

Cadastral Management in the Context of Digital Earth¹

Shuliang Wang

LIESMARS of Wuhan Technical University of Surveying and Mapping (WTUSM)

P.O.Box. Doctoral Class 99-2, Luoyu Road, Wuhan, China, 430079

Tel: 86-027-87650079

E-mail: slwang@rcgis.wtusm.edu.cn

ABSTRACT Land is one of the main contents of Digital Earth. And it is also the medium of national sovereignty and supreme political right. When Digital Earth is studied, land management is had to be concerned about because rare and unregenerated land resource becomes less and less. Among land subjects, cadastral is fundamental. Based on the 3S(GPS,GIS and RS), this paper does research on how to establish and perfect micro and all level's Digital Cadastral in order to manage cadastral in the context of Digital Earth. That includes: land objects on the earth's surface in Digital Cadastration; getting feature information with GIS (Geographic Information System); collecting spatial information with GPS (Global Positioning System); to monitor dynamic land with RS(Remote Sensing),GPS and GIS; to refine databases of Digital Cadastral and make Cadastral Data Warehouse, in order to intelligently manage Digital Cadastral in the text of Digital Earth with the help of Ddata Mining.

KEY WORDS Digital Earth, Digital Cadastral, Land Management, 3S, Cadastral Data Warehouse, Data Mining

1. Introduction

Labor is the mother of wealth, while land is the father of fortune. And land provides human beings with clothes, eating, house and walking. So land is very fundamental for mankind. Without land, man is unable to live on the earth. Unfortunately, rare and unregenerated land resource is becoming less and less, especial to plantation, due to population, industry, pollution, desert, salina and so on. In spite of that, man uses and destroys land on the earth as quickly as he can. If people want to exist and develop well, the conflict between themselves and land is had to be paid more attention to. If land resource is able to be utilized generation by generation, it is suggested land should be managed firstly. So Digital Cadastral management, one of the main land management contents, will play an important role under Digital Earth

At the same time, land is the medium of national sovereignty and supreme political right. And territory is the focus embodiment of the national authority and dominant right of treasures. Furthermore, digital land is one of the main contents of the digital earth. Digital Cadastral information timely presents the national sovereignty of territory, the dominant right of treasures, land management, land use, land exploitation, land reclamation and protection. In the world, it reflects the change of land resource in Digital Earth. Hence, establishing Digital Cadastral has to be the unification of land character, land use right's type, land quantity and land quality. Then how to manage

digital land in Digital Earth is important, and how to intelligently manage the Digital Cadastral in the text of Digital Earth with the help of data mining is also needed, which can directly serves for protecting the earth (especial to land), the national sovereignty of territory, the dominant right of treasures and land management.

In the following, the technology on how to establish Digital Cadastral, how to manage cadastral well in the context of digital earth are put forward. Finally, intelligent dynamic land management is suggested, aided by Data Mining and 3S.

2. Cadastral Management

Cadastral management is one of the important national administrative management measures, which develops with the progress of productivity and productive relationship. Thank to Digital Earth, cadastral owns new contents. Cadastral survey, land registration, land grading, land statistics and so on of cadastral management will become digital. At the same time, the management measures with politics, law, economy and technology are going to be more scientific, more reasonable and quicker. This will do great good to land and the sustainable development of mankind and Digital Earth.

In order to manage Digital Cadastral in the context of Digital Earth, it is necessary to learn about the content, form, expression means of cadastral essentials and other relative ones, for they are the fundamental factors to construct Digital

¹ This project is supported by National Natural Science Foundation of China. No. 49874002

Cadastral.

Cadastral essentials include land ownership, land use right type, ownership limit, land position, land area, land use and land price. And their forms are listed in the following. Land ownership includes land possession right, land use right and other rights. There are allocation, transaction, transfer, share, rent, mortgage and so on in land use right type. Land limit includes national limit, all-level administrative area's limit, village limit, land classification limit, land parcel limit. For land use, in urban area, it's divided into 10 I-grade and 24 II-grade classifications and for rural area, 8 I-grade and 54 II-grade ones. For land area, in town, it includes land parcel area, the total area of every street, and the total area of every classification. In rural area, it includes the area of every classification in I-grade and II-grade according to the present land use status for every village, every town and every county. In addition, the area of state-owned land and flying land is included.

Mainly, feature essentials prefer to building and constructure such as house, toilet, road, bridge, water tower, municipal facilities, river, lake and sea, dykes and dams etc. And estate shape has plane shape, level (height or depth), building structure. Artificial feature modality includes building or constructure occupied land area, total building area, house building area, land use rate and land capacity rate (land use intensity). Topographic essentials include plain, hilly country, plateau, mountainous country and basin. Their forms are plain, lowland, platform, peak, ridge, hillside, saddle, mountain spur, gully, escarpment and cliff etc. And artificial feature forms include contour, symbol and data model. The expression means of cadastral, feature and topographic essentials. There are cadastral map, land parcel map, land parcel sketch, street sketch and map for land planning, reclamation, utilization and protection. Tridimensional map, other professional maps and Digital Cadastral are also included.

3. Digital Cadastral

Taking into account the manpower, financial, capacity, computer software and hardware, we'd better grade Digital Cadastral, then establish it with feature and spatial information. Whichever model is employed, the conditions for composing the same data model in future should be considered. In China, Digital Cadastral is divided into state, province, urban-rural data model, according to the grade of administrative area. Macroscopical type, which is used for management and supervision, adapts to state. While microcosmic type, which is used for management and dynamic change, is suitable for

the other 3 ones. When condition is mature, province-grade Digital Cadastral constitutes the state-grade one, and the state-grade Digital Cadastral does the world-grade one, which is the essential of Digital Earth. We may draw a conclusion that the key to establishing Digital Cadastral should be focused on the mode and quality of county-grade and the technical condition for constituting higher-grade one. After every country has established his Digital Cadastral, Digital Earth will be able to monitor land dynamic change. At that time, people can make better use of land and protect land more easily.

3.1. Get Feature Information

The essentials of cadastre, feature and topography are the main contents of Digital Cadastral. Cadastral are the direct information about cadastre, and feature, topographic ones are the related information. In the model, cadastral essentials, which reflect land ownership, land use type, land location, boundary, land utilization, land quantity and quality, can be used to make qualitative and quantitative analysis in the affairs of land management and utilization. The related information, which directly reflect land present utilization status, the density and intensity of land utilization, the status of land source and assets, serves as the basis of analysis and calculation planning, land reclamation planning and land protection planning.

Based on the state-formulated standards, Urban Cadastral Regulations and Land Present Utilization Status Technology Regulation, Digital Cadastral information can be classified feature and spatial information in China's cadastral survey. Feature information can be gotten, referring to the requirements of establishing Digital Cadastral with GIS or LIS (Land Information System). If both of them don't exist, people have to do land general survey or land detailed survey.

3.2. Coordinate. System. of. Spatial. Information

Basing on Chinese areas and all-level administrative areas, and the quantity of zones from west to east, we should select the 6-degree-zone coordinate system for the state-grade Digital Cadastral, the 3-degree-zone one for the other 3 grades. Furthermore, in the area where y-axis length deformation value is required to be less than 2.5 centimeters per kilometer, arbitrary-zone coordinate system that can be converted should be selected. In such regions, arbitrary-zone coordinate system is employed for construction and land management. But in Digital Cadastral, it can be automatically converted into 3-grade-zone

coordinate system. Hence, when programming and designing the function, we must consider the zone conversion calculation of the coordinate system and its automatic reduction.

Compared with the normal geodetic controlling net in the uniform coordinate system, the geodetic data bench in the uniform coordinate system is ideal. That's to say, canton's geodetic data bench does good to Digital Cadastral. It employs GPS to establish a controlling net for an administrative area as a whole just once, in which all the points are of the same grade, high level, high precision, multiple function, even distribution of relative position error, without error transmission or accumulation. According to the grade of administrative area, it's classified as state, province, city and country grade. B-grade net and C-grade net is due to the precision. However, it had better be established once for all, without considering the grade of administrative area and precision.

3.3. Establish the Data Foundation of Digital Cadastral with Gps

In geodetic data bench, GPS points are the same grade, identical precision, and relative location error within the designed limit. Furthermore, the error distribution is even, without accumulation and transmission. At the same time, the long and short semi-axis extent of error ellipse won't be multiplied with the application of starting data or revolve vertically. Moreover, its relative location precision is high, and the conditions for surveying are up-to-date and superior. The precision of geodetic data bench is high, no lower than C-grade. The GPS points in geodetic data bench are distributed densely in urban area, serving as C-grade points. They can also be used as D-grade, E-grade or other lower-grade controlling points to develop lower-grade controlling net. In rural area, they are sparsely distributed for developing lower-grade points. We can select appropriate GPS controlling points for all kinds of engineering because geodetic data bench has clear error gradient. So it is multi-function.

The methods have been experimented in some cities and counties in China. And the results have been widely applied in cadastration and engineering surveying. The cost is much less than the traditional angulation, and the time is curtailed twice. So it is sung high praise for by the land management department.

3.4. Methods on Collecting Spatial Information

There are several methods to collect spatial information: all-analysis, general-analysis, partial-analysis, map-analysis, 3S.

All-analysis method directly collects coordinates of cadastral, feature and topographic essentials in the fields, employing Total Station EDM'S, or electronic -optic distance-measuring instrument, theodolites and matched electronic books. The coordinates being put into microcomputers, we can plot land parcel maps. After the plotted land parcel maps are verified with corresponding land parcel sketch, the coordinates can be stored into database for establishing the model. With this method, information is collected without digitization.

General-analysis method is similar to all-analysis. But it has different way to get essentials excluding coordinates. Partial-analysis directly takes coordinates of administrative limits, street surrounding lines, and some obvious limiting-points. Feature and partial cadastral essentials are supplemented in the office according to land parcel sketches, or surveyed in the field with plane-table. Then the 1:500 cadastral maps are digitized to get the coordinates of other essentials. With map-analysis, the coordinates of essentials are all got in the office by digitizing 1:500 cadastral maps.

In rural area, we conventionally carry out classification survey in the field with 1:10000 topographic maps and transfer in the office, then rectify it according to the film graphic grids. After the area adjustment to every map, the 1:10000 cadastral maps and ownership limit maps are formed. But, we must digitize the cadastral essentials from the cadastral maps, and feature and topographic essentials from the topographic maps. The coordinates of administrative limit, which are gained in the rural boundary surveying, should be put into the database to formulate all-level administrative area. And the digitization focuses on the ownership limit.

Summarizing the experience of rural land detailed survey and considering the level of modern science and technology, we advise to employ 3S technology for rural cadastral. Thus we can realize the total automation of cadastral surveying and mapping, with less time and expense but high quality. First, GPS and geodetic data are adopted to quickly establish the geodetic data bench for the administrative area, which forms the data basis of the area. Then, aerial triangulation aided by GPS (Membership Deren Li) is employed. After the appropriate scale of airphotos is selected, according to the precision of rural cadastral surveying and mapping, aerial photogrammetry and aerial triangulation with GPS can be operated synchronously. Because the GPS points in the geodetic data bench are of high grade, and whose error is evenly distributed, we can take advantage

and high relative precision of position, of which to densify control points that can meet the requirement of precision and density. Finally, the Digitized Surveying Software System (WTUSM) is used to collect the information of cadastral essentials. And the coordinates are stored into the Digital Cadastral.

4. Monitor Dynamic Land with 3S

When Digital Cadastral is set up, the digital land of Digital Earth is also built up. Digital Cadastral can produce all kinds of scale cadastral maps, land parcel maps, land general planning maps and so on. And two-dimensional coordinate outputs of geodetic data bench are able to satisfy the daily cadastral surveying and mapping. As we know, expensive and rare land resource is becoming less and less, especial to plantation. However, the world is unable not to development. Digital Cadastral management in the context of Digital Earth provides a technical way to monitor dynamic land use. Aided by RS, GPS, GIS and so on, people can protect their own land and make good use of it. At the same time, Digital Cadastral information changes every day. And land notification is the daily work of land management. In order to maintain the Digital Cadastral information as well as the fact, it is necessary to modify cadastral as land dynamic change. RS and GPS technology can do this easily. For example, RS gave a realism Chinese area submersed by flood in 1998 timely, and GPS provided Chinese government with trustful information, so as to fight against flood. Aided by land, biology, chemistry and other subjects, all kinds of band RS image will play an important role in Digital Cadastral.

Furthermore, the feature information should strictly match the facts, state new laws and regulations. In China, Land Management Law was just modified, of which new land use control system is had to be obeyed in the feature information. For spatial information, all analysis method can be employ to correct small change areas. And it had better apply RS, GPS and GIS technology in big changes.

5. Intelligent Management

The cadastral feature and spatial information are connected according to the requirement. For example, cadastral map number, land parcel number, geographic name, feature name and unit name etc are stored in database to connect the Digital Cadastral and LIS, GIS and Digital Earth.

The information about cadastral, feature and topographic essentials is large, Cadatral information can be classified as urban information and rural

information according to administrative area; urban cadastral survey and rural land utilization status survey according to the standard and methods of survey; urban state-owned land, rural collective-owned land, state-owned logging station and water area according to land ownership; feature information and spatial information according to GIS and LIS technology; direct information and related information according to the feature of information. Traditionally, basing on the character of cadastral information, we can select one or several key words for retrieving. A series of related exterior information can often be gained. Unfortunately, we haven't made full use of cadastral information resource stored in the database for so long.

In fact, there are unlimited resources hidden in Digital Earth. Data Mining is one technology to discovery knowledge from databases. We can firstly refine databases into Cadastral Data Warehouse according to the requirement. Then the concealed knowledge can be revealed by Data Mining, such as land utilization rules, reasonable historical advice on how to protect plantation and so. It should be intelligent for cadastral management in the context of Digital Earth to manage land and serve for man.

Established Cadastral Data Warehouse is an extreme large database, which differs from general databases. It is the integrated data set with the exact topic, dynamic but stable. Data in Cadastral Data Warehouse mainly includes Integrated Data, Detailed and Summarized Data, Historical data, Interpretable Data and so on. If Cadastral Data Warehouse is able to detect the cadastral data world successfully and effectively, it is the focus for Data Mining to discover useful information. Data Mining can find knowledge, which is concealed, unknown, potential, trustful, new, effective, useful, understood. So people may defend dangerous land forwardly, and deal with questions in time. When Data Mining works, users define the aim problem firstly. Then the system of cadastral Data Mining does with the problem in Cadastral Data Warehouse automatically, aided by computers and network. At last, the result is evaluated. And the good information is put into practice. To sum up, the method and technology of Data Mining is the most important.

6. Conclusion

Land is one of the main contents of Digital Earth. And the world-grade Digital Cadastral will have to be established. Some methods to develop Digital Cadastral management are suggested in this paper. 3S(GPS, GIS, RS) will play an important role in Digital Cadastral. In order to intelligently and

automatically manage land resource and make good use of it, Cadastral Data Warehouse has to be established. And Data Mining should be employed further in Digital Cadastral. However, there are many other subjects of digital land, which are waiting for being studied, for mankind owns only one limited and ungenerated land on the earth, Digital Earth.

References

- Deren Li & Tao Cheng. 1995. Knowledge Discovery From GIS Databases. *Acta Geodetica et Cartographica Sinica*. Vol.24(1):37-44
- Deren Li, 1996. GPS Applied in Photogrammetry and Remote Sensing. Press of Surveying and Mapping.
- Fao.Feslm. 1993. An International Framework for Evaluating Sustainable Land Management. World Soil Resources Report 73. Rome
- Fuling Bian. 1996. Geographic Information System Principles and Methods. Press of WTUSM. Wuhan, China
- Deren Li, Xiuxiao Yuan etc. 1997. Automatically Aerial Triangulation Aided by GPS. The 10th Chinese Academic Conference of Remote Sensing Technology. Qingdao, China. Proc:72-79
- Jiyu Liu. 1996. GPS Kinematic Carrier Phase Measurements for Aerial Photogrammetry. *Photogrammetry & Remote Sensing* 51:230-242
- Shuliang Wang, Chunsheng Sun & Chun Yan. 1999. On Land Utilization Type of Land Basic Price. *Chinese Land Science*. Vol.13(3): 6-8
- Tao Jin. 1997. Land Is Crying-----Let's Protect Plantations Man Replied On. Press Of Guangxi Science and Technology.
- Zuolin Sen & Shuliang Wang. 1997. Land Management Science. Press of WTUSM. Wuhan, China