UNDERSTANDING THE URGENCY FOR 3D CADASTRE IN INDONESIA: DEVELOPMENT & VISUALIZATION OF A HYBRID 3D CADASTRE MODEL

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ABSTRACT:

Limited land resources and vertical growth in big cities signify rapid urban developments in many developed and less developed countries. Multidimensional cadastral registration system more and more regarded as a need in land administration to better manage the development of public infrastructures and land ownerships. Unfortunately, in Indonesian context, 3d cadastral registration has only been introduced since 1985 for apartment ownerships. Public infrastructures, modern architectural facets over public infrastructures as well as over and underground urban facilities have not been captured as cadastre objects in the current cadastre system. In addition, the representation of apartment units, public infrastructures has not been done in a single system. This paper examines the prospects and challenges in the acquisition methods, registration and mapping system of 3d cadastre objects in a typical urban environment in Indonesia. Modelling and visualization of 3D cadastre is designed to meet requirements for representing geometric properties of space and right entitled to a certain subject accurately as mandated by the Law but not yet implemented properly. A prototype of 3D Cadastre model was developed using PostgreSQL PostGIS database and visualized as an X3D and GoogleEarth application.

KEY WORDS: 3D Cadastre, 3D Properties Registration, Spatial Database, 3D Visualization

1. INTRODUCTION

Recent developments in urban cities utilize more and more spaces over and under land cadastre parcels. One can immediately see this from the construction developments in big cities such as towers, multi-storey buildings, underground parking lots as well as public infrastructures like flyover and underground infrastructure. Arrangements are needed to ensure good governance in land administration and to anticipate possible conflicts resulted from vertical developments in urban areas. In this respect, conflicts to be avoided can be either horizontal or vertical conflicts, for example between one government agency with another government agency as well as between government agencies with right owners.

In the context of Indonesian land administration, Agrarian Law (5/1960) has been the source for administering and managing land matters. As the Agrarian Law was based on the Customary Law, hence rights on the land is not covering rights on the objects over and under the parcel (known as horizontal dividing principles or "horizontale scheiding"). For this reason, to cope with rapid developments of urban facilities and buildings in big cities, government initiated new regulation in relation to acquisition and management of apartment rights which can be functioned as places to stay, shops and offices. This regulation was regarded as the Apartment Law (16/1985). The Law introduces new system to register rights on apartment ownerships. Not only rights on the common parcel and rights on the apartment unit are registered, but limited rights on common part and common object are also registered into the system. Further, aspects related to technical implementation of 3D registration are defined in the Government Regulation (PP) no. 4/1988, especially article no 41.

According to 3D cadastral approach typology offered by Stoter (2004), the Indonesian case can be considered as Registration with 3D tag. In Article no 9 (PP 4/1988) , it is stated that rights ownership (strata title) consists of: a copy of Land Book, Floor Plan or Blueprint of the Unit, and values of Proportional Comparison.

Although the 3D tag provides sufficient legal documentation for the rights owner, the current approach has drawbacks. This includes the fact that the floor plan has no means to be integrated with cadastral map as a single system. Hence, the representation of 3D geometries of the unit and its orientation to other objects as required in article 41 of PP 4/1988 was not possible. Further, current practices do not require a plan survey activity to attach or verify 3D dimensions of the floor plan before used as a legal document. In this respect, the paper looks at the possibility to enhance the registration and mapping of 3D cadastral objects into the current

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cadastral database systems (hybrid approach) in order to enable better good governance and to enable better anticipation and resolution in land conflicts.

The paper will investigate the necessity of a 3D cadastre using the so-called Hybrid approach in Indonesia. For this purpose, the development and visualization of a Hybrid 3D Cadastre model will be presented.

2. METHODS

In order to simulate the process of verification of 3D measurements and 3D objects mapping, a case study involving two building objects in the university campus area was initiated to explore opportunities and challenges the development and visualization of 3D hybrid cadastre.

For this purpose, a subsequence activities was completed in the case study:

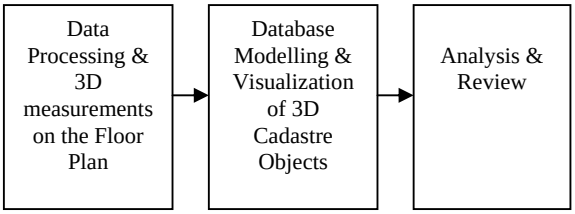
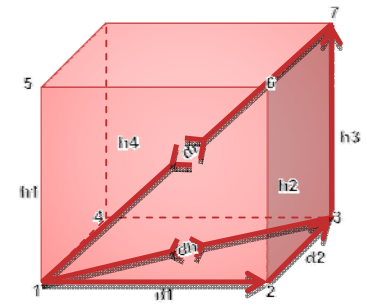


Figure 1. Research activities done to explore opportunities and challenges of 3D Hybrid Cadastre

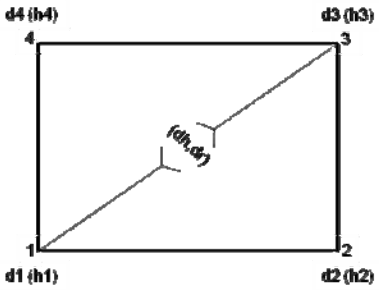
2.1. Data Processing & 3D Measurements on the Floor Plan

Field measurements were required to produce 3D coordinates of parcel boundaries and the building outlines. For this purpose, field survey activities were done in order to: determine exact position of 3D objects against horizontal and vertical reference points and to acquire 3D coordinates of building façade and outlines.

As 3D outlines have been acquired, the next step was to add 3D measurements on the floor plan. This activity was argued important to verify the correctness of horizontal and vertical measurements on the floor plan, which was later to be used in the process to apply for a strata title of apartment unit. For this activity, distometer was used to validate and add 3D measurements of the floor plan. In this respect, the floor plan was considered as an annex to the Field Survey Form (Surat Ukur).



a. Illustration of measurement processes done to verify horizontal and diagonal distances of a registered apartment unit



b. Rules proposed to put diagonal and horizontal distance measurements on the Filed Survey Form (Surat Ukur)

Figure 2. The proposed rules to be used to develop field sketches in the Field Survey Form

Field data from GPS and Total station measurements (for building outlines) and Disto measurements (for the floor plan verification) that were put in the Field Survey Form were then input into measurement form in Microsoft Excel. This approach was chosen as horizontal distances, diagonal distances, and 3D coordinates can be easily processed using spreadsheet forms. Further the measurement results were then converted into ASCII format (*.scr) in order to be displayed and processed as CAD drawing in AutoCAD Map.

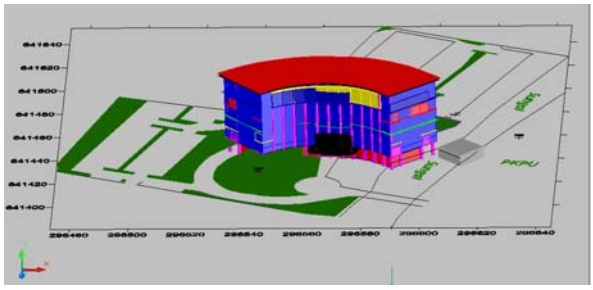


Figure 3. The resulted AutoCAD drawing of Postgraduate School Building of UGM generated from measurements of building outlines and floor plan.

2.2. Database Development and Visualization of 3D Objects

As the building outlines and the floor plan were successfully plotted into AutoCAD Map, the next stage were the storage of 3D coordinates into the database. The database system used in the work was Postgre SQL PostGIS that has abilities to handle 3D geometries and implement Simple Feature Specification from Open GIS Consortium.

Tables related to object classes: “Model of 3D objects”, “Persons”, and “Right or Restrictions” were created to store the data. The approach was utilized to follow approach used in Stoter (2004) who modeled a Hybrid 3D Cadastre as the following.

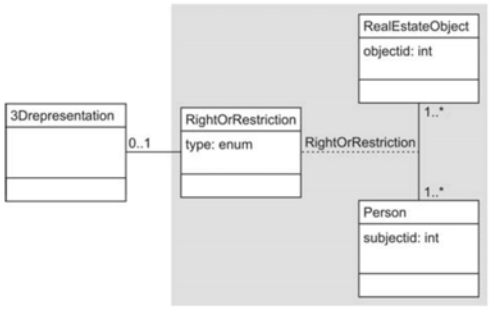


Figure 4. Hybrid approach of 3D cadastre (Stoter & Salzmann 2001)

In this case, simulation data was used as in fact the buildings used in the case study were managed by one management in the university. Five tables developed include:

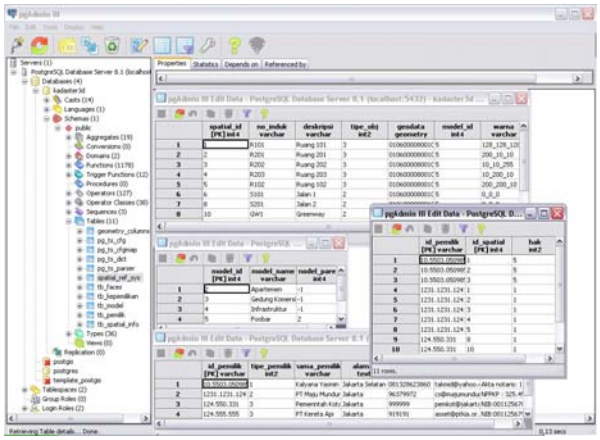


Figure 5. 3D Cadastre Database used in the study

From the 3D model developed, spatial functions and operators that were used to test the geometry include:

o St_intersects(geometry a,geometry b)

This function is used to test whether a intersects b (result: Boolean).

o St_intersection(geometry a,geometry b)

This function is used to find out the intersection surface resulted when a intersects b (result: geometry).

o Geometrytype(geometry a)

In order to check the geometry type of a construct, this function is used.

o Isempty(geometry a)

This function is used to verify whether a geometry is empty.

o Operator &< (a &< b)

This operator can be used to inspect whether a geometry is reside on the left side of the b geometry.

o Operator &> (a &> b)

This operator can be used to inspect whether a geometry is reside on the right side of the b geometry.

o Operator &<| (a &<| b)

This operator can be used to inspect whether a geometry is reside on the bottom side of the b geometry.

o Operator |&> (a |&> b)

This operator can be used to inspect whether a geometry is reside on the right side of the b geometry.

For visualizing the data, there can be two approach: first to make use of X3D (XML for 3D in which X3D viewer is required), secondly visualized through the GoogleEarth using KML (Keyhole Markup Language). The application was developed as web application (PHP and AJAX application).

3. RESULT AND ANALYSIS

From literature review on the Law and Government Regulation related to Registration of Rights of Apartment Unit and from the case study, it can be seen that legal aspect related to registration of 3D cadastre objects need technical improvements. Some improvements were needed for some reasons:

1. The Floor Plan, which is utilized as a part of legal documents in issuing ownership rights of cadastre objects i.e. apartment units, has not been integrated into the cadastral map. In addition, the Field Survey Form for each of the unit should also show/display the actual 3D measurements of the space. Thus, requirements stated article 41 of Government Regulation for exact 3D geometries representation for each of 3D cadastral unit together with subject and right or restriction applied on it can be really fulfilled.
2. For that reason, a verification process done by Land Office before registering the object should be considered.
3. Public infrastructures and urban facilities that has 3D geometries need also arrangements and regulation.

Accurate representation and organization of these infrastructures and facilities will ensure good governance and will anticipate possible land conflicts.

From field survey experiments, some strategies to reach optimal and efficient results can be given:

1. In order to survey building outlines and to verify 3D measurements of cadastral units, in area where technical reference points for land parcels are available in proper distribution then field surveys with Total Stations are sufficient (GPS Survey is not necessary).
2. In order to gain height reference efficiently, in the future, the distribution of national height reference points is required to be more dense. Alternatively, there should be arrangements and synchronization across institutions regarding the availability of local height reference monument for each complex building construction.
3. The zero height of the building is recommended to be the leveling surface of the first floor (according to the Floor Plan).
4. The Floor Plan verification can be done using Disto meter. From the case study, it can be seen that the proposed rules for expressing 3D measurements were proven workable to be put in the Field Survey Form.

From mapping and database development activities, some strategies can be presented here
1. During the data processing the coordinates used were geographic coordinates. For the Floor Plan, the coordinate transformation (to TM 3° grid system) can be done after the building outlines were completed.
2. The result of height measurements of the Floor Plan can be used later as a base to develop the height of the 3D Model.
3. Further, from 3D model developed, the rights and the subjects associated to the unit/space can be inputted into the database system.
4. The Prototype developed were built based on the hybrid approach. In this respect, the prototype models the physical registration of the object where rights and restrictions can be applied on the parcels and the objects. As such, rights (and restrictions) applied on objects and on the parcels can be different.

Regarding the prototype resulted, two kinds of approach were investigated. The first approach is the use of X3D (XML for 3D) to visualize the 3D Cadastre Database (stored in Postgre SQL) and to query object relationships (Figure 6). The second approach was the use of KML to visualize 3D Cadastre Database (Figure 7).

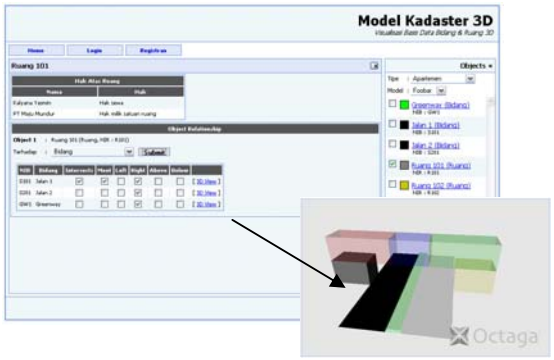


Figure 6. 3D cadastre Model represented as X3D

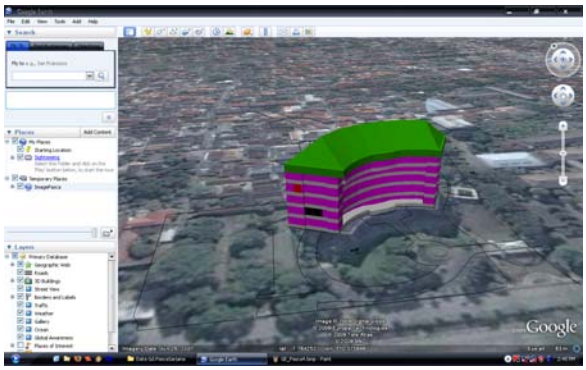


Figure 7. 3D Cadastre Model represented as KML in GoogleEarth

4. DISCUSSIONS

Hybrid approach for 3D Cadastral registration in Indonesia can be seen as the most suitable approach. This can be understood as the survey and mapping system of cadastral system are 2D-oriented. Changes and developments from 2D into Volumetric (3D) will be burdening Land Office and users in terms of the complexities of data conversion, system migration as well as institution capacity and legal aspects. So it is better to concentrate to complete 2D registration (parcel) while integrating 3D objects registration in urban environments into the cadastral systems. 3D tag option as it is now implemented (based on the Law and Governmental Regulation) will indeed easily be implemented but it has drawbacks on its sustainability to represent exactly 3D geometries of 3D objects and to avoid possible conflicts on the use of space below and over the parcels for apartment and infrastructures. The main drawback is that the representation of its 3D geometries has no means to be integrated with the cadastral map.

Assuming, the hybrid cadastre approach was chosen, then a big picture of initial steps required to be done involve:
- Management of data related to objects, rights or restrictions and subjects into spatial database
- It would be ideal when the basic map including height information is available. As the basic map is available in large scale, then land parcels could be projected into the terrain surface that referred to the height reference .
- Buildings outlines and infrastructure over or under the earth are then projected into the referenced parcels

Prototype was successfully developed as an internet application. This is specifically required to support efficient data exchange and effective management of spatial data organization. The overall processes of identification of cadastral objects, registering the objects, developing The Land Book, managing the database can be enhanced with developments of the Internet Technology. In this respect National Land Information System has been initiated through Presidential Decision

no 34/2003 about National Strategy on Land Matters to support integrated and reformed policies on land administration including endorsement to empower land information in support e-government, e-commerce, e-payment. The use of internet to enhance 3D cadastre management is also in line with Presidential Order no 85/2007 about Networks of Spatial Data Infrastructure to support data sharing and data exchange of 3D data in land matters related to legal, fiscal and planning aspects. The initiative was to facilitate data sharing and data exchange across the agencies through the arrangements and the use of standards and specifications (Groot and McLaughlin 2000).

5. CONCLUSION

In regard to the publication of the ownership rights on the apartment unit as stated in the Law no 16/1985 and Government Regulation no 4/1988, it is required to have the Floor Plan get legalized by the Land Office. In relation to this, the common practice was the Land Office gets the copy of Floor Plan from the consultant and no have chances to verify or validate the measurements. Considering more and more apartment units were offered to the public and more and more public infrastructures are built in a complex architectural design, intersecting or overlapping the spaces, accurate rights and space representations are argued to be of urgent to ensure sustainable law enforcement in land administration. For this reason, 3D measurements on the Floor Plan to verify or validate the actual use of the spaces are necessary to be done.

From the case study, it was apparent that the current database technology can cope with the complexity of registration of 3D cadastral objects. The relationship tests between spaces or apartment units involving rights, subjects and geometries can be done properly. Nevertheless, full support to 3D geometry types of Spatial Database and their interconnection to the CAD application and Information Visualization application can be of usefulness to the 3D cadastre practices.

As the hybrid approach is considered to be most appropriate method in terms of efficiency and human resources capacity, therefore 3D representation of multi-storey and high buildings as well as public infrastructures need to be integrated into current cadastral systems. As discussed in previous section, several steps are required for this, especially the attachment of 3D measurements on the Floor Plan should be considered in line with the values of Proportional Comparison (NPP – Nilai Perbandingan Proportional).

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