A LADM-based 3D underground utility data model: a case study of Singapore

Dr. Jingya YAN
Postdoctoral Researcher
Jingya.yan@arch.etzh.ch

LADM Workshop 2019
02 Oct. 2019

Team

FUTURE CITIES LAB (SEC):
Prof. Dr. Gerhard Schmitt, Principal Investigator
Prof. Dr. Andreas Wieser, Co – Principal Investigator
Rob van Son – Project Coordinator
Dr. Jaw Siow Wei – Researcher
Dr. Yan Jingya – Researcher

SINGAPORE LAND AUTHORITY (SLA):
Dr. Victor KHO, Senior Deputy Director
Richard LOO, Executive Surveyor
Sandy TEO, Executive Surveyor
Dr. Kean Huat SOON, Principal Surveyor

STADT ZÜRICH:
Dr. Gerhard Schrotter, Project Advisor

DIGITAL
UNDERGROUND
Underground Utility in Land Administration-- Background

- **Good standards, guidelines and practices** for underground utility mapping are key enablers for ensuring data quality.

- City of Zürich (GeoZ): a consolidated map of underground utilities

- UK begins to the registry of underground utilities and creates a national underground assets mapping platform in 2018

- **LADM:** a flexible conceptual schema from three main aspects: organizations, rights and spatial in formations.
Land administration in Singapore

- A Singapore-based LADM model: 2014
- Management of cadastral data of land parcels, cadastral survey data and land administration data.
- The Singapore profile inherit LADM objects, attributes and relationships.
- SG_Lot is inherited from LA_SpatialUnit to describe cadastral information of land parcel.
Underground Utility for Land administration in Singapore

Tasks and business processes depending on reliable information

- Land valuation
- Land acquisition & purchase
- Assessment of encumbrances
- Land transfer & sales
- Land rejuvenation
- Planning & coordination
- Interim land use
- Location and removal of encumbrances
- Provision of information
- Interim use planning
- Evaluation of proposals for underground development

State Land

Lifecycle

Current issues:

- The existing data sources: hardcopy, 2D CAD and geospatial format
- As built or as-designed data
- Lack of information and unreliable
3D Underground Utility Data Model – Geometry

- **Utility Networks** is inherited from **LA_LegalSpaceUtilityNetwork**.
- The class **Utility Network Node (2D)**, **Utility Network Segment (2D)** and **Utility Network Surface (3D)** are components of **Utility Network**.
- Integration of 2D and 3D geometric information
3D Underground Utility Data Model – Land Administration

- Aim to support ownership management of utilities and land administration management.
- Connection of LADM and utility network
- Integration of underground objects with attributes from Singapore LADM, a Singapore-based LADM model customized specific for local use.
3D Underground Utility Mapping: Workflow of Case Study

Data Capture

Data Processing

produce

New collected data

Data Integration

Existing data

Data Storage

Application
Data Source: The Existing 2D Data

- The existing 2D utility data
- The 2D cadastre data
Large Scale Underground Utility Mapping: Technology

• The Pegasus: Stream mobile mapping platform
• A Stream EM GPR
• Leica Pegasus Two photo and laser scanner

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall weight</td>
<td>228 kg (500 lbs)</td>
</tr>
<tr>
<td>Max. acquisition speed</td>
<td>15 kph (9mph)</td>
</tr>
<tr>
<td>Power consumption</td>
<td>72W</td>
</tr>
<tr>
<td>Positioning</td>
<td>Survey wheel and/or GPS or Total Station</td>
</tr>
<tr>
<td>Scan Rate per Channel (@512 samples/scan)</td>
<td>87 scans/sec</td>
</tr>
<tr>
<td>Scan Interval</td>
<td>17 scans/m @ 200 MHz</td>
</tr>
<tr>
<td></td>
<td>33 scans/m @ 600 MHz</td>
</tr>
<tr>
<td>Antenna Footprint</td>
<td>Width 1.84m</td>
</tr>
<tr>
<td>Number of Channel</td>
<td>38</td>
</tr>
<tr>
<td>Antenna Central Frequencies</td>
<td>200 MHz (34 channels)</td>
</tr>
<tr>
<td></td>
<td>600 MHz (4 channels)</td>
</tr>
<tr>
<td>Antenna Spacing</td>
<td>6cm</td>
</tr>
<tr>
<td>Antenna Polarization</td>
<td>Horizontal (HH) and Vertical (VV)</td>
</tr>
</tbody>
</table>
Large Scale Underground Utility Mapping: Study Area

- 9 study areas
- The Stream EM cover width: 1.75m
- Lane width: 3.2m+
- A single lane: 2 scan track
- Toa Payoh:
  - 1.8km
  - 4 lanes
  - 5-6 hours

<table>
<thead>
<tr>
<th>Scanning Location</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canberra</td>
<td>October 22, 2018</td>
</tr>
<tr>
<td>University Town, NUS</td>
<td>October 23, 2018</td>
</tr>
<tr>
<td>Punggol</td>
<td>October 24, 2018</td>
</tr>
<tr>
<td>Sengkang</td>
<td>October 24, 2018</td>
</tr>
<tr>
<td>Woodlands Spectrum</td>
<td>October 25, 2018</td>
</tr>
<tr>
<td>Toa Payoh</td>
<td>October 26, 2018</td>
</tr>
<tr>
<td>Ang Mo Kio</td>
<td>October 26, 2018</td>
</tr>
<tr>
<td>Marina Boulevard</td>
<td>October 28, 2018</td>
</tr>
<tr>
<td>Raffles Boulevard</td>
<td>October 28, 2018</td>
</tr>
</tbody>
</table>
Newly collected GPR data

radagram

CAD

GIS
Identification

Overlay of GPR and the existing data

• Line 1: No matching existing record
• Line 2: The maximum distance < 0.5 m
• Line 3: The distance < 0.3 m
• Intersect, and the maximum distance 1m.
• 30 out of 109 detected utility segments were identified
Implementation -- Querying

- Connection of land parcels and utilities through spatial relationships: contains.
Implementation -- Visualisation
Conclusion

• To develop a study case to organise 3D underground utility data for land administration.

• The relationship of underground utilities and surface is very **important** in the land administration.

• Current significant issue: lack of **accurate and reliable** underground information.

• **Integration** of GPR data and the existing data.

• How to use the existing data?

• How to integrate the existing and new collected data?

• How to integrate different newly collected data?

• We need **3D cadastre** to support underground utility in land administration.
THANK YOU

Jingya Yan, Kean Huat Soon, Siow Wei Jaw and Gerhard Schrotter: A LADM-based 3D Underground Utility Data Model: A Case Study of Singapore

https://digitalunderground.sg/