Registration of 3D Spatial Objects for 3D Cadastre

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Abstract

This paper presents a research work to develop a 3D land registration system for 3D cadastre objects. In general, current 2D land registration is managed separately by two agencies, i.e. Land Offices (LO) and Department of Survey and Mapping Malaysia (DSMM). Each agency has their own registration system, namely, Computerized Land Registration System (CLRS) and Digital Cadastral Database (DCDB) respectively. Previous research revealed the drawbacks of existing registration system especially on 3D cadastral objects, and obviously this situation has to be tackled if a full 3D registration needs to be realized. This 3D cadastre registration will serve as a first attempt to develop a more complete system. The main idea of the work is to combine the two databases i.e. CLRS and DCDB. The work also aims to enhance current registration system especially for 3D objects e.g. buildings. This paper attempts to elaborate on developed schema for the combine CLRS and DCDB database and focus on the aspect of 3D registration for 3D objects. The design of the registration system will be presented i.e. the conceptual and the logical model. The output from the experiment will be highlighted, i.e. database queries of the 3D objects and incorporated with a simple GUI.

Keywords: 3D cadastre objects, spatial databases and registration system

1.0 INTRODUCTION

In Malaysia, the cadastre system is control by two main entities namely Department of Surveying and Mapping Malaysia (DSMM) and Land Offices (L.O). DSMM is responsible for the registration of cadastral objects i.e. land parcel boundaries. Their mission is to enhance quality in surveying and mapping services along with managing the geospatial. On the other part, land office are responsible for the registration of cadastral objects i.e. land parcel boundaries and legal rights attach to the cadastral objects i.e. land registration respectively. The current system only involve with 2D maps and no effort towards 3D registration yet. Our intention for 3D registration in this research is more towards apartments title i.e. strata title and stratum title. Advance technologies make it possible to communicate different system in single environment system. In this case, there are two system practiced namely CLRS and DCDB. It is good to have interoperability system between these mention system in 3D registration.

A complex system needs a clear and concise method to show the representation of data modeling. It is the same thing happen in cadastre data modeling. Unified modeling language (UML) is a design mechanism that not only involves data modeling but the entire of the system environment. It is now a trend to use UML rather than conventional entity relationship diagram (ERD) which has a decent relationship in GIS data modeling. They are several types or components of UML diagrams namely Class diagram (a data modeling diagramming language), object diagram (class diagram for only one set of objects), use case diagram (use to show the interaction among actors, e.g. customers, employees), sequence diagram (shows an interaction of objects arranged in time sequence), collaboration diagram (shows the object and messages that are passed between those objects in order to perform some functions, statechart diagram (a standard state transition diagrams that shows what states an object can be in and what causes the object to change states), activity diagram (type of a flowchart and represents operation and decision points) and implementation diagram (shows the system components and how they interact and can either show the software or hardware components of the system). In the proceeding section we use UML class diagram to show the 3D cadastre data model.

Section 2 of this paper describes the concept of modeling 3D registration illustrated in unified modeling language (UML). Section 3 discusses the technical part of Oracle database. Here, the geometry data types used to store 3D objects will be shown. The explanation on 3D visualization using Autodesk Map 3D will be describe in section 4. Finally, the conclusion of the current work and future experiment will be remark.

2.0 CORE CADASTRAL DOMAIN MODEL (CCDM)

Core Cadastral Domain Model (CCDM), (van Oosterom et. al 2006) has been introduced as a model for land registration purposes. The development of this model is design as a base for various land registration practice in different countries. Two important goals of this model listed in (van Oosterom et. al 2006) are; (1) avoid reinventing and re-implementing the same functionality over and over again, but provide a extensible basis for efficient and effective cadastral system development based on a model driven architecture (MDA), and (2) enable involved parties, both within one country and between different countries, to communicate based on the shared ontology implied by the model. The UML class diagram of the CCDM is shown in Fig. 1.

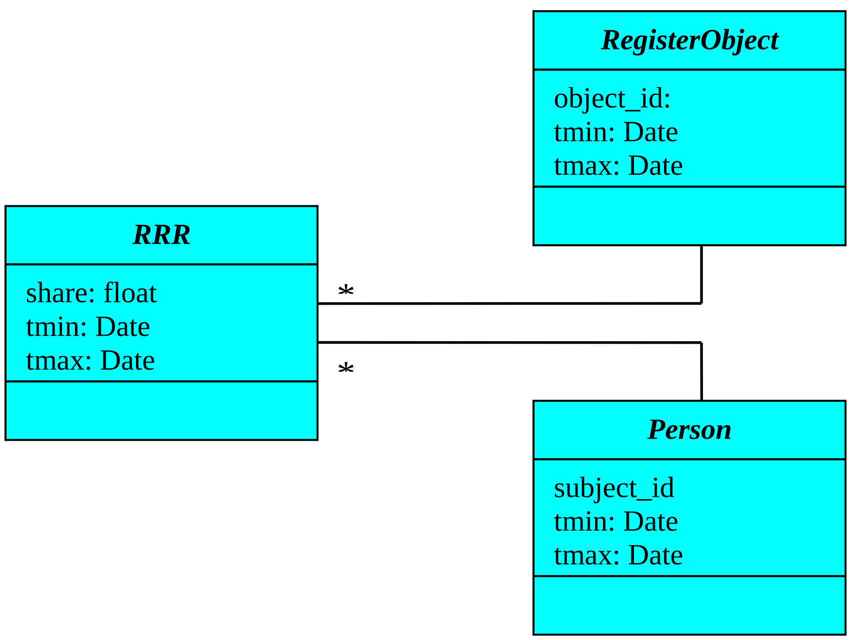

Fig. 1: UML Class Diagram Concept of CCDM: Person, RRR (Right, Restriction, Responsibility) and RegisterObject, (van Oosterom et. al 2006)

CCDM is developed within three classes namely RegisterObject, Person and RRR. Register Object is the real estate/property object while Person is the person or non-natural person who owns the RegisterObject. The RRR is stands for right, restriction and responsibility. The relationship of RegisterObject and Person is bound within the RRR. There is no direct relationship within RegisterObject and Person.

2.1 Malaysian Cadastre Data Model

CCDM is designed as the base for various land registration system. Therefore, it can also used to describe Malaysia cadastre data model. The definition of these three core classes can be derived from (Chong, 2006). Table 1 shows the component of CCDM that follows with the Malaysia Cadastre System. These categories are base from the CCDM classes and reflected in the National Land Code 1965 and Strata Title Act 1985.

Table 1: Component of CCDM base on Malaysian Cadastre System

Persons (NLC: s.43)	• Natural persons (excluding minors less than 18 years old) • Corporations, sovereigns, governments or organisations • Persons authorised to hold land under the Diplomatic and Consular Privileges Ordinance 1957 • Bodies expressly empowered to hold land (e.g. Trade union Ordinance 1957)
RegisterObject	• Lot (land parcel) (NLC: s.516) • Parcel (building parcel) (STA: s.4) • Stratum (underground volume) (NLC: s.92A)
RRR (Right, Restriction and Responsibility)	• Rights (e.g. extent of general disposal under NLC: s.44 • Responsibilities (duty rent – e.g. survey fees, premium, annual quit rent etc.) • Restrictions (e.g. category of land, express and implied condition etc.)

2.2 3D Cadastre Registration Model

Hybrid cadastre proposed by Stoter, 2004 is a good start towards implementation of 3D cadastre in Malaysia. The concept of hybrid cadastre is to preserve the current 2D registration and add the 3D component in the registration system. There are two approaches to register 3D object namely registration of right-volume and registration of 3D physical object. The UML data model of these approaches is illustrated in Fig. 2 and Fig. 3 respectively. The *3Drepresentation* of each approach is embedded in the CCDM base model.

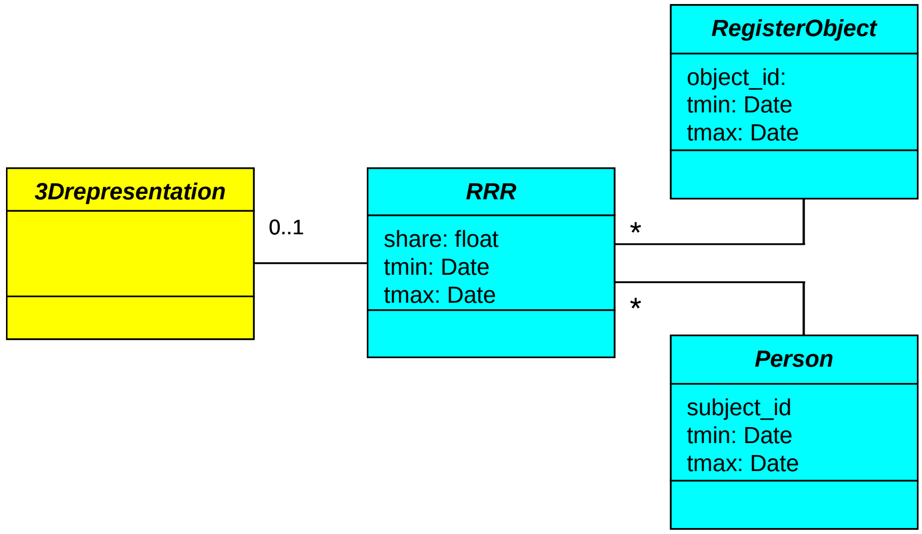

Fig. 2: UML Class Diagram of the Hybrid Cadastre (Right-Volume)
(Stoter, 2004, van Oosterom et. al 2006)

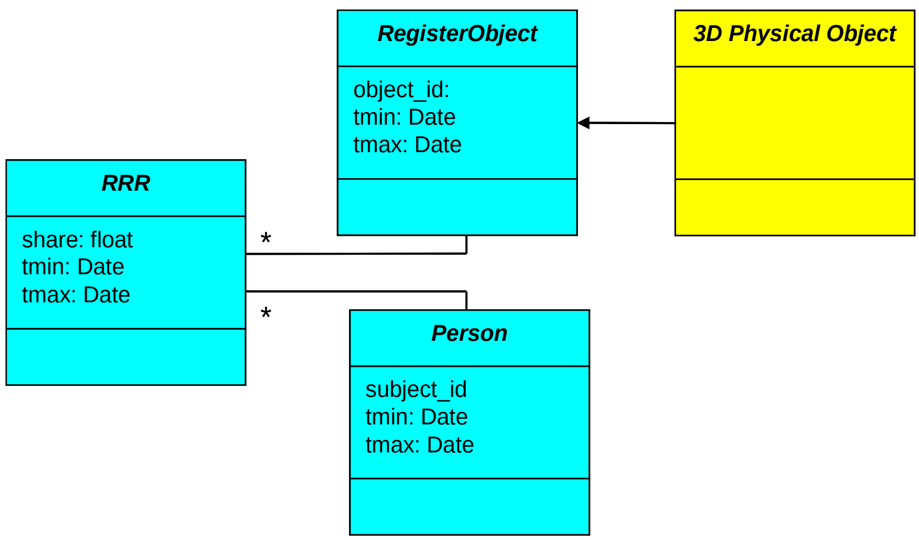

Fig.3: UML Class Diagram of the Hybrid Cadastre (3D Physical Object)
(Stoter, 2004, van Oosterom et. al 2006)

In the implementation phase, the 3D proposed registration model proposed for 3D cadastre is focused on the combination of two different databases. Currently, there are two different databases for cadastre registration namely the land attributes of legal rights and the spatial geo-database i.e. the cadastre object. The interoperability of the system is shown in Fig. 4 where the two databases are combined in single system. The introduction of 3D cadastre object in the registration model is shown in Fig 5.

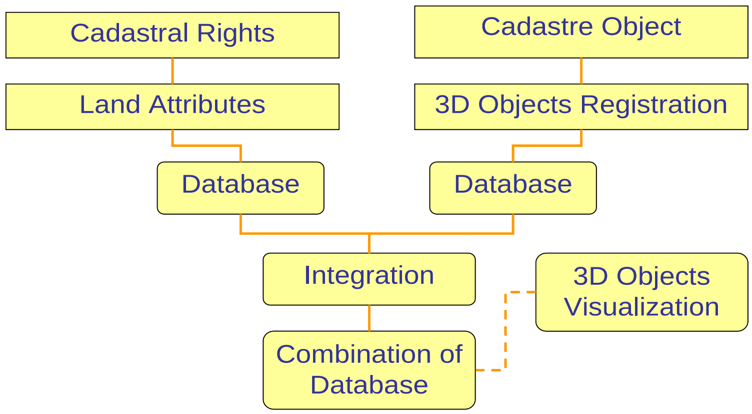

Fig. 4: Integration of Cadastral Registration and Land Registration in a Single Database

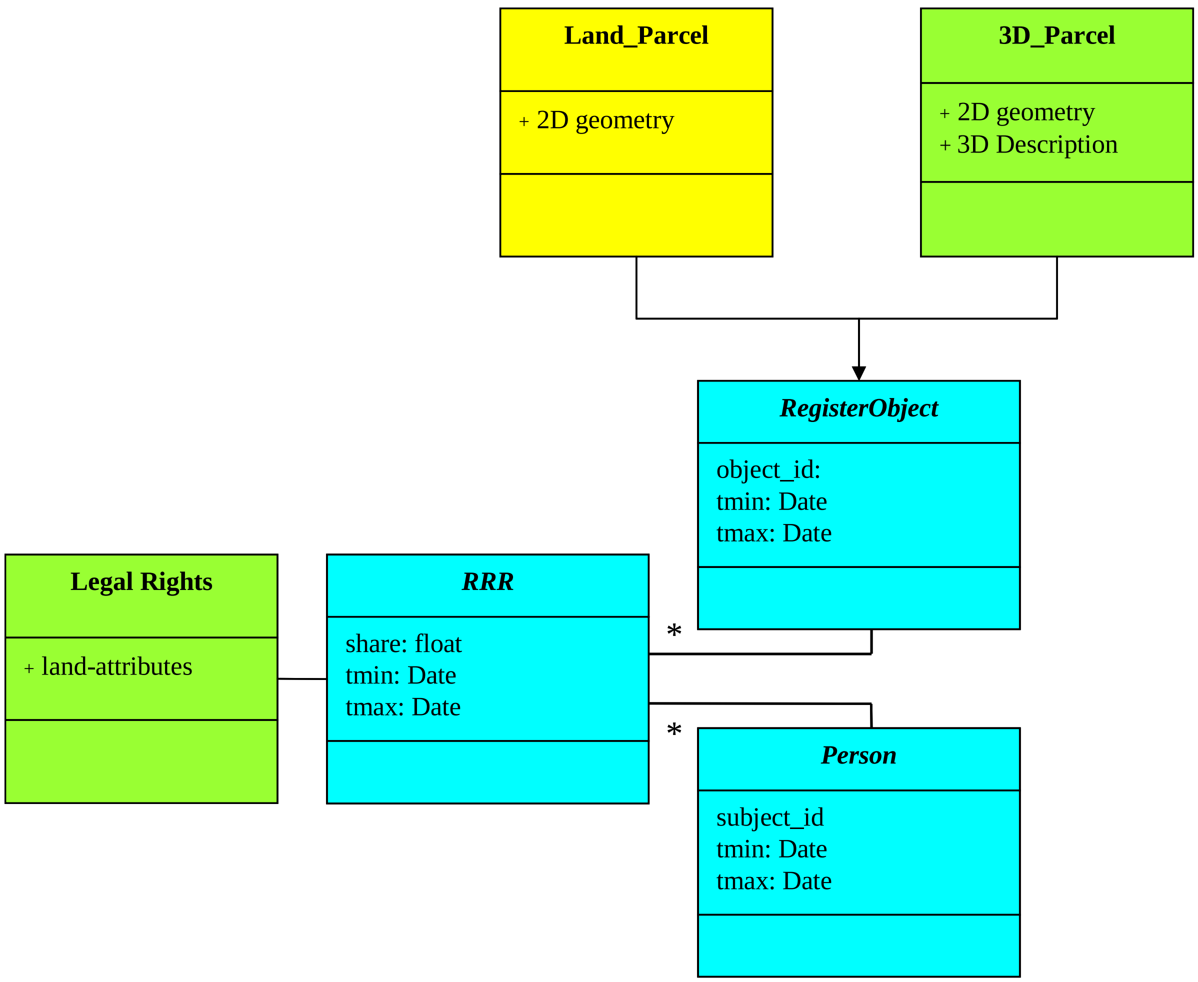

Figure 5: UML Diagram of 3D Cadastre Land Registration Model

3.0 ORACLE SPATIAL

Spatial database is a database system. It offers spatial data type in its data model structure and also in the query language. Structured Query Language (SQL) is a language used to interact with the spatial DBMS. SQL plus is one of the features provided by Oracle to write coding in the database. This coding follows a specific schema and depends on the specific purposes. Basically, there are three components of SQL language namely data definition language (DDL), data management language (DML) and data query. Some of the basic examples of instruction to perform in the database using SQL are; Data Definition Language (DDL), e.g.: create table, alter table and drop table; Data Manipulation Language (DML), e.g.: delete, update, insert, select, commit; and lastly Data Query e.g.: using logical operators; and, or, not.

Oracle spatial has functions and procedures to perform with spatial data. It helps to store, access and analyze spatial data in the Oracle database. This is done using a SQL schema to interact with the database. Some of the features provided in the oracle spatial schema are as follows:

- A schema (MDSYS) that supported the geometric data types
- Has spatial indexing mechanism
- Have operators, functions and procedures to perform spatial analysis operations
- Can work with data of nodes, edges and faces in topology data model
- Has network data model
- Can work with geo-raster data features
- Oracle spatial support object-relational model for representing geometries
- Store the geometry for vector data type in SDO-GEOMETRY.

Geometry that describes a spatial object is stored as an object in the oracle spatial in form of single rows and in a column calls SDO_GEOMETRY and in a user-define table. The component of SDO_GEOMETRY object type is shown in Table 2. Each of the SDO_GEOMETRY columns needs to be accompanied with additional column in the database with information of the unique primary key. Commonly, these tables are calls spatial table or spatial geometry tables.

Table 2: Data Type of Geometry of SDO_GEOMETRY in Oracle Spatial

Data Type	**Remarks**
SDO_GTYPE	Indicate types of geometry. The value is in 4 digits in the format of dltt. d means number of dimensions (2,3 or 4). l specifies which dimension (3 or 4) contains the measure value for the linear referencing system. tt identifies the geometry type. e.g.: SDO_GTYPE value 3003 indicates three-dimensional polygon.
SDO_SRID	It is used to identify a coordinate system (spatial reference system) that associated with the geometry.
SDO_POINT	Defined using the SDO_POINT_TYPE object type which has the attributes of X,Y and Z.
SDO_ELEM_INFO	This attribute indicates how to store coordinates in the SDO_ORDINATES attribute.
SDO_STARTING_OFFSET	The offset of SDO_ORDINATES

SDO_ETYPE	Indicate type of elements
SDO_INTREPRETATION	Interpret SDO_ETYPE
SDO_ORDINATES	Stores array of coordinates to make up the spatial object

3.2 Registration Of 3D Cadastre Objects with Oracle Spatial

The process to register 3D cadastre objects in oracle spatial involve with two main processes as follows.

(A) Organization of Spatial Datasets in Oracle Spatial

- Create geometry table in the Oracle Spatial database
- Load spatial datasets i.e. cadastre data of apartments (strata title plan)
- Update metadata of the geometry table
- Create index for spatial database

(B) 3D Visualization

- Setup connection within Oracle Spatial and Autodesk Map 3D
- Import geometry table into the Autodesk Map 3D
- Display the 3D cadastre object

The 3D objects register in this experiment is base on polyhedron type. It is made up from several flat faces that enclose a volume (Arens, 2003). The structure of polyhedron storage is shown in figure 6.

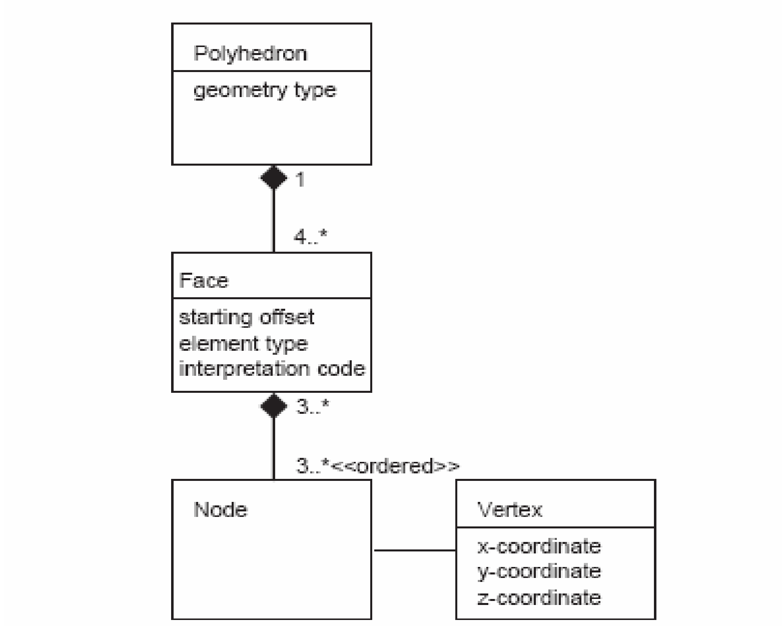

Fig. 6: UML Class Diagram Describing Polyhedron

3D object registration of polygon (faces)

In order to store spatial data in the database, spatial geometry data table needs to be created as illustrated in Fig. 7.

```
--@c:\face.sql;
--sqlldr a/a face.ctl
LOAD DATA INFILE *
INTO TABLE face
REPLACE
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"'
TRAILING NULLCOLS
  (
     entityid,
     geometry COLUMN OBJECT
     (
          SDO_GTYPE INTEGER EXTERNAL,
          SDO_SRID INTEGER EXTERNAL,
          null_pt FILLER CHAR,
          SDO_POINT COLUMN OBJECT  NULLIF geometry.null_pt="pt"
          (
            X INTEGER EXTERNAL,
            Y INTEGER EXTERNAL,
            Z INTEGER EXTERNAL
          ),
          SDO_ELEM_INFO VARRAY terminated by ';'
          (elements FLOAT EXTERNAL),
          SDO_ORDINATES VARRAY terminated by ':'
          (ordinates FLOAT EXTERNAL)
     )

   )
```

Fig. 7: Creating Spatial Geometry Table in the Oracle Spatial

Spatial table metadata is then updated and index is created as shown in Fig 8.

```
insert into user_sdo_geom_metadata values
('face', 'geometry', mdsys.sdo_dim_array(
mdsys.sdo_dim_element('X', -100, 500, 0.5),
mdsys.sdo_dim_element('Y', -100, 500, 0.5),
mdsys.sdo_dim_element('Z', -100, 300, 0.5)
),NULL);

drop index face_I;

create index face_I on face(geometry) indextype is mdsys.spatial_index
parameters('sdo_indx_dims=3');
```

Fig. 8: Updating Geometry Metadata and Creating Index in Oracle Spatial

4.0 3D VISUALIZATION WITH AUTODESK MAP 3D

Oracle spatial only stores information of spatial data in the geometry table. Each of the dataset can be retrieved from the database using the *entityid* given for each face as in Fig. 9. Oracle spatial has capabilities to view the geometry only in 2D. In order to view the geometry in 3D, other visualization supporting software is needed e.g. Autodesk Map 3D. The integration of Oracle Spatial and Autodesk Map 3D follows with a specific schema.

```
SQL> select entityid, geometry from face where entityid=2;

  ENTITYID
----------
GEOMETRY(SDO_GTYPE, SDO_SRID, SDO_POINT(X, Y, Z), SDO_ELEM_INFO, SDO_ORDINATES)
--------------------------------------------------------------------------------
         2
SDO_GEOMETRY(3003, NULL, NULL, SDO_ELEM_INFO_ARRAY(1, 1003, 1), SDO_ORDINATE_ARR
AY(0, 32.72, 12, 0, 32.72, 9, 0, 27.52, 9, 0, 27.52, 12, 0, 32.72, 12))

SQL> |
```

Fig. 9: Spatial Data Retrieve in the Face Table

Autodesk Map 3D has the capability to connect with Oracle database. Fig. 10 and Fig. 11 illustrate the result of the connection of the two systems (i.e. Autodesk Map 3D and Oracle Spatial). The final output of the 3D visualization wire-frame and rendering image of 3D cadastre objects is shown in Fig. 12(a) and 12(b) respectively.

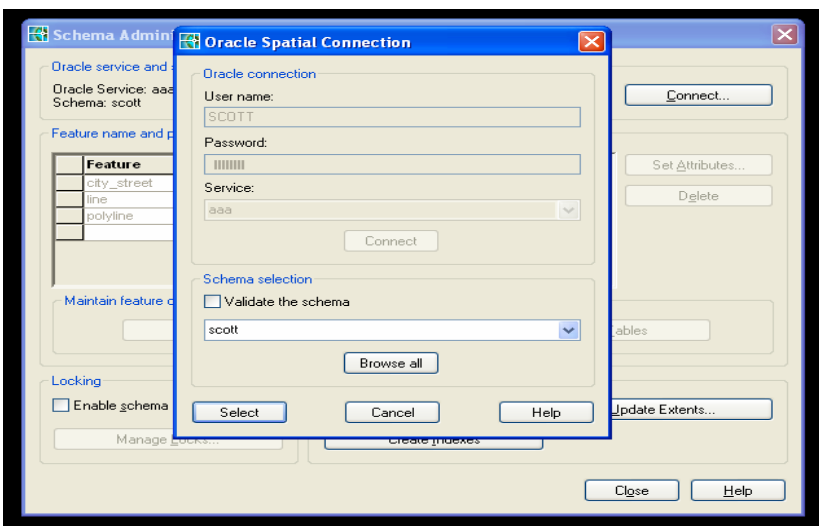

Fig. 10: Oracle Spatial Connection with Autodesk Map 3D

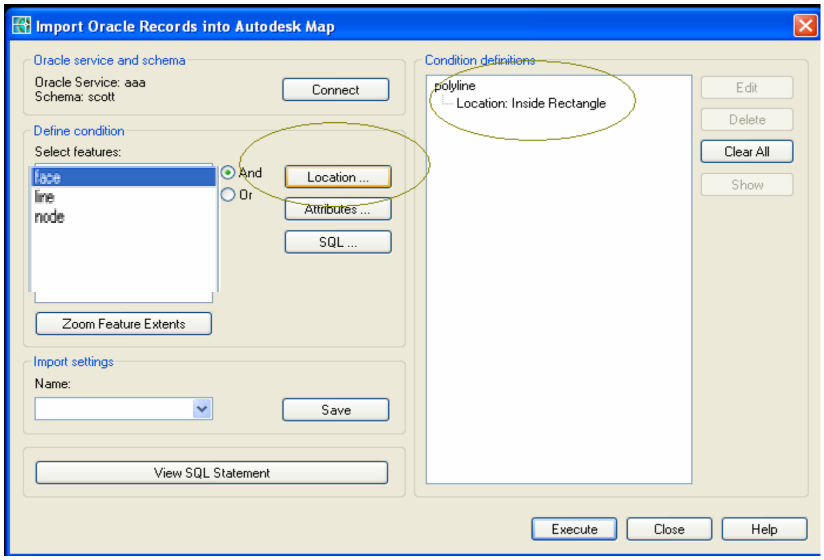

Fig. 11: Oracle Records imported in the Autodesk Map 3D

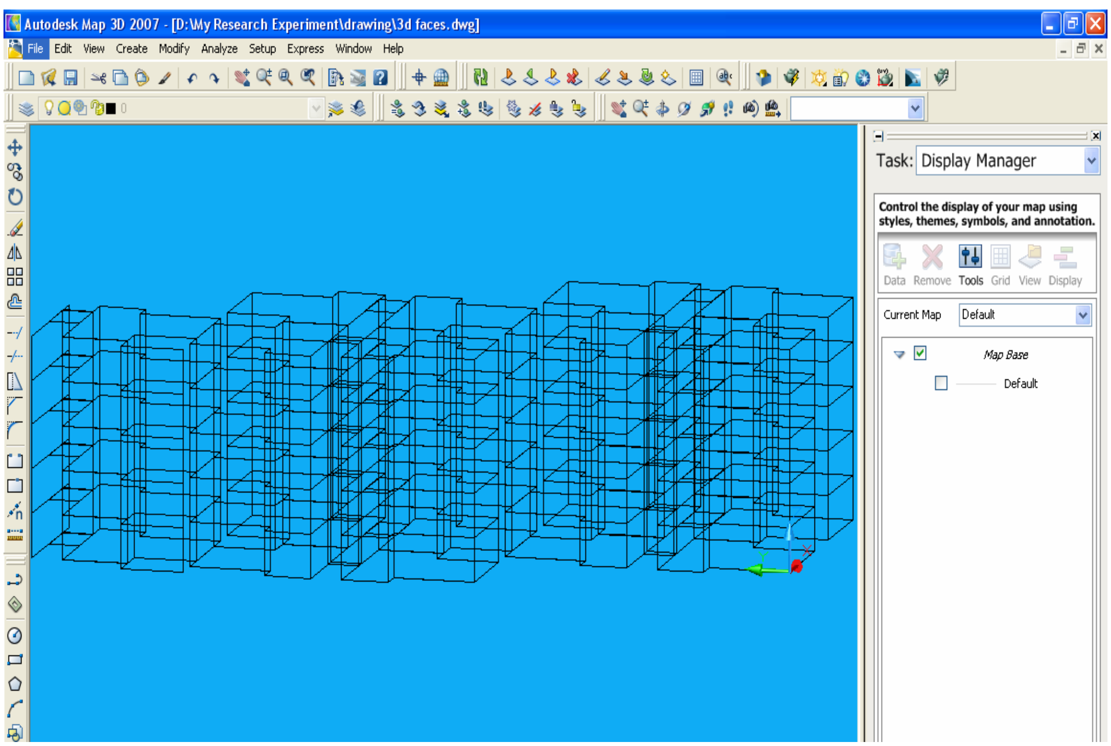

Fig. 12(a): 3D Wire-frame Visualization of 3D Cadastre Object

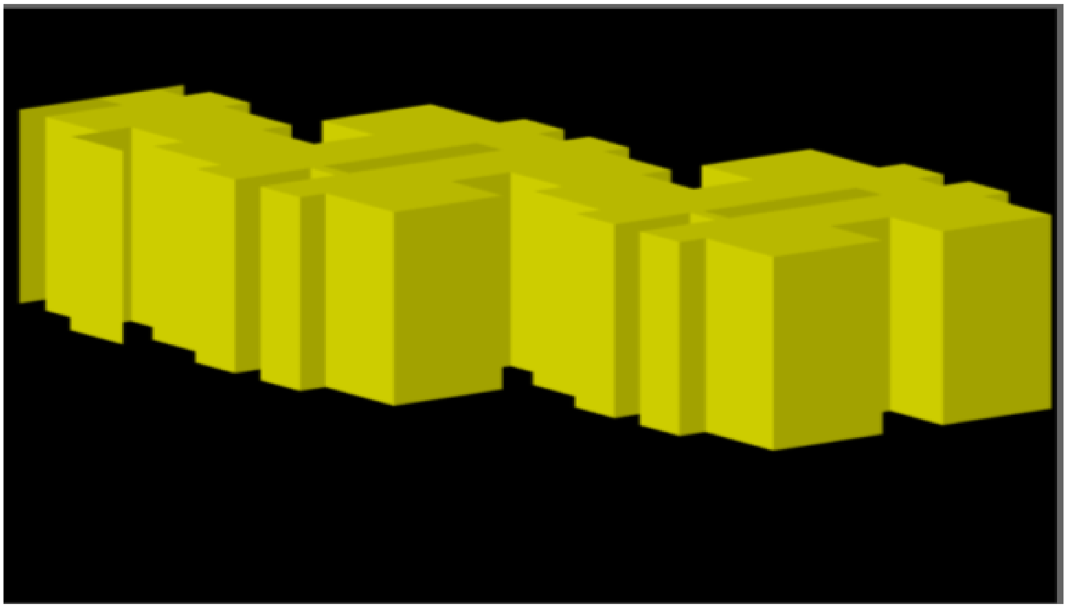

Fig. 12(b): Rendering View of 3D Cadastre Objects

5.0 CONCLUDING REMARKS AND FUTURE WORKS

The 3D cadastre land registration model introduce in this paper is basically expanded from the CCDM model. Three main classes in CCDM namely *RegisterObject, Person and RRR* have been transformed to suit with Malaysian cadastre system. In the proposed registration model, new class namely *3D parcel* has been derived from *RegisterObject* to hold 3D objects. The *3D parcel* spatial is bound within 2D geometry and 3D description. In the experiment, Oracle Spatial was used to store the cadastre dataset i.e. 3D parcel using the existing data type i.e. *SDO_Geometry*. The 3D objects are presented as a polyhedron type. It is made within sets of faces that enclose to form a 3D object. The visualization of the 3D cadastre objects is shown in the Autodesk Map 3D. The experiments in this paper only focus on the spatial component. In the near future, we hope to work on spatial query on the 3D parcel.

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