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FIG WORKING WEEK 2017
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From digitalisation to augmented reality

National Technical University Of Athens
School of Rural and Surveying Engineering

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).

3D Real World VGI Applications (1/2)

I. Acquisition of 3D Information

- *OpenStreetMaps* (2004)

→***huge potential*** in fulfilling the requirements of CityGML LOD1

II. Acquisition of complete 3D Models

- *Google 3D Warehouse (2006)*

✓ 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

  → Model kit

  ✓ 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 → 3D Building Reconstruction

Data Capturing

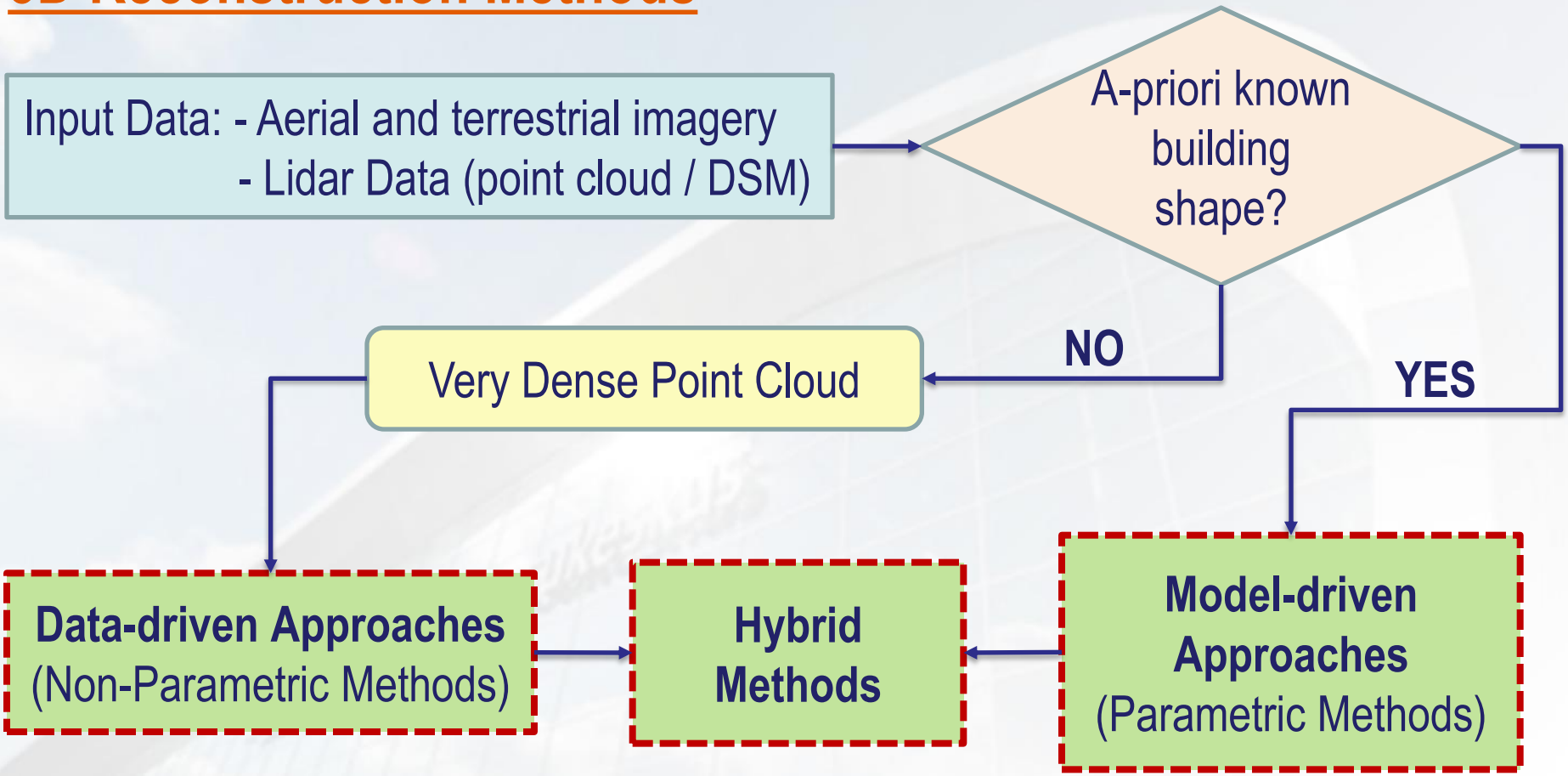
- **Tools** → laser meters, terrestrial and/or aerial imagery, GPS or even terrestrial laser scanning

  - ✓ Included in modern smartphones **multi-sensor-system**
  - ✓ **In the Future…**barometers, stereo cameras such as Kinect

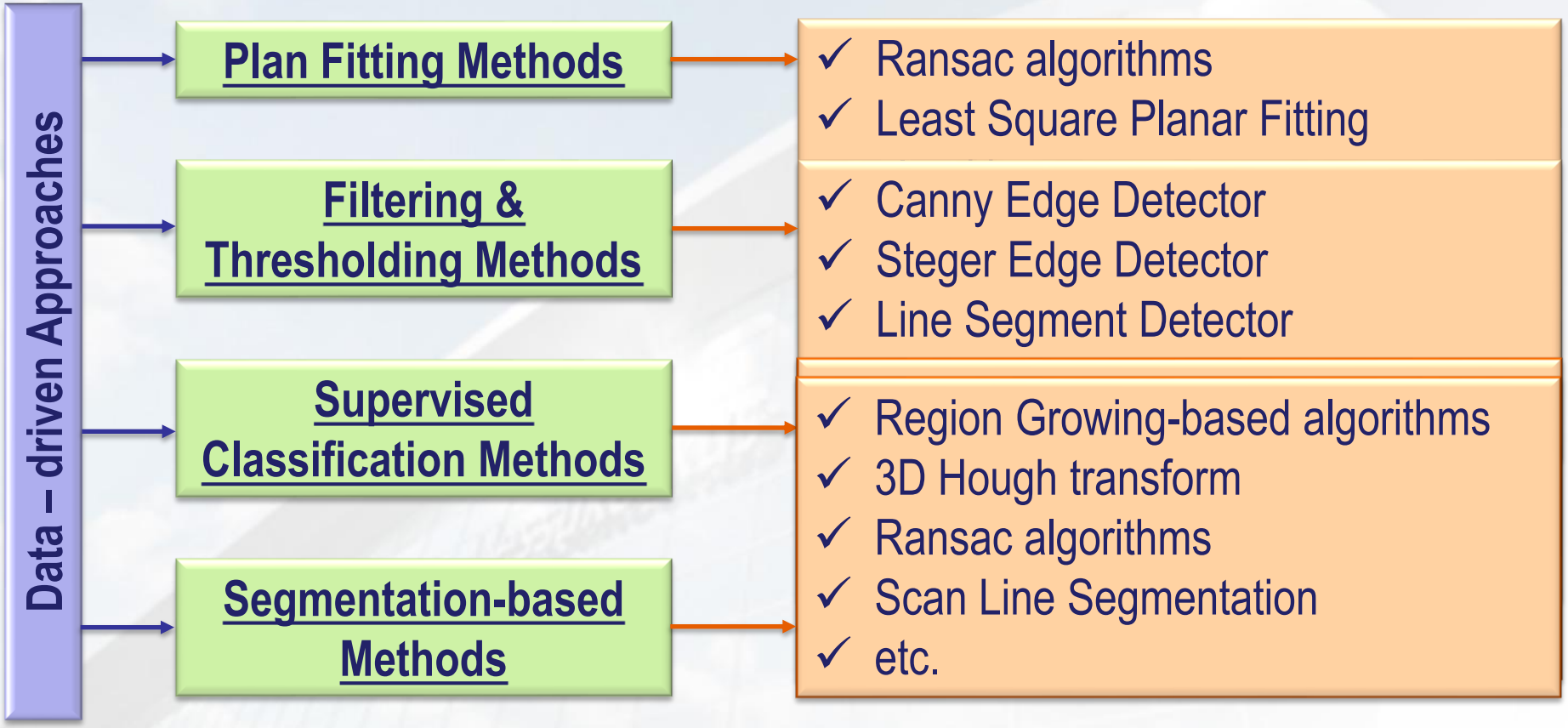
  → images from sharing sites and social networks such as Flickr, Instagram, Panoramio, Picasa, Pinterest

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

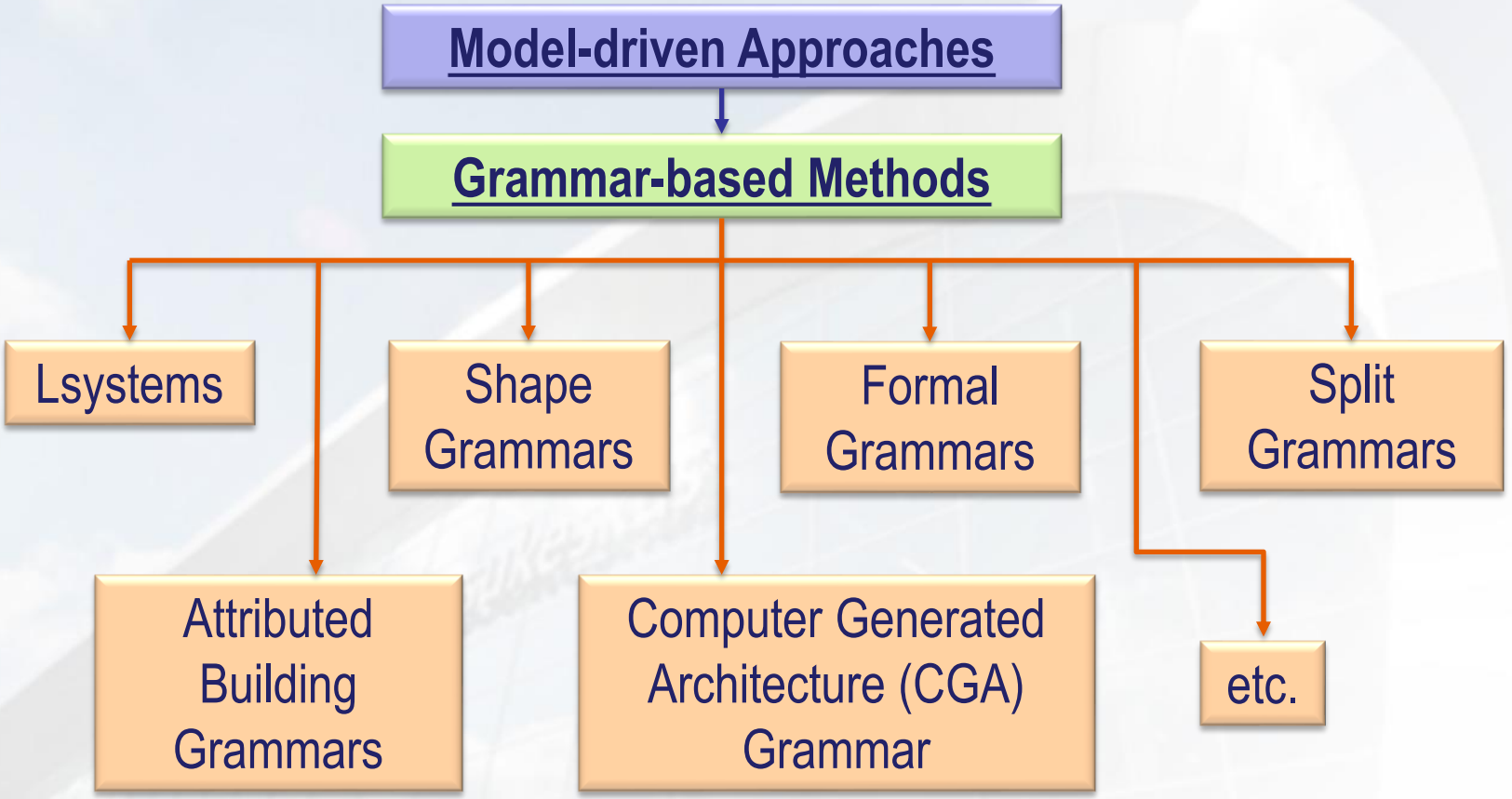
3D Reconstruction Methods



Data-driven Approaches (Non-Parametric Methods)



Model-driven Approaches (Parametric Methods)



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**

ASSESMENT OF CURRENT TECHNIQUES AND ALGORITHMS

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
- ✓ hight 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**

- Declaration of rights- Submission of supporting documents - **Web application**
- Compilation of **preliminary 2D crowdsourced cadastral maps,** by right holders

Help needed?

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

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

Help needed?

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

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

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

Parametric Modelling

(i) Floor : 0 Height : 3m

(ii) Floor : 2 Height : 3m

(iii) Floor : 4 Height : 3m

3D property Models

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
  usage of modern low-cost IT tools and m-services
- ✓ 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!