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Surveying the world of tomorrow - From digitalisation to augmented reality

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Review of the 3D Modelling Algorithms and Crowdsourcing Techniques - An Assessment of their Potential for 3D Cadastre

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Introduction

- Current research trends:
  - Integration of the 3rd D / 4D Cadastre,
  - Adoption of automation
  - Low-cost but reliable procedures
  - Use of VGI procedures
  - Usage of modern IT tools and m-services for cadastral data acquisition

- VGI geo-data-future
- Internet-based automated photogrammetric solutions, for the 3D world

Crowd and each one of internet-users may be defined as a potential neo-photogrammetrists (Leberl, 2010).
I. Acquisition of 3D Information
     → huge potential in fulfilling the requirements of CityGML LOD1

II. Acquisition of complete 3D Models
     ✓ user generated 3D models
     ✓ user must have a certain level of 3D modelling skills
3D Real World VGI Applications (2/2)

III. Creation of 3D Models

- 3DVIA (Virtual Earth) and Building Maker (Google Earth) (2007)
  - Oblique images
  - Birds-eye images
  - User without 3D modelling skills
- Free-to-use 3D object repositories (Archive3D7, Shapeways8 etc.)
- OSM-3D, OSM Buildings, Glosm, OSM2World, KOSMOS Worldflier etc.

2D vectors + crowdsourced images $\rightarrow$ 3D Building Reconstruction
Data Capturing

- **Tools** → laser meters, terrestrial and/or aerial imagery, GPS or even terrestrial laser scanning
  
  - ✔ Included in modern smartphones **multi-sensor-system**
  - ✔ **In the Future...** barometers, stereo cameras such as Kinect

- images from sharing sites and social networks such as Flickr, Instagram, Panoramio, Picasa, Pinterest

- **3D Modelling Software** :
  
  - ✔ **Commercial** (Agisoft)
  - ✔ **Free-to-use** → low-cost alternative (Autodesk, 123D Catch or My3DScanner)
3D Reconstruction Methods

Input Data:
- Aerial and terrestrial imagery
- Lidar Data (point cloud / DSM)

A-priori known building shape?

Data-driven Approaches (Non-Parametric Methods)

Model-driven Approaches (Parametric Methods)

Hybrid Methods

Very Dense Point Cloud
**Data-driven Approaches (Non-Parametric Methods)**

- **Plan Fitting Methods**
  - Ransac algorithms
  - Least Square Planar Fitting

- **Filtering & Thresholding Methods**
  - Canny Edge Detector
  - Steger Edge Detector
  - Line Segment Detector

- **Supervised Classification Methods**
  - Region Growing-based algorithms
  - 3D Hough transform
  - Ransac algorithms
  - Scan Line Segmentation
  - etc.

- **Segmentation-based Methods**

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Model-driven Approaches (Parametric Methods)

- Lsystems
- Shape Grammars
- Formal Grammars
- Split Grammars
  - Attributed Building Grammars
  - Computer Generated Architecture (CGA) Grammar
  - etc.
VGI AS A DATA SOURCE FOR 3D RECONSTRUCTION

- VGI approach to photogrammetry poses additional challenges
- Modern software → deal with difficulties: ✓ unknown and varying focal length, ✓ lighting changes, and ✓ incompatible images

BUT common problems remain

- Main issues: ▪ incomplete models
  ▪ repetitive structures and symmetries → gross errors
  ▪ models are not geo-referenced with appropriate accuracy

- Solution: ✓ small data clusters
  ✓ reconstruction of each cluster
  ✓ digital cameras, consumer-grade single-frequency GNSS → Coarse Absolute Orientation
**Model-driven Methods:**
- robust
- high computing speed
- cost effective
- topologically correct model output
- less sensitive to noise
- no need for specific 3D modelling skills
- prior information about building shape
- Limited model library

**Data-driven Methods:**
- no need any prior knowledge about building structure
- flexible
- textured models
- very dense point cloud
- high computational cost
- sensitive to noise
- require specific 3D modelling skills
- Topological errors

**VGI data – Main Error**

**Occlusions**

**3D Cadastre - Key Element**

**Volumes** of buildings – preserve property rights

**Best fitted solution - Model-Driven Methods**
Proposed Framework – Preliminary 3D Cadastre (1/2)

- Provision of the orthophoto with the areas under cadastral survey
- Demarcation of property boundaries by the right holders at real time on the basemap

Existence of ground plans?
- YES → Selection of property’s footprint
- NO → Digitizing a polygon - Mobile application

Help needed?
- Provided either by volunteers or by professionals
- Demonstration videos of the mobile/web applications by NCMA

- Declaration of rights- Submission of supporting documents - Web application
- Compilation of preliminary 2D crowdsourced cadastral maps, by right holders
Proposed Framework – Preliminary 3D Cadastre (2/2)

- **3D BUILDING MODELS – 3D CADASTRE**
  - Insertion and storage of 3D models into a cadastral platform – **Web application**
  - Creation of 3D building model → Model-Driven Approach (Parametric modelling) – **Mobile application**
    - Insertion of **additional information**: building height, ridge type, images.
    - **3D Parametric reconstruction** of the building
    - **Texture needed?** if YES → Texture mapping using collected images

- **Compilation of preliminary crowdsourced 3D building models by right holders**

**Help needed?**
- Provided either by volunteers or by professionals
- Demonstration videos of the mobile/web applications by NCMA
In-house developed application on Android (1/3)

- **Self-developed open-sourced** Mobile Application
  - 3D cadastral data acquisition
  - 3D visualization of real properties (LoD1)

- **Software tools:**
  - Visual Studio 2013 – IDE
  - ArcGIS Runtime SDK for .NET (100.0.0)
  - Xamarin.Android
  - JDK 8, Oracle
  - ArcGIS Online Server
  - Programming Language C#

- **Test Device:**
  - (i) API level 19,
  - (ii) Screen dimensions 5.25in
In-house developed application on Android (2/3)

Floor: 4  
Height: 3m

Parametric Modelling - 3D property Models
In-house developed application on Android (3/3)

- Determination of (1) property
  - Floor: 0
  - Height: 3m

- Determination of (1) property
  - Floor: 1
  - Height: 3m

- Determination of (3) properties
  - (i) Floor: 0
  - Height: 3m
  - (ii) Floor: 2
  - Height: 3m
  - (iii) Floor: 4
  - Height: 3m
CONCLUSIONS

A cost effective solution is required for the initial implementation of a FFP 3D Cadastre

- Advantages:
  - Transparency
  - Citizens’ participation - decisive role of property owners
  - Management of complex areas – multiple levels of rights
  - Cost effective and less time consuming solution
  - Guaranteed protection of properties
  - Reliability
  - Simplification of the procedures – no need for specific 3D modelling skills
  - Improvement of spatial planning and infrastructure development
Thank you for your attention!