Remote Sensing Approaches Used in Chinese Urban Land Use Analysis [1]

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ABSTRACT

Both land use inventory and change detection of urban areas are key problems in urban general planning. In China, the traditional approach of urban land use inventory is based on ground surveying. Recently, remote sensing data were studied for their potentials in this field.

This paper will briefly present some results of urban land use analyses with applications of remotely sensed data in Beijing and Tianjin. Thereafter, some results obtained with traditional and remote sensing approaches for Nanjing metropolitan area will be compared. The color infrared aerial photographs have been used as the major remote sensing data for urban land use classification and residential type analysis.

INTRODUCTION

The traditional approach for urban land use inventory and mapping in China is to make ground survey and to draw sketch map in the field, to compile land use map, to make analyzing table based on acreages measured from the map (Song et al, 1985). The scales of base maps for field work and indoor map compiling are usually 1:2,000 and 1:5,000 respectively.

Between 1979 to 1983, China made three airborne remote sensing experiments in urban and rural-urban fringe areas around large cities. These were Changchun (1979), Tianjin (1980) and Beijing (1983). The purposes of these experiments ranged from new sensor testing to applications in many different disciplines. The data obtained include black and white, multiband, color, and color-infrared (CIR) airphotos; and digital multispectral scanner images from visible to thermal spectral regions. Among the later two experiments, several aspects of urban land use and land cover study have been made.

In the experiment of Tianjin area, two studies have been made using CIR airphotos to map land uses at an urban area and land covers at rural-urban fringe. Shi (1983) used 1:10,000 CIR airphotos in the land use mapping of Hebei District, one of the major urban regions of Tianjin. This study established its own classification system based on referring other systems from both domestic and overseas. In addition, the demands of local planning agency and the characteristics of CIR image were also considered. The study was

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accomplished through selecting interpretation signatures, visual interpretation, field verification and map compilation. The interpretation accuracy reported was over 80 percent.

In another study, Wang et al (1983) used CIR airphotos at two different growing seasons (May and September, 1980 scaled at 1:10,000 and 1:25,000 respectively) in land cover mapping at a 1500 Km^2 rural-urban fringe. Although they adopted similar procedures as in Shi's work, the classification system was modified from Anderson et al (1976), and the emphasis was on the agricultural land covers. Unfortunately, no accuracy was given.

In the experiment of Beijing, three studies has been reported on urban growth trend, vegetation coverage and construction structure within old Beijing city. Other studies for urban land use analysis are perhaps still underway. One characteristic of this experiment is that all the data obtained has been digitized and stored in digital format in order to allow computer processing. Using acquired in 1951, 1959, and 1983, Yu (1986) studied the urban growth of Beijing. By selecting Tian-an Men Square as the origin, he calculated out the urban expanding rates along 16 directions.

Jia (1986) using airphotos acquired in 1983 in combination with population registration data obtained in 1984, investigated the construction structure and population distribution of the old Beijing city which is the region within the second city Wall. Airphotos were first used to calculate the residential and non-residential construction densities. Based on these data, maps were produced such as of construction storeys, population density and other related indices. It was reported that this method was about 5 times faster than did conventional method.

Li and Liu (1986), using 1:2,000 color airphotos studied the vegetation density of the built-up area of Beijing. The vegetation distribution maps were generated in a way of drawing tree crowns and greenland boundaries from rectified airphotos onto transparencies, then mosaicing these transparencies and reducing the scale to expected one. The area was calculated out by measuring vegetation coverage in 100m x 100m grid cells. It was reported as a result of ground checking, the accuracy was over 95 percent.

From above description, it is clear that the use of remote sensing data for land use and land cover studies for urbanized area in China has just been started. Many problems remain to be solved before the full potential of remotely sensed data to be recognized. In 1986, research of applying remote sensing data into land use studies with visual analysis techniques was initiated for Nanjing metropolitan area. Data used in this research included B/W, CIR airphotos and Landsat Thematic Mapper (TM) images. Other data and digital methods will be tested in the future. B/W airphotos have been used for land use change detection. Landsat TM images were used for shape analysis of urban areas and regional analysis of city group.

The rest of this paper will only present some works done by using CIR airphotos of this area. The emphasis is on the comparison between traditional method and the use of CIR photographs in urban land use mapping and residential type analysis, according to the requirements of the local planners.

STUDY AREA

Nanjing is located at the south side of Changjiang River, about 300 Km from the estuary. It is one of the six ancient capital cities in China. Since 1949, like most cities in China, Nanjing has been heavily industrialized. Meanwhile the population has doubled. The city has been growing spatially while most of the old constructions have been preserved. The existence of both old and new built-ups makes Nanjing appropriate for the purpose of this study. That is evaluating remote sensing approaches and popularize them if they are proven to be successful. With this purpose in mind, Gulou District, a municipality containing the transition from old to new built-ups of Nanjing was selected.

This area covering about 16.7 Km^2 at the centre of the urbanized area. Few changes have occurred since 1980. The land use data is available from the municipal agencies and the Nanjing Institute of Urban Planning and Design (NIUPD).

METHODOLOGY

The data used in this study is 1:20,000 CIR airphotos obtained in November, 1981. Photointerpretation procedures are similar with Shi's (1983). However, this study has three characteristics. Firstly, the classification system of NIUPD (Table 1), which is also recommended by the State Department of Development, is used instead of creating a new one. Secondly, the field verification is completed for the whole area rather than sampling. Thirdly, residential land use is classified into six types so that further discrimination between residential and land uses for working purposes, identification of areas where modifying or reconstruction is needed, and study of population distribution will be possible. These six types are shown in Table 2.

Table 1: Land Use Classification System for Urban General Planning

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code              classes
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 1      Residential
 2      Public Construction
            including commercial, school, communication, hospital
            and local administration etc.
 3      Institutional (Universities and Colleges)
 4      Industrial
 5      Storage
 6      External Transportation
 7      Road and Squares
 8      Parks and Public Greenlands
 9      Special Land Uses
            including land used by military and people not
            governed by the local agencies
10      Waterbodies
11      Utilities
12      Other land uses
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RESULTS

Land Use Classification of Gulou District

After determination of the interpretation signatures, photointerpretation has been carried out according to the classification system given in Table 1. Gulou District has been segmented into 353 pieces. A field verification of the entire area has been conducted later. 19 misclassifications are found which is 5.4% of the total number of land parcels classified. Most mistakes are made because of the incapability of distinguishing public constructions with residential, and special land uses. Nonetheless, it seems that the general identification accuracy is very satisfactory. It is 94.6%.

Table 2: Residential Types

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code                    types
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11      Old residence
            usually built before 1949, some buildings are even
            several hundred of years old
12      2-4 storey residence
            usually built before 1970
13      New residences over 4 storeys
            usually built after 1970
14      Good quality single family residence
15      Student residence
16      Slum districts
            most of them were built illegally after 1978
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Table 3 illustrated the results obtained with photointerpretation and ground surveying made by NIUPD in 1985. As mentioned before, since 1980, very few land use changes have occurred in this area. Only greenlands are increasing year by year. To compare results in Table 3, it should be kept in mind that the interpretation is made at a scale of 1:20,000 while NIUPD data was obtained at scales lager than 1:5,000. Therefore, many small pieces of land (public constructions are particularly small) which can be mapped at the later scale can not be done at the former one. In addition, if a small piece of land is to be represented at the former scale, it has to be enlarged to some extent. Road, transportation and small river and water bodies are usually exaggerated in this case. Moreover, a small piece of land also causes more errors when it is measured at smaller scales. With these explanations, it is not surprising that the percentages of transportation (6), road and squares (7) and waterbodies (10) are higher in interpreted results. This can be overcome by using larger scale airphotos. It is also logical that the increasing greenlands (8) result in higher percentage and the lower percentage of the idle land use (12) with traditional method as it was used in later dates. In Table 3, over 70% of land falls into the first four land use classes. They are also the most important, and typical land use types for a urban area. It is interesting to analyze the differences between the two approaches in terms of the four categories. For photointerpreted results, only public construction (2) is not reliable. This is because small commercial area are usually distributed along road sides. As roads are exaggerated during mapping at smaller scale, (2) is reduced in area in the same time. Another reason is that some hotel and retail land uses are so small in space that they are neglected and emerged into other uses. The differences of residential (1), institutional (3) and industrial (4) are caused by the following reason. That is when NIUPD making census they usually do not discriminate residential uses when such uses happen to be within the walls of universities or factories. But such uses can be easily identified with photointerpretation method. So remote sensing method results in higher residential, but lower institutional and industrial land use percentages.

Residential Type Classification

Study on residential area is of special interest to many researchers. Planners need to know the population distribution and people's living condition in order to determine where improvements of residence and/or road condition are necessary, where new roads, residences and/or working unit can be located and where emergence facilities arranged. Such details on residential area with traditional approach are usually difficult to obtain. For instance, the finest census is usually made based on the lowest level municipality statistics which gives no internal variation about the population density and the qualities of residential structures. In order to obtain a new inventory has to be made.

Table 3: A comparison of results obtained between remote sensing and

traditional approaches

code	remote sensing method(%)	traditional method(%)
1	34.25	30.82
2	8.57	11.67
3	13.42	16.30
4	14.26	15.09
5	.40	.60
6	1.59	0.04
7	5.78	4.70
8	4.60	6.50
9	13.82	12.27
10	.75	.19
11	1.09	1.28
12	1.54	.54

With remote sensing data interpretation this can be easily done based on the land use classification results. What needs to do is to further classify the residential area in terms of the differences among building structures. A residential type classification is made for Gulou District according to Table 2. The results are listed in Table 4. The qualities of residence are reflected by the residential types. With these data in hand, planners can locate the areas that need to be reconstructed (types 11 and 16). Moreover, as buildings in each type has about the same capability for certain number of people to live within, the population can also be obtained based on areas of each type of residence. In fact, a map of residential types can be used as a surrogate for population density distribution.

Table 4: Areas of residential types in Gulou District

code	area (Km^2)	percentage
11	2.5025	42.2
12	1.8877	31.8
13	0.6667	11.2
14	0.3897	6.6
15	0.2857	4.8
16	0.1992	3.4

CONCLUSION

It can be concluded that by selecting appropriate scales of CIR airphotos, most land use classes of an urban area in China can be mapped with a very high accuracy although the identification of public constructions is poor. The weakness of remote sensing data in interpreting public constructions can be compensated by field checking along roads which is relatively easy to do.

With the remote sensing approach, residential types can be easily classified. Such data are very difficult to get with traditional method because of limited fund problems in most chinese urban planning agencies. It can be anticipated that remote sensing approaches will be used more and more in urban land use studies in China.

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