MOBILE INDOOR LASER SCANNING FOR 3D STRATA REGISTRATION PURPOSES BASED ON INDOORGML

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DEDICATION

ALHAMDULILLAH…..

This thesis is dedicated to ALLAH, my creator and my master, my great teachers and messenger, MOHAMMAD S.A.W who taught us the purpose of life. A special feeling of gratitude to my late beloved parents, HASHIM and JALIAH (may ALLAH bless and grant them). It is also dedicated to my parent in law (may in the grace of ALLAH), who taught me that even the largest task can be accomplished if it is done one step at a time. And special dedicate to my lovely wife, NUR ANIQAH who lead me through the valley of darkness with light of hope and support.

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ABSTRACT

In Malaysia, the current 2D cadastre system is regularly updated by the National Mapping Agency (NMA) and Land Offices (LO). However, this 2D information may not be able to serve complex situations. The 3D strata acquisition and 3D modelling are important for strata title to manage the Right, Restriction and Responsibility (RRRs). This means there is a need for the system to be extended into 3D cadastre environment. One of the data acquisition techniques such as LiDAR from Mobile Laser Scanning (MLS) could be utilised to solve the problem. This research also discusses the 3D geospatial objects generated from the captured point-clouds, modelled in SketchUp and transformed into IndoorGML. In this study, Web application is developed as a platform for generating an integrated XML-IndoorGML schema. Thus, this research contributes on 3D strata modelling especially for the development of 3D strata registration in Malaysia.

ABSTRAK

Di Malaysia, sistem kadaster 2D sentiasa dikemas kini oleh Agensi Pemetaan Negara (NMA) dan Pejabat Tanah (LO). Walaubagaimanapun, maklumat 2D ini mungkin tidak dapat berfungsi dalam situasi yang lebih komplek. Perolehan dan permodelan strata 3D adalah penting bagi hakmilik strata untuk mengurus Hak, Sekatan dan Tanggungjawab (RRR). Ini bermakna keperluan sistem akan diperluas ke persekitaran kadaster 3D. Salah satu teknik untuk menyelesaikan masalah pengambilan data adalah dengan menggunakan LiDAR seperti penggunaan Pengimbasan Laser Mudah Alih (MLS). Kajian ini juga membincangkan objek geospatial 3D dihasilkan dari *point-clouds* yang dicerap, dimodelkan dalam SketchUp dan akhirnya diubah menjadi IndoorGML. Dalam kajian ini, aplikasi web dibangunkan sebagai platform untuk menghasilkan standard XML-IndoorGML secara bersepadu. Oleh itu, kajian ini memberikan impak di masa akan datang kepada pemodelan strata 3D terutamanya dalam pembangunan pendaftaran strata 3D di Malaysia.

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LIST OF ABBREVIATIONS

2D	-	2 Dimension
3D	-	3 Dimension
STA	-	Strata Title Act
BIM	-	Building Information Model
CAD	-	Computer Aided Design
CCD	-	Charge Couple Device
CityGML	-	City Geography Markup Language
COB	-	Commiosiner of Building
COLLADA	-	Collaborative Design Activity
CP	-	Certified Plan
CPSP	-	Certified Proposal Strata Plan
DAT	-	Data file format contains binary or text
E.g/e.g	-	For Example
GIS	-	Geographic Information System
GML	-	Geographic Markup Language
GML3	-	Geographic Markup Language 3
GNSS	-	Global Navigation Satellite System
HDS	-	High-Definition Surveying
HTML	-	Hypertext Markup Language
ID	-	Indentification
IFC	-	Industrial Foundation Classes
IMU	-	Inertial Motion Unit
IndoorGML	-	Indoor Geography Markup Language
ISO	-	International Standard Organization
JIneditor	-	Java Indoor editor
JKPTG	-	Federal Department of Land and Mine / Jabatan Ketua Pengarah Tanah dan Galian Persekutuan

JSON	-	Java Script Object Notation
JUPEM	-	Jabatan Ukur dan Pemetaan Malaysia
KATS	-	Ministry of Water, Land and Natural Resources Malaysia
KML	-	Keyhole Markup Language
LAS	-	Data file format for Laser point-clouds
LiDAR	-	Light Detection and Ranging
LJT	-	Lembaga Jurukur Tanah
LO	-	License Office
LS	-	License Surveyor
MLS	-	Mobile Laser Scanning
NDCDB	-	National Digital Cadastral Database
NLC	-	National Land Code
NMA	-	National Mapping Agnecy
NO	-	Number
NRG	-	Node Relationship Graph
OGC	-	Open Geospatial Consortium
PTG	-	Pejabat Tanah dan Galian
QT Modeler	-	Quick Terrain Modeler
RAW	-	File format for Raw data
RDF	-	Radio Direction Finder
RRRs	-	Righ, Restriction and Responsibility
SKP	-	Data file format from SketchUp software
SiFUS	-	Sijil Formula Unit Syer
TLS	-	Terrestrial Laser Scanning
TOF	-	Time Of Flight
UFI	-	Unique Features Identifier
UI	-	User Interface
UPI	-	Unique Parcel Identifier
VGA	-	Video Graphic Array
VRML	-	Virtual Reality Markup Language
XML	-	Extensible Markup Language

LIST OF SYMBOLS

$\Delta\phi$	-	phase different
f	-	focal length
t	-	time
mm	-	milimeter
cm	-	centimeter
m	-	meter
m^2	-	meter square

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Rapid development of a country created more spaces for industrial and residential buildings land usages. This is indirectly inspiring multilayer building (strata) especially for the development of residential properties such as flat, apartments, condominiums and others. Development of these strata unit is related to strata title plans. This strata title process involves many parties such as Pejabat Tanah Galian (PTG), Surveyors and Jabatan Ukur dan Pemetaan Malaysia (JUPEM). Currently development strata title is done in 3D and to support this process 3D strata registration is proposed for future.

There are various advantages of using 3D strata registration including good accessibility to the legal status of stratified property, digital drawing storage of 3D representation (instead of hard copy in document of title) and access of 3D spatial information through unique parcel identifier of the surface parcel (computerisation instead of manually search for the associated hard copies), and enhancing to include the snapshots of the property from the exterior and interior, or the panorama images.

Strata title is an ownership designed for multi-level apartment blocks and subdivisions with shared areas. As expressed in the National Land Code (1965), the ‘strata’ term refers to building has multiple levels. Strata title was first presented in New South Wales on 1961, to manage with authorised ownership of building apartment blocks.

The urbanization has encouraging to the development and transformation of pattern in property ownership. According to Noh (2012), the demands of high buildings are increasing and they have been built to offer different types of property

tenure other than landed property. The needs for strata title is growing rapidly as the buildings with more than one floor where every floor has many lots are built. It led to the beginning of a new law which is the Strata Titles Act 1985 (STA). Previously, Strata Titles Act 1985 formation of subdivision of the building was provided in the National Land Code (NLC) 1965. There were cons and flaws discovered in the enactment before in relations and terms of technical and also legal requirements. Therefore a new, better and improved legal structure is applied which finally leads to the STA.

STA 1985 is an act to assist the subdivision of buildings in lots or parcels. This act is made of a few applications such as registration, subdivision, and issuance of strata title outline as known as "Strata Title Board". The STA is under the supervision of the Federal Department of Land and Mines (JKPTG) which is under the Ministry of Water, Land and Natural Resources Malaysia (KATS). STA was implemented and enforced starting June, 1985. All types of title applications for the high-rise buildings parcel can be made under the provisions of NLC 1965 before this act was held.

1.2 Problem Statement

The idea of having 3D database for the cadastral system has been discussed and elaborated for a good and efficient management in Malaysia (Hassan, 2017). As reported by Stoter and Oosterom (2006), the 3D development was approach in other domains such as 3D GIS (Geographical Information Systems) and it will make a 3D cadastral realisable. In Malaysia, the current 2D cadastre system is commonly updated by the National Mapping Agency (NMA), i.e. the Department of Survey and Mapping Malaysia (JUPEM). However, this 2D information may not be able to serve complex situations. Thus, there is a need for the system to be extended into 3D cadastre environment.

The authority utilises traditional technique and other existing floor plans for strata modelling. However, the existing technique (i.e. traditional building survey) is

laborious and time consuming for 3D objects modelling purposes. Other than that, it is difficult to get a proper floor plan depending on the building age (old and existing building), developers, local authorities and others. One of the methods is to use Light Detection And Ranging (LiDAR) data to solve the problem.

LiDAR data has been captured and used in various places including in Malaysia. This data has been collected by national and private data providers for various mapping tasks including 3D city modelling, 3D cadastre and strata (Buyuksalih and Bayburt, 2017; Abdul-Rahman, 2016). The data offers several advantages especially its high accuracy despite the high costs and huge data volume. The 3D geospatial objects could be produced from the captured point-clouds and there are many work been initiated by the related agencies for 3D geoinformation. The national mapping agency tries to make use of LiDAR datasets (airborne and terrestrial) for 3D cadastre and recently the authority has deployed indoor laser scanning technique for strata purposes. Therefore, this piece of work suggest to utilise one of the indoor modelling standards, namely IndoorGML for representing 3D indoor features.

IndoorGML has been discussed much at international level. This review includes multi-storey buildings as well as condominiums (Tekavec and Lisec, 2018). With Extensible Markup Language (XML) based data formats (Ilku and Tamas, 2018), this model needs to fit with the existing framework in Malaysia. According to Alattas et al (2018), since XML is a data exchange format which is widely used in the Web, an application with generating database should be developed to support the integrated IndoorGML data.

On the other hand, the indoor laser scanned data could be utilised for 3D strata modelling, thus it forms major experiment in this research. The research also attempts to explore the aspect of accuracy of the generated rooms geometry and intends to briefly incorporate the 3D strata model and 3D strata registration.

1.3 Aim

The aim of the research is to investigate the most appropriate technique for 3D indoor object modelling for 3D strata registration purposes.

1.4 Objectives

To achieve research aim, the following objectives are stated:

(a) To investigate the technology for strata data acquisition.

(b) To develop 3D model for strata purposes.

(c) To suggest a new 3D strata registration framework.

For each objective there are several stages of study have been carried out.

1.5 Research Questions

They are several research questions developed in this study, as listed below.

(a) What are the techniques for indoor data acquisitions?

(b) What are the advantages and disadvantages of the techniques?

(c) How can the data acquisition techniques influence the accuracy?

(d) What is 3D strata and its related object?

(e) How can 3D models be generated, stored and visualised?

(f) What is the current practise on modelling 3D strata within the Malaysian authority?

(g) How can the XML be linked to database?

(h) How to integrate XML with IndoorGML?

1.6 Scope

The scope of study is to cover in terms of data and technology. Thus, there are several important aspects that need to be addressed, as described in the following sections.

1.6.1 Data

This research is focusing on strata modelling that is been provided in JUPEM Head Quarters building in Jalan Semarak, Kuala Lumpur. The data given for level 9 and 10 includes the lift, stairs, floor and room in format *.las and *.raw. Besides that, the as-built plan is also needed as references for data accuracy and errors checking.

1.6.2 Technologies

There are many software that could utilise data downloading, processing and presenting of the 3D strata. Leica Geosystems HDS Cyclone is a software to download and it offers point to cloud operators with the widest set of work process options for 3D laser scanning projects in construction, surveying, architecture, engineering and related applications (Bu and Zhang, 2008). The Cyclone software can let users take benefit of back-sight, traverse, and resection capabilities of the new Leica Scan Station C10 laser scanner for more cost-effective in provide as-built and topographic surveys plan. According to Brenneke and Wagner (2003), some modules could consist of producing a vast array selection of deliverables from the reports to 3D models and maps, animations, movie and light weight 3D data arrangements that can be disseminated freely over the web network. These modules support a wide-range of industries and diligences workflows containing topographic survey, civil engineering, Building Information Model (BIM), as-built 3D models, BIM models and others.

There are two main types of modules that are always used by the user to analyse and process the data such as Cyclone-MODEL and Cyclone-REGISTER. According to the Chang et al (2013), the Cyclone-REGISTER offers with complete set of tools for aligning point-clouds that captured from different scanning positions, accurately and quickly. It also supports the usage of Leica Geosystems HDS targets to geo-reference scan data, as well as it has the capability to make even the overlapping areas of point-clouds – without needing a target or reflector. By decreasing the necessity to place the targets, this results is already in optimum registration, and it offers noteworthy time and also it cuts down the budgets due to low cost (Bu and Zhang, 2008).

While, Cyclone-MODEL has the trade's major most comprehensive and automated set of tools in showing 3D point-clouds as CAD geometry or as engages for surveying, architectural, engineering and other applications that are correlated accurately. Finally, the expertise or professionals can use point-clouds straight processed into objects for vigorous export into CAD (also other applications), and to allow the import of vigorous data from CAD (and other applications) through this multipurpose, versatile and useful module.

Processing software is using SketchUp, formerly known as Google SketchUp, a 3D modelling computer program for a wide-range of illustration applications such as landscape, architectural, mechanical engineering, interior design, film, civil engineering and video game design. SketchUp is also known as a 3D modelling software for generating geometric 3D objects such as scale models, architectural models, interior design items and functional parts.

SketchUp is a program that gives the perfect blend of simplicity and quality: user-friendly interface and easy learning curve. It is available as a freeware version, SketchUp Make while a paid version with extra functionality namely SketchUp Pro. SketchUp is held by Trimble Incorporation which is a surveying, mapping and navigation equipment company. There is an online library of free model assemblies, 3D Warehouse, to which users may contribute models (Xu et al., 2009). It consists of drawing layout functionality which allows surface rendering in variable "styles",

supports third-party "plug-in" applications hosted on a site called Extension Warehouse that offers additional abilities and also allows placement of its models within Google Earth. For point-clouds data the plugin named ‘Undet SketchUp’ need to be used for easy rendering and manipulating the data.

1.7 Significant of the Study

The significant of this study is in order to response to the problem statement which has been stated earlier. Due to the rapid technology on the data collection, it gives more advantages for 3D strata to be covered and more efficient for 3D strata registration. Thus, the standard format for registration especially for 3D indoor will be created.

1.8 Thesis Structure

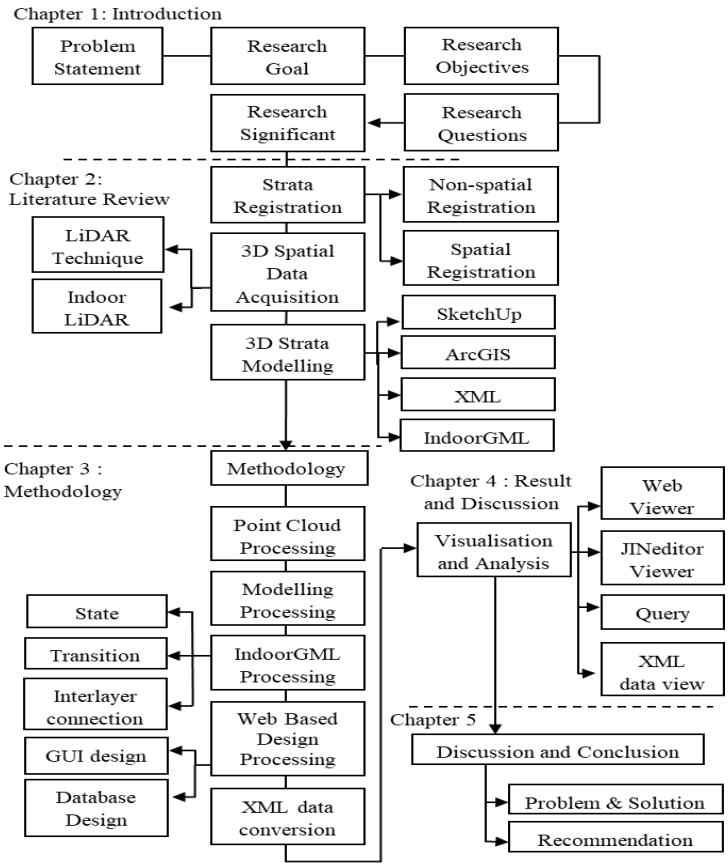

Figure 1.1 Simplified flow of thesis structure

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