The application model of 3D cadastre in practical registration for real estate in China

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Key words: 3D cadaster, real estate, 3D cadastral application, data integration, social public services

SUMMARY

Since the introduction of the concept of 3D cadastre, a great many of significant research results have been done. To promote the development of 3D cadatre, 3D cadastre working group sponsored by International Federation Surveyors (FIG) commissions 3 and 7 was organized by Delft University of Technology in 2001. This working group provides a research and communication platform for the 3D cadastral researchers in the world. With the development of 3D cadastre in recent decades, a great many of technologies including 3D cadastral data acquisition, data validation, data visualization and so on have been developed, which met the basic needs of 3D cadastre. Furthermore, 3D cadastre management systems had been carried out in service in several countries and regions include Queensland in Australia, the Netherland, Sweden, and so on.

Compared with the above countries and regions, 3D cadastral development in China is relatively backward. Lots of theoretical researches include the data modeling and the register frameworks of 3D cadastre were made by Chinese researchers. However, most of the existing studies are carried out from the perspective of theoretical and with few associated practical applications in cadastral registration and management. The purpose of developing 3D cadastre is to better serve the needs of cadastral management. With the development of nowadays socio-economic, demands for 3D cadastral visualization, multi-purpose real estate registration and other 3D cadastral data services are increasing.

This paper mainly introduces the ideas and parts of research results of a joint research project launched by Nanjing Normal University and Bureau of Land and Resources of Xinyi recently. The project is also supported by the Department of Land and Resources of Jiangsu and Bureau of Land and Resources of Xuzhou. The aim of the project is to establish a 3D cadastral management, data visualization and registration model for cadastral management and apply them in regional registration. Firstly, we review the real estate registration development history as the background of this project. Secondly, problems and public complaints refer to current cadastral registration are analyzed as the demands for 3D cadastral management and registration. A 3D cadastral modeling method adapted to practical demands is briefly introduced at last.

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1. INTRODUCTION

With the increasing complexity of urban land use in vertical direction, cadastral registration with flat polygon appears to be problematic. Registration and describing detail land use rights in complex conditions become more challenge for traditional 2D cadastral registration. Consequently, 3D cadastral registration was introduced to solve the above problems. As numerous developments for 3D cadastre being carried out, 3D cadastral theories have been significantly developed in the past years (Stoter 2003, Benhamu 2003, Tse 2003, Zlatanova 2004, Stoter 2005, Döner 2011, Van Oosterom 2013, Shojaei 2014, Lee 2015, Shojaei 2016, Drobež 2017, Polat 2017, Alkan 2018). These 3D cadastral research studies the aspects of legal and registration framework, 3D cadastral rights representation and visualization, 3D cadastral modeling and so on. Theoretical research results for 3D cadastre in the past decades promote the development and implementation of 3D cadastral registration in the world. There have been many countries and regions began to implement the 3D cadastral registration.

3D cadastral development in China also attracts great attention. Legal framework, demanding for 3D cadastre, 3D cadastral data acquisition and modeling, 3D cadastral registration model and other relative fields for 3D cadastral development in China have been studied (Lin 2006, Zhan 2006, Zhu 2008, Guo 2010, Wang 2012, Guo 2013, Ying 2015, Zhang 2016, Yu 2017, Fu 2018). However, comparing with advance countries and regions in 3D cadastral development, 3D cadastre in China is still in theoretical research stage. Traditional cadastral management with 2D polygon remains the major means. While the purpose of 3D cadastral research is to solve problems in practical traditional cadastral management, we believe that research should be conducted from the perspective of current cadastral data status and specific demands for 3D cadastre. Therefore, this paper focuses on the concrete demands from publics for 3D cadastre and the cadastral registration current status in practice. A 3D cadastral model based on current cadastral management data is proposed according to public demands for 3D cadastre. Application of our model in practical cadastral management is discussed in this paper.

This paper is structured into four main sections: Current situation for 3D cadastral development, especially in China, is analyzed in introduction. Section 2 briefly reviews registration rights relations and the cadastral registration model development in China. Public demands for 3D cadastre are analyzed as well. Section 3 introduces a 3D cadastral data model based on practical cadastral management data. The application scenarios of our data model are discussed as well. Paper is finish with conclusion in section 4.

2. CADASTRAL REGISTRATION MODEL IN CHINA

2.1 Cadastral rights system

One of main functions for cadastral registration management is to describe ownership rights among different parcels clearly. Different rights configuration leads to different registration systems. In China, the ownership of land and the right to use it are separated. Land is owned by country or collective organization while land users have the right to use the land within the prescribed way. Accordingly, land use rights and buildings' ownership rights on land are registered and managed by different department for a long time. Land ownership rights and other related rights connecting to the specific users of the land are registered by land management department while the buildings attached to the land that do not record at land parcel registration stage are only symbolically recorded in surveying and mapping database. Buildings attached to land parcels are surveyed and registered by another special department in which land parcels' information are ignored at both surveying and registering stage. Generally, the concept of cadastral management should include land parcels and related buildings. The situation is different in China. The concept of cadastral management refers only to land parcel management. Separation of land and related buildings registration and management can lead to various problems.

2.2 Land parcels and related buildings Registered separately

2.2.1 Parcel registration

Land parcels and related buildings' rights are surveyed, mapped and registered separately before 2015. Land parcels registration includes two stages: the first stage is surveying and investigation basic information of the land parcels (physical objects), the second stage is registration related rights attached to the land parcels (legal objects). Land parcels registration at legal level is based on the surveying information of corresponding physical objects. Legal objects and physical objects for the same land parcels are connected by a unique coding which includes the information of land parcels spatial location.

Coordinate information for the physical objects are collected through measurement at the stage of land parcels' surveying and investigation. Related information for land parcels including physical address, boundaries information in four directions, basic information for buildings existing in the land parcel, ownership type of the land parcel, land parcels' usufruct acquisition mode, basic information of land parcels' holder in use, and so on are recorded as well. Rights, restrictions and responsibilities information of land parcels are recorded at the stage of legal registration in which land parcels are redefined in form of semantics from a legal point of view. Information of legal objects including duration of right to use, legal registration area, basic information for the holder of the right in use, location, ownership type, land parcels' usufruct acquisition mode, and other relative information of rights, restrictions, responsibilities prescribed by law are recorded.

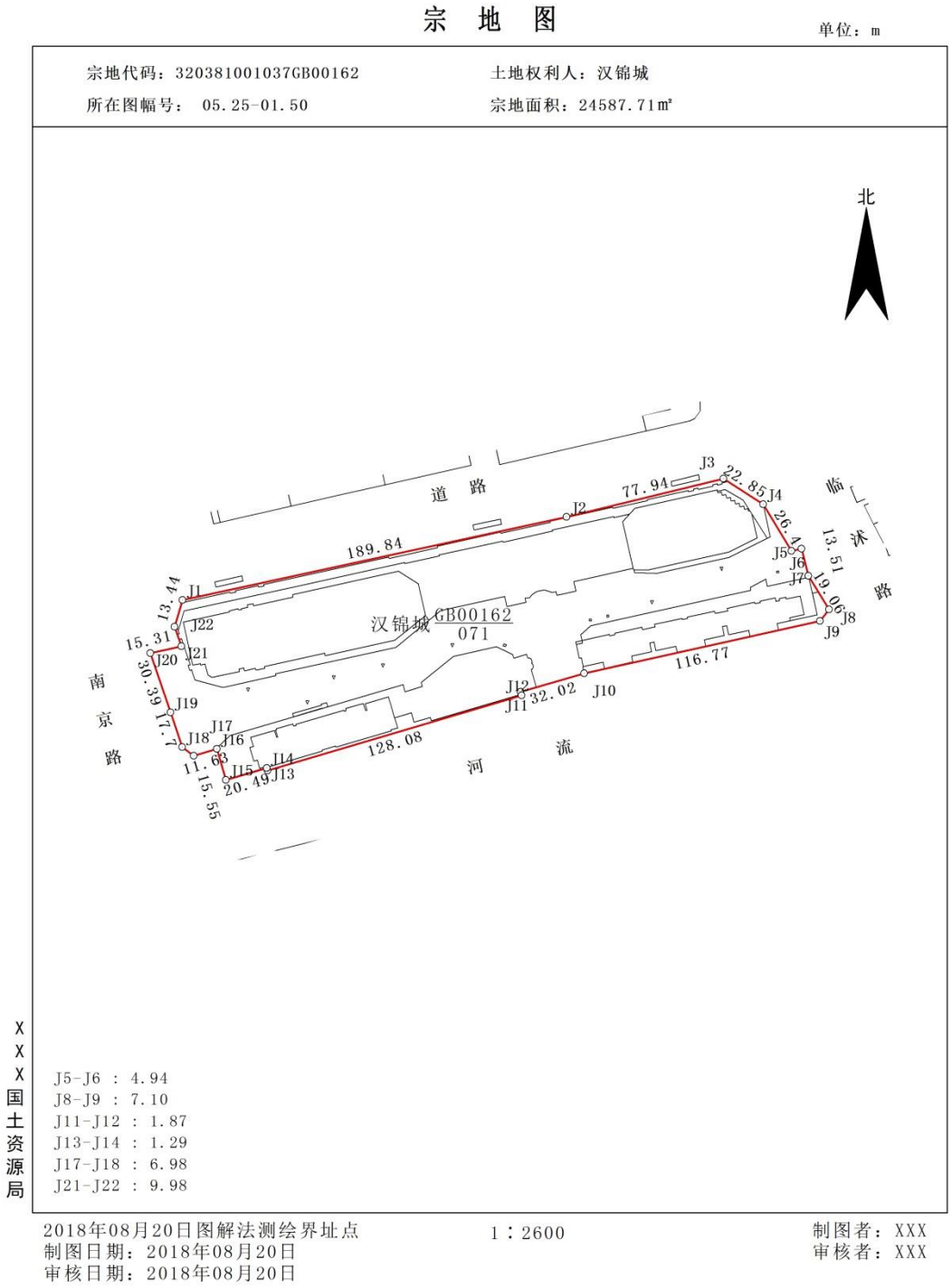

Figure 1. Physical information for land parcels

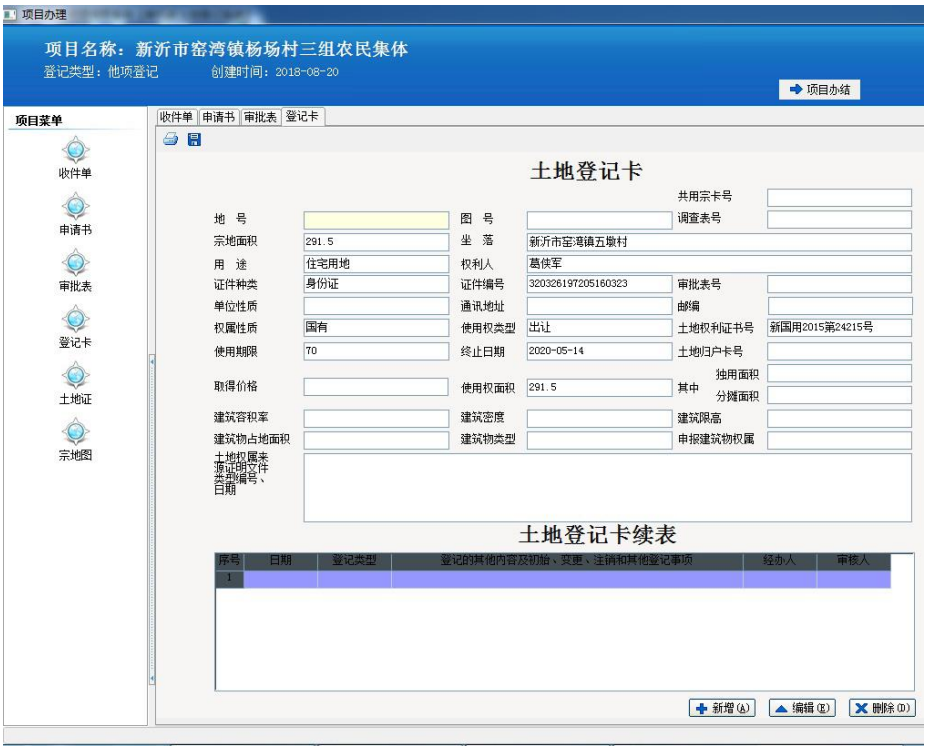

Figure 2. Rights registration information for land parcels

2.2.2 Building registration

Similar to land parcel registration, buildings registration also includes two stages: the first stage is surveying and investigation the basic information of buildings (physical objects), the second stage is registration for related rights attached to buildings (legal objects). Buildings registration only focuses on the rights that related to buildings themselves which is rather different from land parcels registration. Land parcels information related to buildings is not considered in the process of buildings registration.

Physical information of buildings is obtained at the stage of buildings surveying and investigation. Spatial coordinate of the buildings is not collected at the stage which is different from land parcels surveying and investigation. The main task of buildings surveying and investigation is to investigate and record following information: boundaries of the buildings, relative spatial location of buildings, buildings' area, construction time, structure of the buildings, buildings use, internal housing information contain in buildings, and so on. Figure 3 and Figure 4 are two examples for buildings' physical information showing in registration platform.

Buildings' property rights stipulated by legal regulations are registered at the stage of buildings registration. Legal information for buildings include owner of the buildings, structure of the buildings, construction area for registration, acquisition mode of the buildings, duration of use and other rights, restrictions and responsibilities according to relative law. Figure 5 is an example for buildings' legal information registering in registration platform.

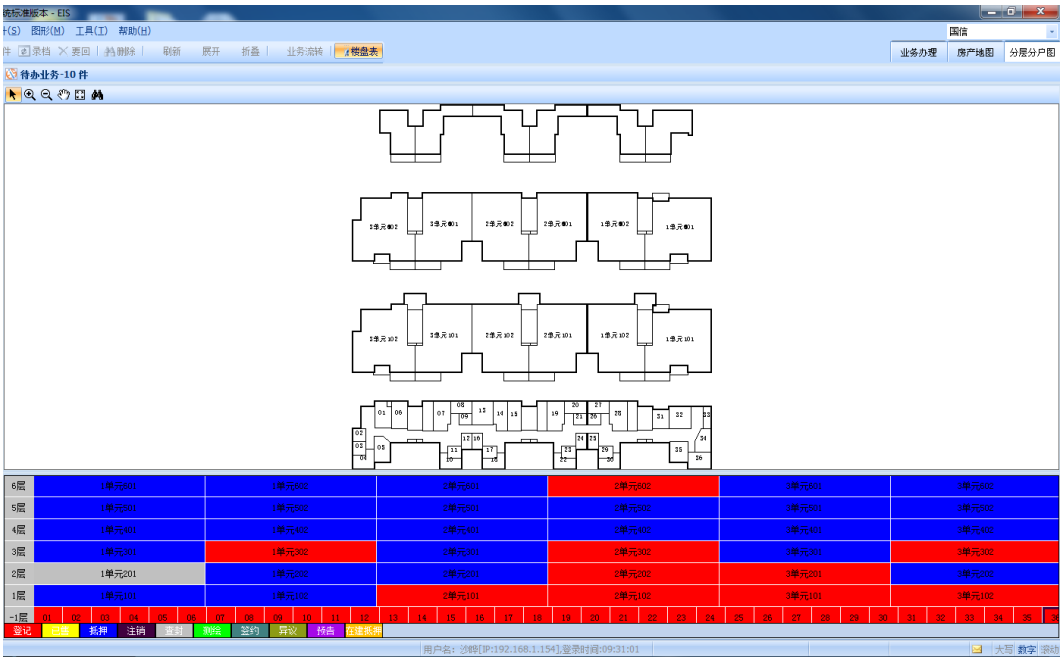

Figure 3. Table information of building property

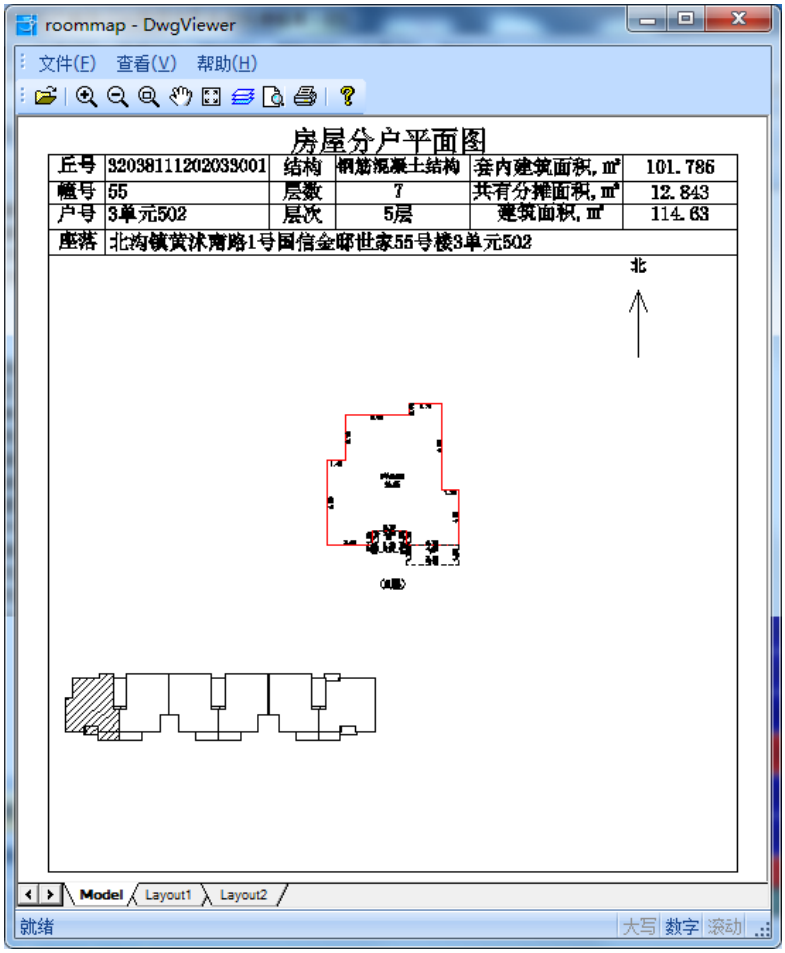

Figure 4. House surveying information in buildings

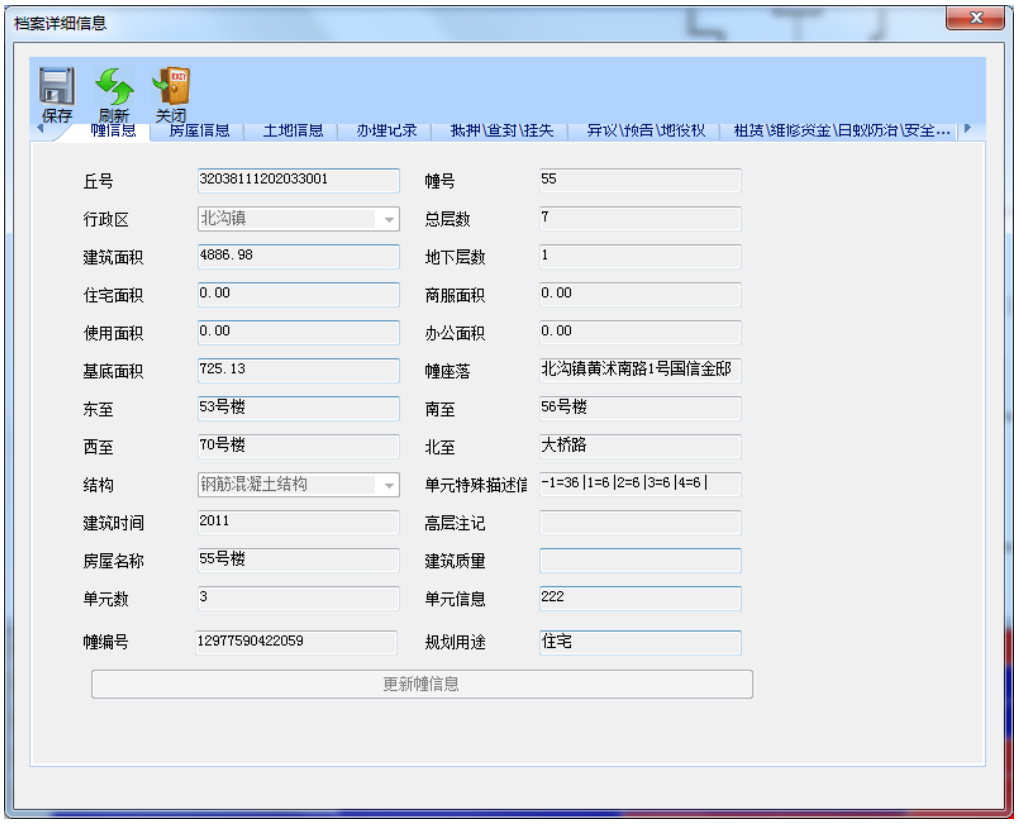

Figure 5. The registration information of buildings

2.3 Unified registration mode of real estate

There are many problems in mode of the land parcel and related buildings registered separately. For example, relationships between land parcels registration and related buildings registration are insufficient while physical objects of buildings are location on the land parcels. Several same types of rights connect to land parcels and buildings are registered repeatedly in different forms by different department. This phenomenon always leads to conflict with ownership rights. Accordingly, a new cadastral registration mode, called unified registration mode of real estate, is implemented in China after 2015. Different registration types including land parcels, buildings, forestry, grassland, and ocean are registered managed by the same department. The advantage of unified registration mode of real estate is remarkable. On the one hand, it avoids duplication of registration in different fields with many common characteristics. On the other hand, it can reduce ownership conflict significantly.

Land parcels and related buildings are registered as an entity in unified registration mode of real estate. There are two stages including real estate surveying and investigation for physical information, and real estate registration for legal information according to relative laws. Buildings' coordinates which are ignored in original buildings registration mode are collected and matched to land parcels' coordinates at the first stage. Physical information of land parcels and buildings is integrated with established rules resulting in real estate physical information as well. Duplicate information of land parcels and buildings in the original registration mode is deleted in this stage. The legal information for real estate integrated from the original land parcels and buildings legal information is described and registered at the

stage of registration. All the rights, restrictions and responsibilities attached to relative real estate will be registered and managed in an unified form.

2.4 Public demands for a 3D cadastre

Since real estate surveying data include lots of information like structure of the buildings, house size and pipelines contained in buildings, there is a great demand for public to query these information in an intuitive way. Traditional 2D real estate data cannot fit these demands efficiently. Real estate represents in 3D cadastral space can describing those information clearly which is very helpful for public to design decoration scheme.

3. 3D CADASTRAL MODEL AND APPLICATION IN PRACTICE

3.1 Data source for 3D cadastral modeling

Physical information of real estate is the basic data for registration. There are many useful information contain in physical information of real estate including ownership of real estate, surveying area, spatial local, constructing information of internal functional area, design information pipeline for water, electricity, gas, and so on. All above information that will be designed in the process of real estate planning and construction must be gathered in the stage of real estate surveying and investigation that is organized in CAD format as shown in figure 6. This information contained in CAD files is very important for multipurpose cadastre and 3D cadastral modeling. Since above information cannot be integrated and visualized efficiently in 2D cadastral management mode, we constructed the 3D cadastral model based on the CAD files which include above information.

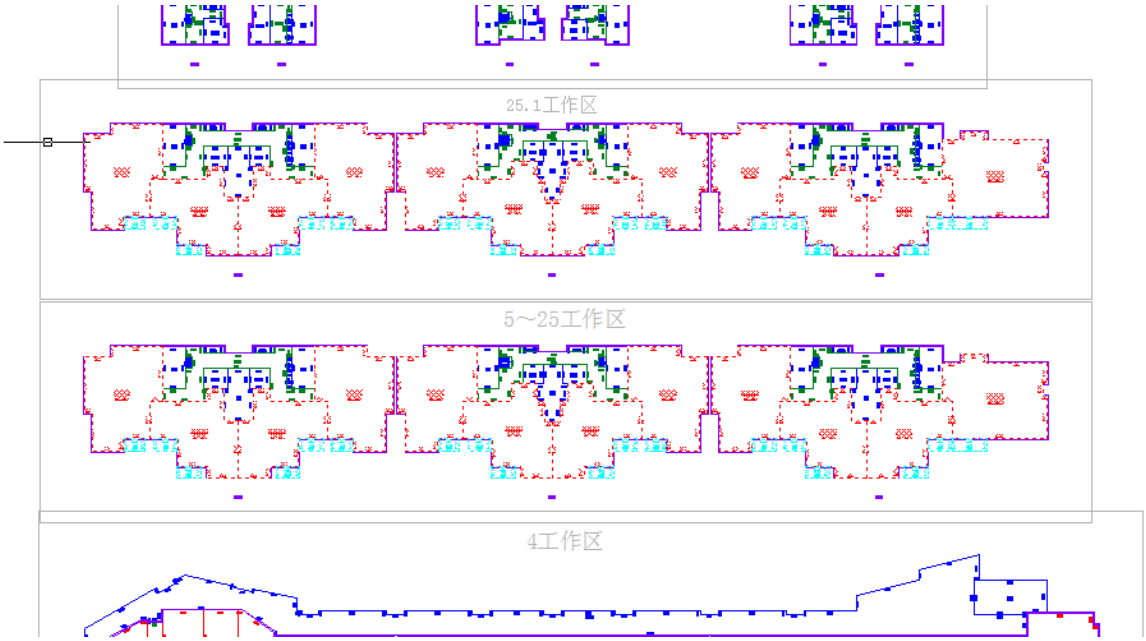

Figure 6. Real estate physical information organized in CAD format

3.2 Modeling method

The framework of 3D real estate modeling proposed in this paper is shown in figure 7. It can be categories into five stages: real estate analyzation, reconstruction for components relationship, 3D modeling for building components, available space extraction, and spatial relationship reconstruction. Buildings relations between available space and construction components are analyzed at the first stage. Relationships among construction components including aggregation relations, inclusion relations and adjacency relations will be reconstructed in 3D space at the second stage. The 3D geometrical information modeling for construction components will be modeled at the third stage. Current 3D modeling methods will be analyzed first of all. Then, those modeling method for 3D cadastral objects will be discussed. The proper 3D modeling method will be design according modeling data sources at last. We construct 3D model of construction components by pulling up organized in building surveying data in form of CAD files vertically according to their heights information. Available space in buildings will be extracted by spatial analyzing the architecture of related buildings at the fourth stage. Attribute information, geometrical information and boundary information for available space will be extracted at this stage. Spatial relationships among cadastral objects include adjacency relationship, connected relation and aggregation relation will be reconstructed at the last stage. Figure 8 is an example of 3D cadastral objects modeling using the method shown in figure 7.

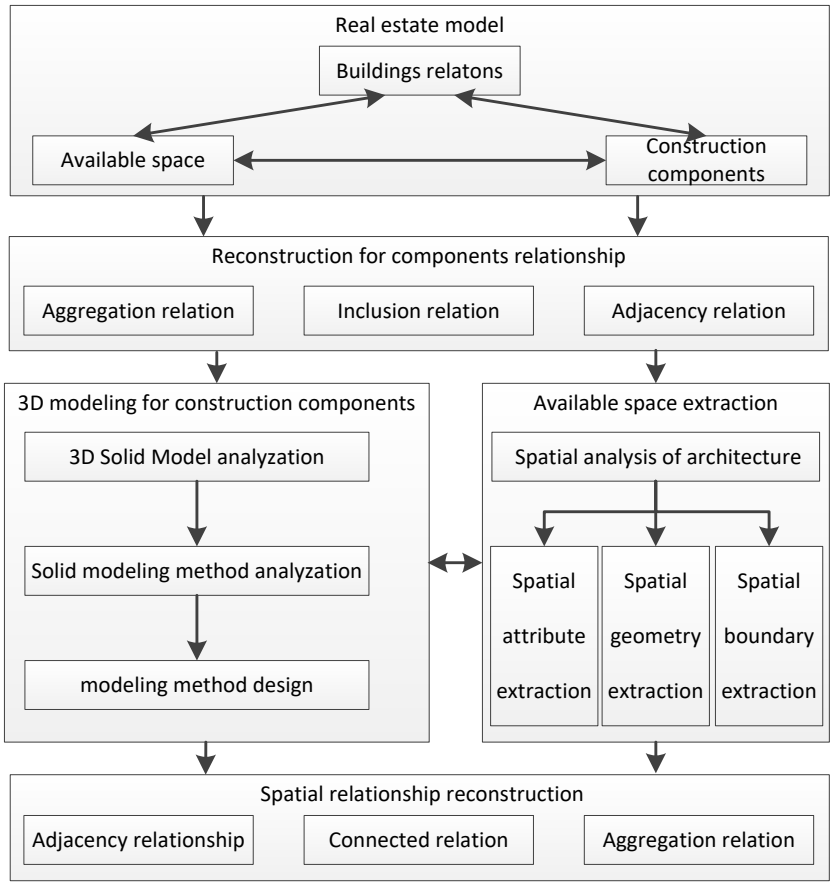

Figure 7. The framework of the 3D real estate modeling

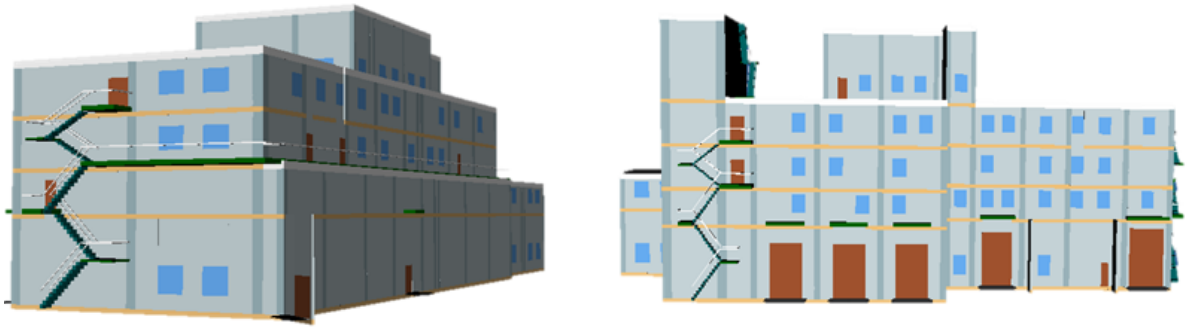

Figure 8. An example of 3D real estate buildings

Since the 3D cadastral model is constructed according to the practical surveying rules and fit to practical registration, both physical and legal information for real estate objects is considered in the data model. Physical objects and related legal objects refer to the same real estate are identical. This is important to apply the 3D cadastral model in practical registration.

3.3 Application in practical registration

Due to the large population and limited land in urban area, city area housing is mainly in the form of residential buildings. There are many households in the same buildings. The real estate house people registered in government department is not the whole building but only an independent room in the building. The area registered on real estate ownership certificate is not the construction area of the room. The area of public territories like stairs, elevator, corridor, pipeline shaft, and so on is apportioned by the relative households. For example, if your registered area is 100 square meters, the available area can be used may be only 80 square meters while the rest area is apportionment of public territories. It is difficult for 2D real estate data to describe the distribution of the apportionment area of public territories which is very concerned by public. Hence one of important application scenarios is showing the apportionment area distribution of public territories to public in 3D visualization of real estate illustrated in Figure 9.

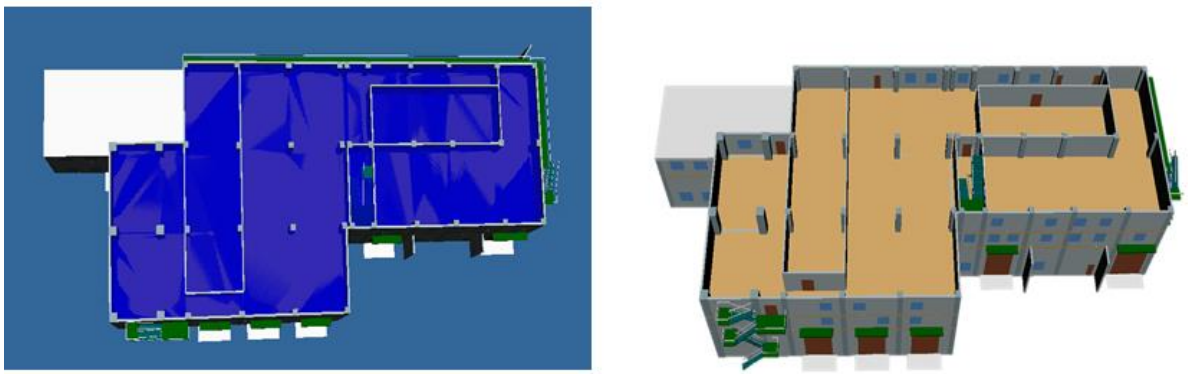

Figure 9. Interior information and apportionment information for a household

Another important application scenario is showing the ancillary information for public decoration in 3D form. Householders often do not know which walls cannot be broken because of load-bearing structure or pipelines in the walls. This information is containing in real estate surveying data that is difficult to describe in 2D form. In our 3D real estate

modeling above information is expressing to help householders planning their decoration scheme.

4. CONCLUSION

This paper briefly reviews the cadastral registration mode development history of real estate in China. Cadastral rights system is discussed as well. Then a 3D cadastral model based on current real estate surveying data is proposed according to public demands for 3D cadastre. Application pattern of our model in practical cadastral registration and management is discussed in this paper at last.

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BIOGRAPHICAL NOTES

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