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Geometrical data validation in 3D digital cadastre − A case study for Victoria, Australia

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ABSTRACT

Data ambiguity and invalidity can cause significant expensive issues in the cadastral domain (e.g. legal disputes). An automated data validation can significantly help to reduce the potential issues. Quality assurance has been comprehensively investigated in various domains, however, the validation of 3D cadastral data is still in its early development. The availability of various regular and irregular shapes for 3D cadastral objects and modern building designs has resulted in a critical need for developing validation rules to ensure data validity and quality.

The land registry in Victoria, Australia, is investigating the technical requirements for implementing a 3D digital cadastre. The study of 3D cadastral data validation requirements has been part of this ongoing investigation. This study is being undertaken in three main phases including 1) developing geometrical validation rules, 2) developing non-geometrical validation rules, 3) implementing an online service to validate 3D cadastral data.

This paper aims to discuss the initial outcomes of the first phase of the aforementioned study which has focused on developing geometrical validation rules for 3D cadastral objects. The paper reviews the development of four geometrical validation rules which have been formalised using mathematical expressions to check the individual 3D parcels and their relationships with adjoining or neighbouring parcels. The first validation rule checks the compatibility of the cancelled parcel against the created parcels. The second rule deals with parcel collision detection which is required for flagging unacceptable intersection of 3D objects. The third rule ensures the faces forming a 3D parcel are flat. The fourth validation rule assures 3D objects are watertight. The paper concludes with a discussion around the impacts of the proposed validation checks on the subdivision process and future research for the Victorian 3D digital cadastre.

1. Introduction

The density of our urban environments is increasing and the lack of available land has led decision makers to think about the proper use of spaces above and below the ground. Cadastral systems deal with these spaces and associated rights, restrictions and responsibilities (RRRs). In recent years, there has been a growing trend towards more efficiently using spaces. However, the current cadastres do not efficiently register and present complex ownership rights in mixed-use and high rise developments (Shojaei et al., 2013; Aien et al., 2015; Ho et al., 2015). Shojaei (2014) has reported some of the main shortcomings of current cadastral systems.

A 3D digital cadastre is expected to facilitate the registration process (Aien et al., 2012), save time and cost, increase transparency in land and property transactions, and improve land use and management (Shojaei, 2014). For example, in a 3D digital cadastre, overlapped spatial units can be validated and geometries can be checked to ensure rights are protected and disputes are minimised.

The State of Victoria has been moving towards a digital cadastre since the introduction of ePlan in this jurisdiction. ePlan is a collaborative program between the Australian land authorities and the surveying industry, in conjunction with ICSM.[1] which aims to replace paper and PDF plans with digital files (Olfat et al., 2016). In 2009, the ICSM endorsed the national ePlan as an agreed conceptual data model of a cadastral survey that meets the needs of the jurisdictions in Australia. In 2011, an ePlan Protocol was developed to map the

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[1] The Intergovernmental Committee on Surveying and Mapping

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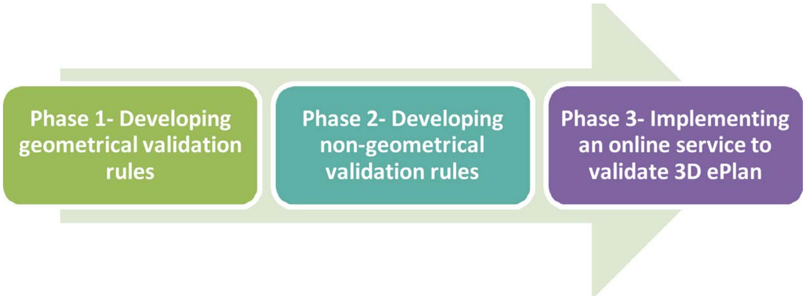

Fig. 1. Phases of 3D cadastral data validation in the Victorian 3D digital cadastre investigation.

components of the ePlan data model to LandXML, a specialised XML data file format containing civil engineering and survey measurement data commonly used in the land development and transportation industries[2]

Following the release of the ICSM's strategy on Cadastre 2034, the ePlan Working Group has started to investigate the requirements for supporting 3D building subdivisions in ePlan. Cadastre 2034 Strategy has a vision to enable people to understand their RRRs related to land and property in a spatially accurate and 3D environment. This vision leads to changes in current subdivisional processes. From the process point of view, 3D data must be available to provide accurate information of the land and property. This often leads to new methods of data collection and sourcing. Having the required 3D data, the analysis and registration will give a better picture of RRRs (ICSM, 2015).

The emphasis is towards achieving a 3D digital cadastral system that enables the community and stakeholders such as councils, referral authorities, real estate agencies, insurance companies, developers, and architects to readily and confidently identify the location and related interests to land and property. The key element of this change is to ensure the efficiency of the cadastral system in Australian jurisdictions. This requires a strong commitment of stakeholders to improve the management and sharing of cadastral information and enhance their systems and infrastructures to enable this change (ICSM, 2015).

To facilitate this commitment in Victoria, Land Use Victoria (LUV) commenced investigating the technical aspect of a 3D digital cadastre in 2014 by looking at various topics including 3D data modelling, storage, validation, and visualisation. In the data modelling study, the LandXML data model was investigated in terms of supporting 3D cadastral objects and the most appropriate modelling approach was identified (Shojaei et al., 2016). In the data storage study, various approaches for storing LandXML files are currently under investigation. As part of the data visualisation study, a 3D visualisation prototype[3] was developed to showcase the concept of 3D cadastre and its benefits (Olfat et al., 2017). The initial outcomes of the 3D data validation study are also discussed in this paper.

Data validation controls the data quality and helps avoiding data issues in the future. It is to ensure the consistency, integrity, correctness and completeness of data (Wagner et al., 2013). Data validation is not a new topic and it has been investigated in different disciplines such as 3D City Models (Kazar et al., 2008, and Wagner et al., 2013), medical image processing (Gerig et al., 2001), and DBMS[4] (Arens et al., 2005). In 3D cadastre, low data quality may cause confusion in interpreting the ownership boundaries which may cause problems during or after property registration (Aien et al., 2014). Therefore, 3D ownership rights must be correct and unambiguous, as an error or ambiguity in data can cause expensive legal disputes (Thompson and van Oosterom, 2014).

In Victoria, there is a 2D ePlan validation service in place which identifies some of the errors and potential problems in plans at an early stage and allows the surveyor to correct or justify them prior to the examination process. This will result in a reduction in the number of refusals and requisitions in the registration process. There are 128 ePlan validation rules supported by this service which cover three main areas of 'survey accuracy (e.g. parcel area, parcel observations closure)', 'survey examination rules (e.g. appropriate title connections)' and 'metadata completeness (e.g. easement purpose)'.

Validation rules for 3D cadastre can be classified into two main categories including non-geometrical and geometrical rules. Non-geometrical rules look at the semantics of 3D objects to support the business of cadastre. For example, the address of a parcel must be correctly captured. Semantic checks are easier to implement compared with geometrical ones. In contrast, geometrical rules look at the geometry of objects. Geometrical validation is more complicated in a 3D cadastral context compared to 2D cadastre due to the variety of possible shapes and geometries in space (Karki et al., 2010). These rules could be classified as internal and external rules. Internal rules assure objects are correctly defined. For example, is the boundary of an object complete and there is no gap? However, external rules assure objects have correct relationships to other neighbouring objects. For example, two 3D objects must not clash.

As part of the 3D cadastral data validation, a study with three phases has been designed and shown in Fig. 1.

As shown in Fig. 1, the first phase deals with developing geometrical validation rules. The second phase is related to the development of non-geometrical (semantic) validation rules and in the third phase, an online service similar to the current Victorian ePlan validation service,[5] will be implemented.

The aim of this paper is to discuss the progress of the first phase of 3D cadastral data validation research in Victoria. The four geometrical rules developed so far in this phase are discussed in detail. More validation rules will be developed during this research. This study has focused on LandXML data format, as the current digital data format in the Victorian digital cadastre project (ePlan). The rest of this paper is organised as follows: Section 2 gives an overview of the validation of 3D cadastral objects. Relevant studies are reviewed in Section 3. In Section 4, the development of four major 3D geometrical validation rules is addressed. Section 5 discusses the impacts of the proposed validation checks on the subdivision process and concludes with a direction for future research.

2. The need for validating 3D cadastral objects

Geometric correctness is a key factor for the quality of a 3D cadastre. Standards should define the measures and outcomes for geometric modelling of 3D objects. ISO (International Organisation for Standardisation) have developed standards for the data quality of spatial data. These standards establish the principles for describing the quality of geographic data and specify components for reporting quality information. They also provide an approach to organising information

[2] www.landxml.org

[3] www.spear.land.vic.gov.au/spear/pages/eplan/3d-digital-cadastre/land-victoria-3d-eplan-prototype.shtml

[4] Data Base Management System

[5] Available at: https://www.spear.land.vic.gov.au/spear/eplanPublicServices/Prepare.do