the area, unmanned aerial vehicles are used to get photos.

(3) Location by web map
During the investigation process, location information on the web map is confirmed and record for the subsequent process.

3.2.5 Data process

(1) Coordinate transformation
Using the ArcGIS software, data of GPS device are exported and converted from latitude and longitude coordinate system into Shenzhen local coordinate system.

(2) Sketch vector
Taking buildings as basic unit, vectors of the illegal constructions for sale are sketched by using the results of previous outdoor work and comparison of multi-temporal remote sensing images.

(3) Thematic mapping
Thematic maps are made using GIS overlay technology with geological disaster layer, road red line layer, basic farmland layer, etc.

3.2.6 Building database

Geospatial database is built to store all the data which can contain both vectors and raster data. Each building has a record in the database which contains a vector that has all the properties obtained from investigation forms and photos of survey forms and buildings.

3.3 Monitoring application

At present, the monitoring process based on multi-source data and 3S technology has been put into practice to form routine business. In the first quarter of 2014 in Shenzhen, 87 illegal buildings for sale are found amount which 40 of them are the stock ones, the rest are the new ones that are distributed in six administrative regions. The sale area, price, and other building information are obtained.

Using remote sensing data and other data, the distribution thematic map of the 1st quarter of 2014 are made. It can be found that the spatial distribution clearly shows that an obvious spatial aggregation is existed.

While collecting 12 leaflets, removing duplicates and already surveyed ones, there are 5 buildings confirmed by the fieldwork. All the leaflets of the 5 buildings can be used as an evidence for the further law enforcement.

These monitoring results can provide powerful support to the governments to understand the sale market of illegal constructions and to make better decisions on treatment of them.

4 Conclusions

In the paper, an application mode of monitoring illegal constructions based on multi-source data and 3S technology is studied. For the specific type of illegal constructions which are for sale, not only the traditional routine data and field survey data but also the network data are introduced into the monitoring process. To target objects, media and network monitoring data, web map and street view data are also used to improve the efficiency of monitoring. In field survey stage, aerial images are used to obtain the target photos. Meanwhile, 3S technology is widely used in every section of the monitoring which has played a great role in the monitoring. According to the results of the application mode in Shenzhen, it shows that the mode achieved certain results and can provide valuable experience for monitoring illegal constructions for sale.

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