Digital twin of the environment with laser scanning

Contents

- What is digital twin? And laser scanning?
- How to collect laser scanning data
- Combining and processing data
- Applications

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Digital twin

- Digital replica of a living or non-living physical entity
  - Based on real data
  - Can be refined using new data

- Laser scanning
  - Tool for collecting 3D data of the environment

Laser scanning

- Technique for measuring 3D data
- Active ranging using laser
  - LiDAR: Light Detection And Ranging
- Scanner controls the measuring beam
  - Short laser pulses or continuous wave
  - Receiver logs the incoming signal
- Range determined based on time-of-flight or phase difference

https://www.d3ds.net/3d-laser-scanning

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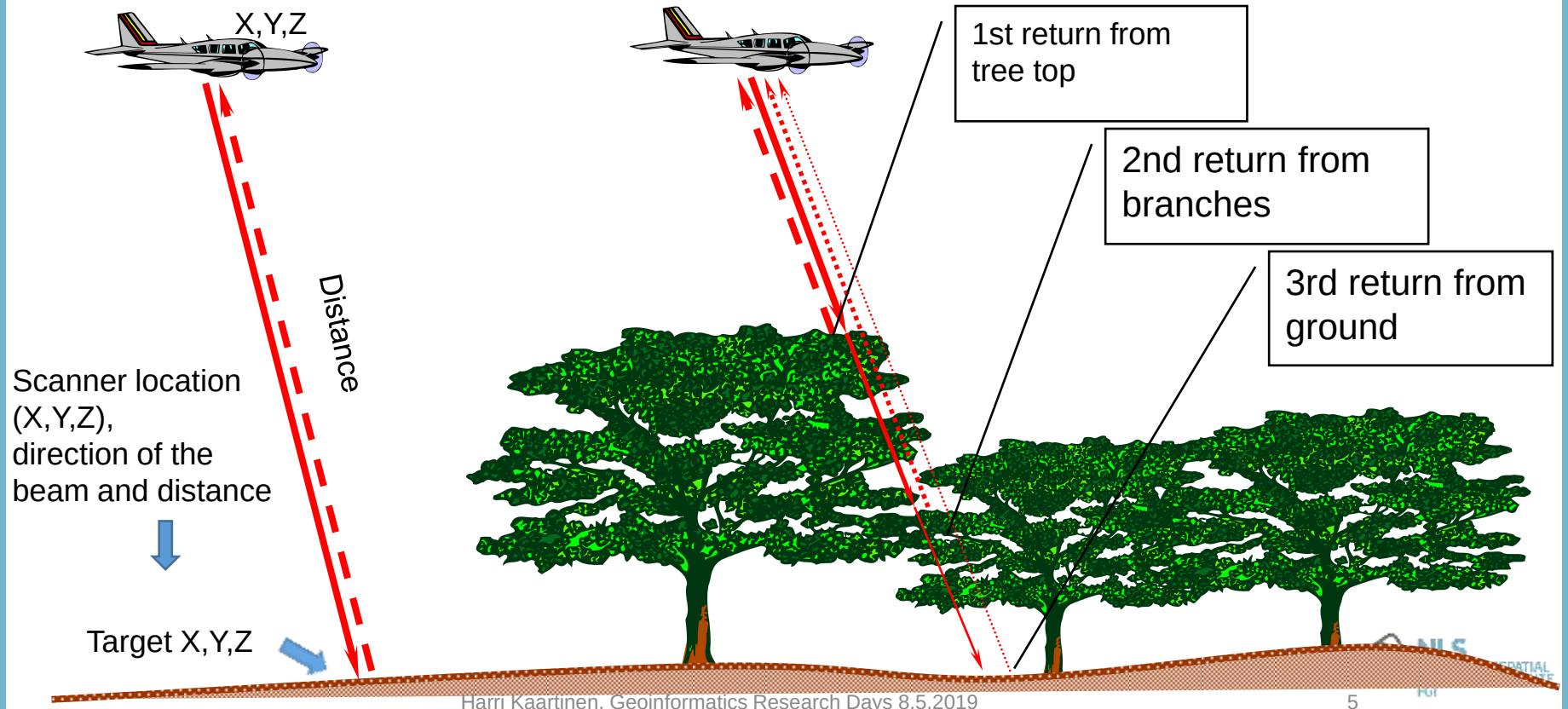
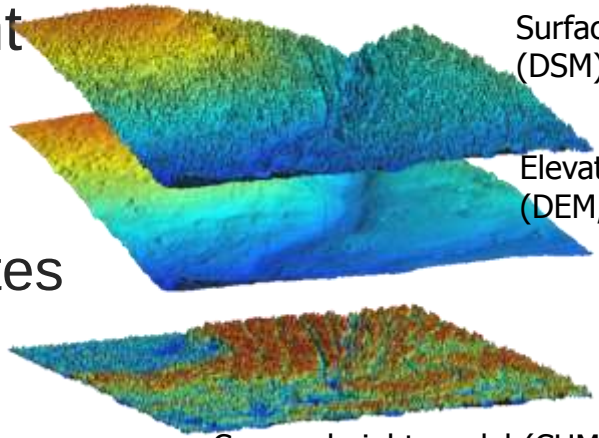

X,Y,Z
Distance
Scanner location (X,Y,Z), direction of the beam and distance
Target X,Y,Z
1st return from tree top
2nd return from branches
3rd return from ground

Laser scanning

- Laser scanning produces point clouds
  - Object as 3D points
  - Points may have other attributes
    - Timestamp, intensity, reflectance, color value…



Surface model (DSM)

Elevation model (DEM, DTM)

Canopy height model (CHM), Normalized surface model (nDSM)

c. St-Onge

National point clouds

- National airborne laser scanning is part of topocrafic database production
  - 2008-2019, point density 0.5 pts / m^2
- Second round starts 2020
  - Cycle 6 years, except Northern Lapland 12 years
  - Point density 5 pts / m^2
  - Syncronized with aerial photography

National ALS 2008-2018

Point clouds

Point cloud can also be collected with

- Terrestrial laser scanning TLS
- Mobile laser scanning MLS
- Drone laser scanning and imaging
- Portable SLAM systems
- Autonomous vehicles
- Stereophotogrammetry, depth cameras, SAR

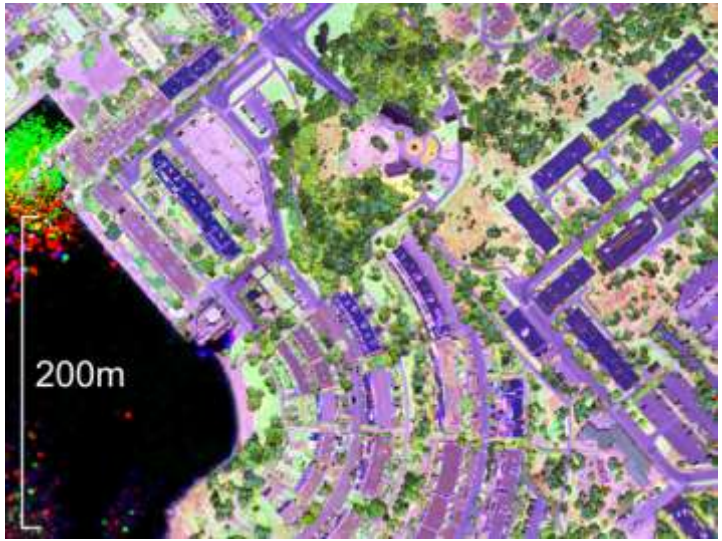
Airborne laser scanning

- Typical point density 0.5-20 pts / m^2
- In addition to XYZ information interpretation of returned laser signal
  - Single channel intensity, multispectral, full waveform
- With single-photon technique point densities 10-100 times higher

Airborne laser scanning

Multispectral laser scanning

- Object scanned with several wavelengths
- Ambient light independent ”color imaging”
- Land cover classification accuracy 96%



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Airborne laser scanning

Single-photon, Harris Geiger

- Flying altitude up to 11 km, point measurement frequency 200 Mill./ sec.
- Scanning Finland with 8 pts./m^2
  - ”Normal” ALS 109 days
  - Geiger 6,5 days

Mobile laser scanning

Multi-platform MLS

- Vehicle based
- Portable systems

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Mobile laser scanning

Mobile laser scanning

Data collected by (autonomous) vehicles

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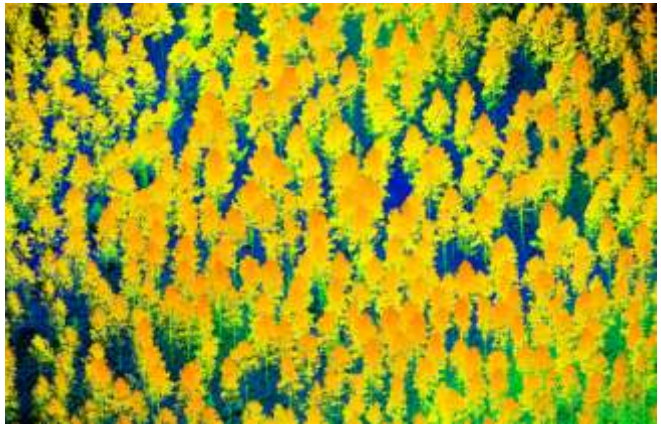
Drone laser scanning and imaging

- Detailed mapping of single objects or smaller areas



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SLAM systems

SLAM: Simultaneous Localization And Mapping

- Light-weight portable systems
- Especially for indoor mapping

How to combine point clouds

- ALS, MLS and drone point clouds are typically georeferenced using GNSS-IMU data
- TLS data is often and SLAM data always in system's own coordinate system
- Data combined using known or common features
  - For example ICP (Iterative Closest Point), planes, lines or 3D forms

How to combine point clouds

- Point density varies especially in TLS and MLS data
- Algorithms for intelligent sparcification may be needed
  - Less terabytes, homogenious point density

How to combine point clouds

Utilization of multisource data

- Attribute and meta data information
  - Date
  - Accuracy and sensor information
  - Spectral information
- Semantic point clouds
  - Every point has an attribute of what object it represents (building, spruce, traffic sign…)

Applications for dense point clouds

Examples

- Detailed elevation models
- Land cover classification
- Detailed mapping of built environment
  - Buildings, corridor mapping
- Single tree level mapping
- Change detection

National dense point cloud

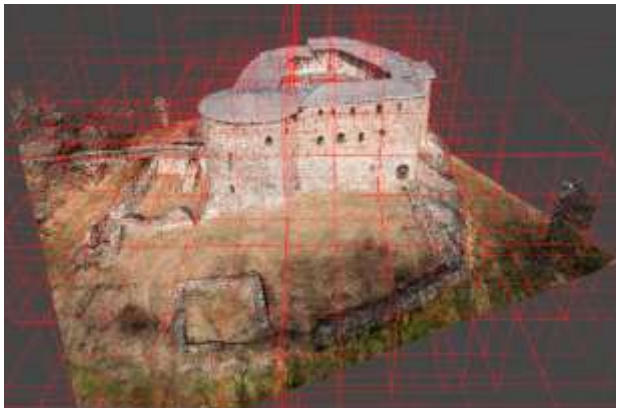
Possibilities

- Savings
  - Increased automation
  - Avoiding overlapping actions
- New business opportunities for companies

National dense point cloud

Challenges (reseach topics):

- Automated feature extraction
- Managing multisource data
- Data amounts and point densities
- Data distribution
- Data visualization
  - Skip modeling, use point cloud?



What about the digital twin?

Once you have a digital replica of your object, study site etc.

- You have a digital twin of one time frame
- If you wish to refine it with new data
  - Acquire new time series for change detection
  - Use various sensors and link data to your 3D replica

More information

Academy of Finland Strategic Research Council project COMBAT/Pointcloud
www.pointcloud.fi

Academy of Finland Centre of Excellence in Laser Scanning Research
www.laserscanning.fi