Laserscanning

- A Technological Challenge

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Agenda

- Introduction to this research
- The different theories behind
- Why is it a challenge?
- Automatic building reconstruction
- What are the perspectives?

Introduction

- Centre for 3D GeoInformation started in 2001
- Identified laserscanning (lidar) as an important technology from the beginning
- Use DSM and DTM produced from laserscanning to model buildings automatically
- Partnered with surveyors to invest in ground laser scanner in 2003
- Will continue to do research within the field of laserscanning - New projects coming!

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Theories behind!

- Lidar - LIght Detection And Ranging
  - NIR - Near infrared area of the em spectrum
  - Much shorter wavelenght than radar
    - from 700 nm to 1500 nm
    - Possible to measure same size object as λ
- In economic surveying we differ between two applications
  - Airborne Lidar
  - Ground-based Lidar

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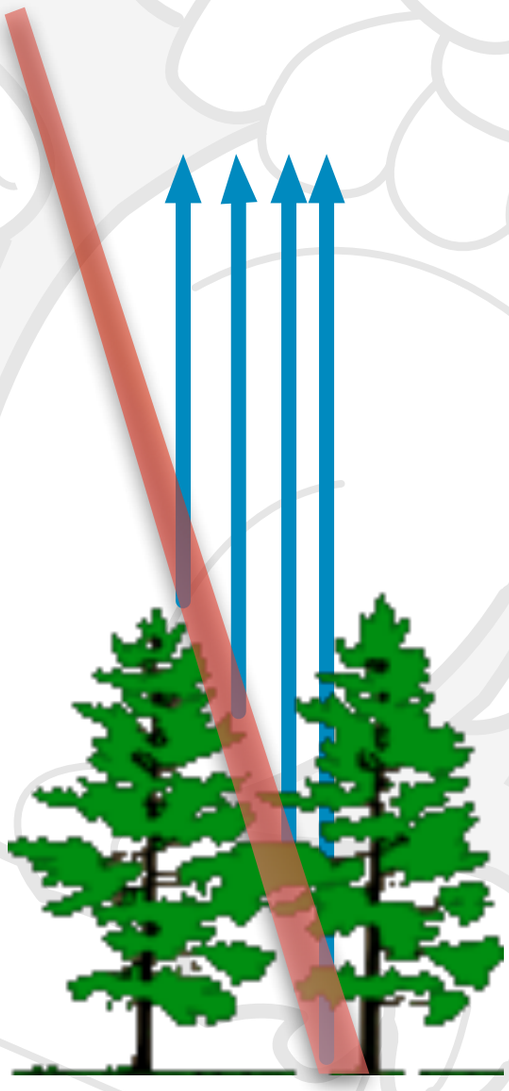
Physics

- Semiconductor laser
  - Most common Nd:YAG = neodymium-doped yttrium aluminium garnet, Nd:$Y_3Al_5O_{12}$
  - Laser light is re-directed through a set of mirrors (deflection) towards a target
  - Range is measured through the reflection of the pulse sent from the laser
  - Typical measurement is time of travel for a micropulse
  - Due to divergence in the laserbeam, there can be multiple returns

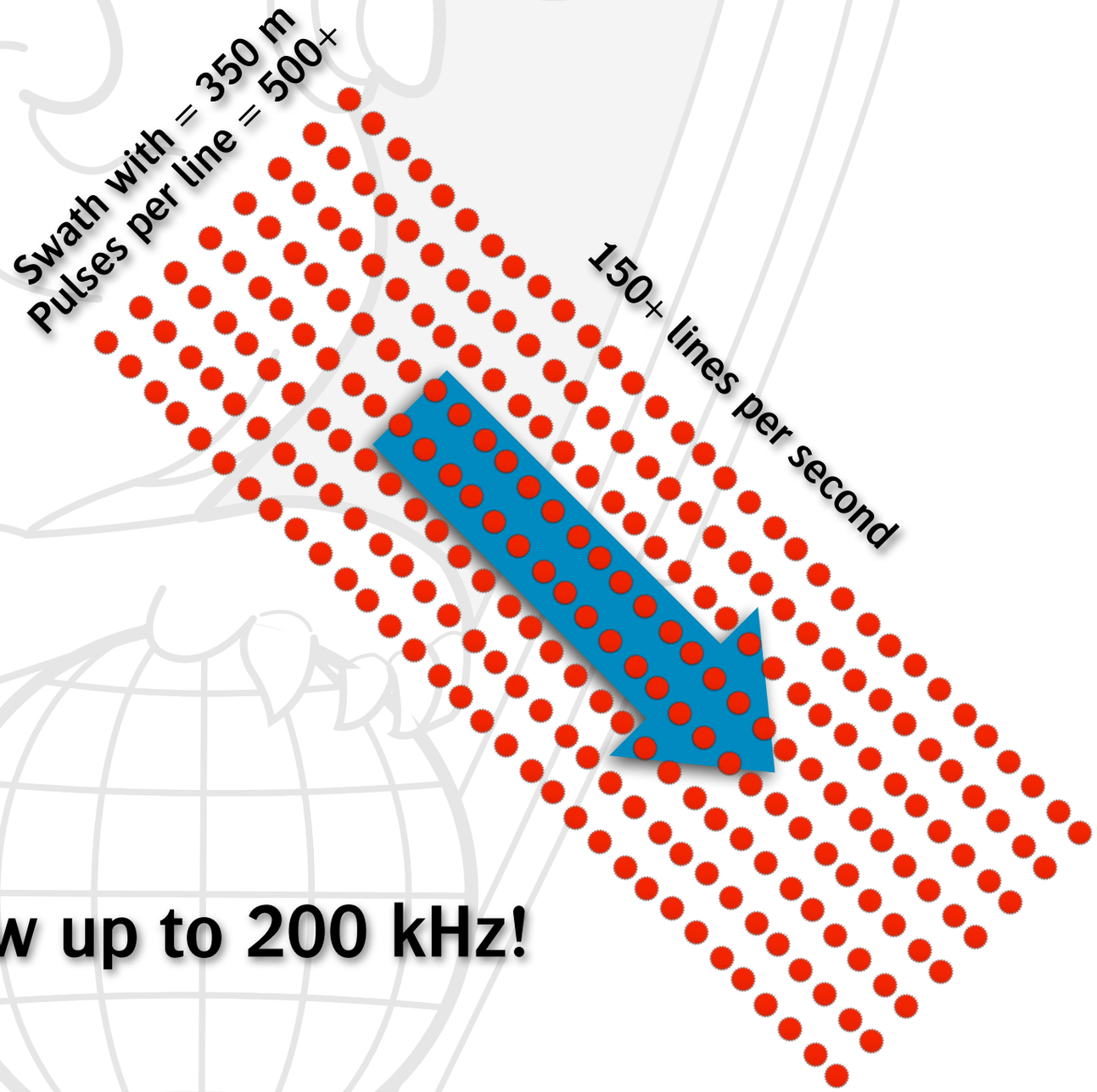
Airborne Lidar

Multiple returns



Flight path

(Depending on swath angle, flight height and speed)



Now up to 200 kHz!

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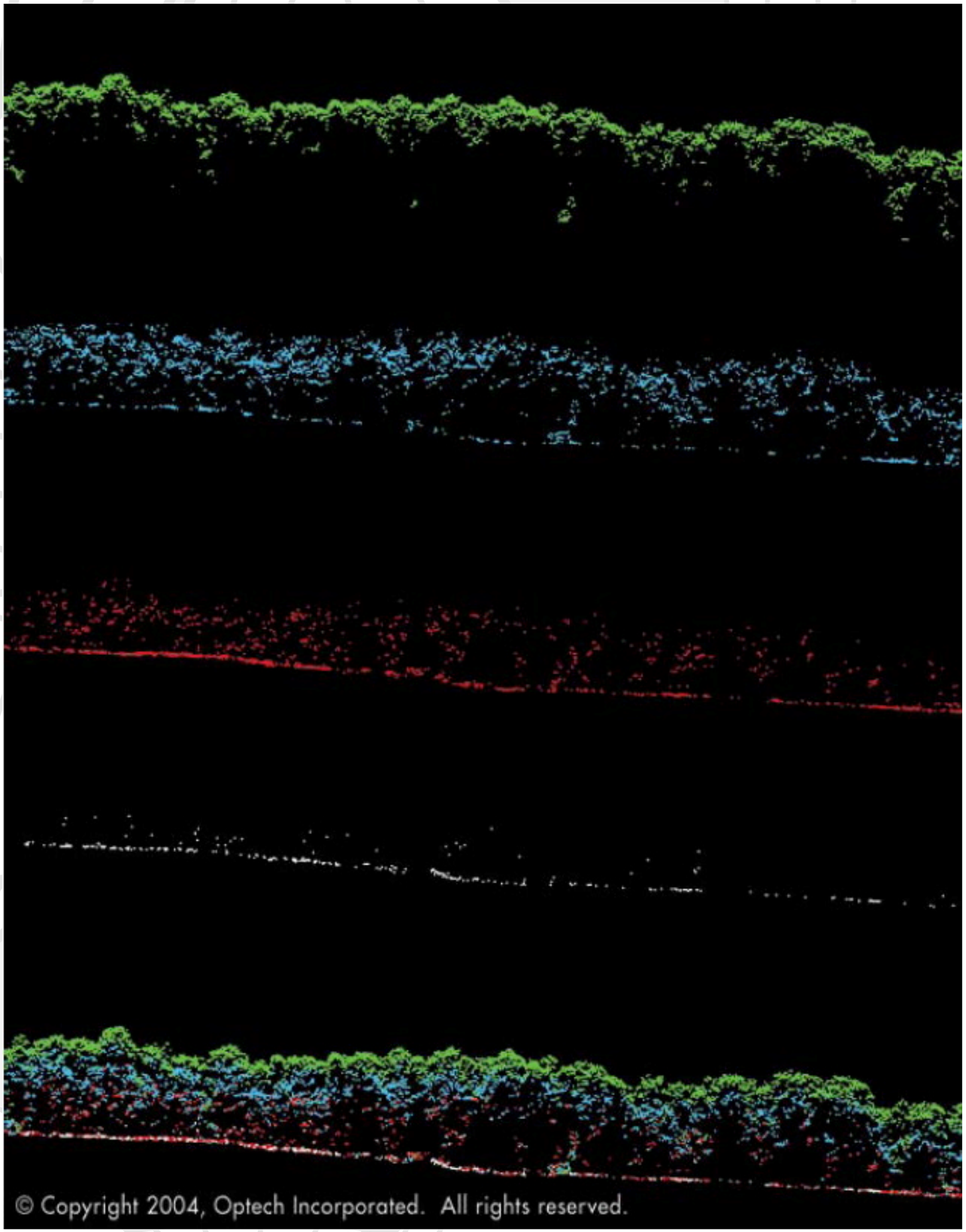
First hit

Second hit

Third hit

Fourth hit

All hits



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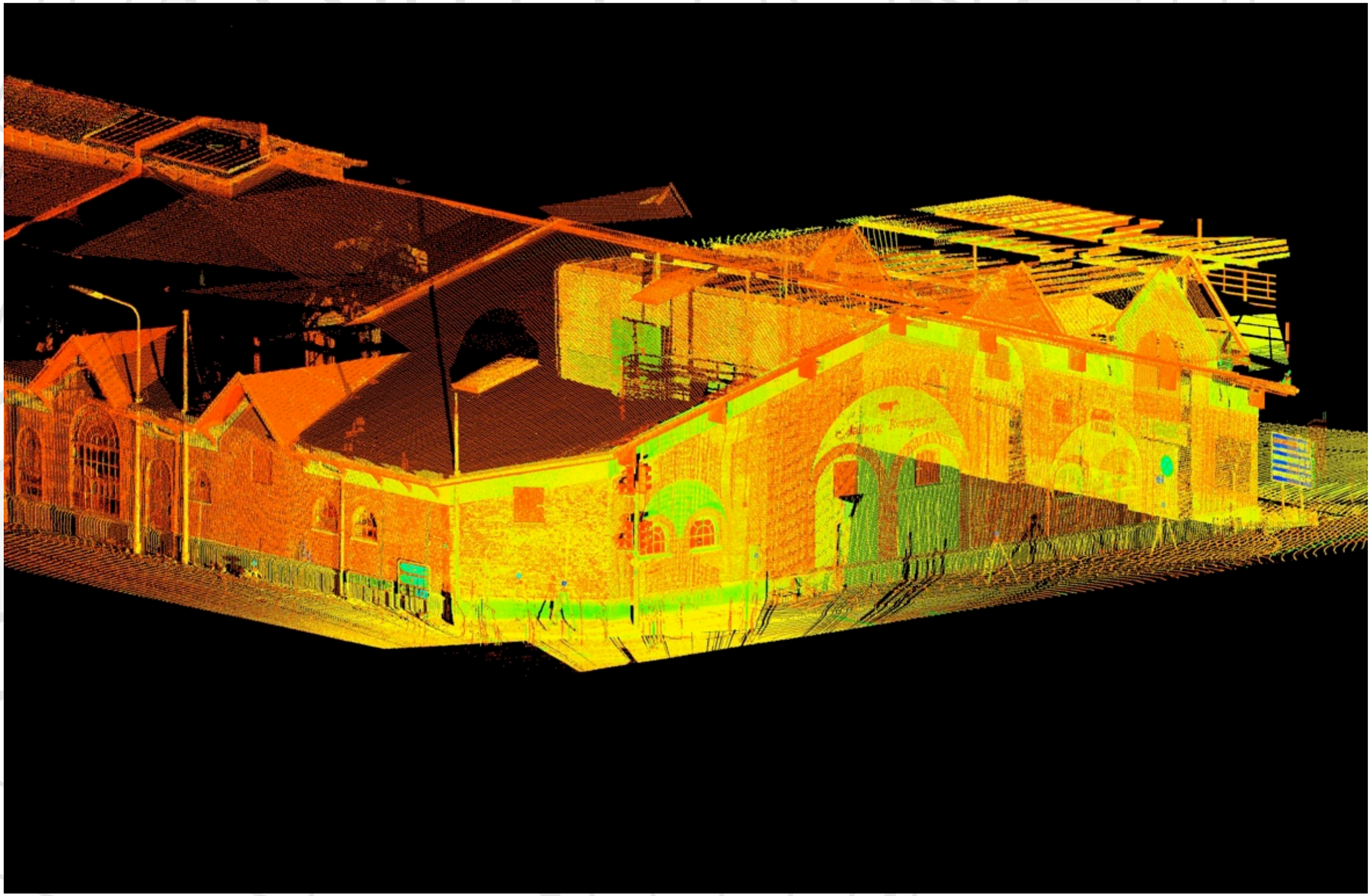
Ground-based Lidar



Courtesy of Nellemann & Bjørnkjær, Aalborg

The challenge for research

- Practical problems
  - Growing requirements for data storage
  - Automatic adjustment of individual scans
  - Building reconstruction
  - Representation of spatial objects
- Theoretical problems
  - Algoritms for optimization of fitting point clouds
  - Face/feature recognition
  - Indexbuilding of faces/features
  - Datamodels and 3d topology
  - P2P networks and geovisualization

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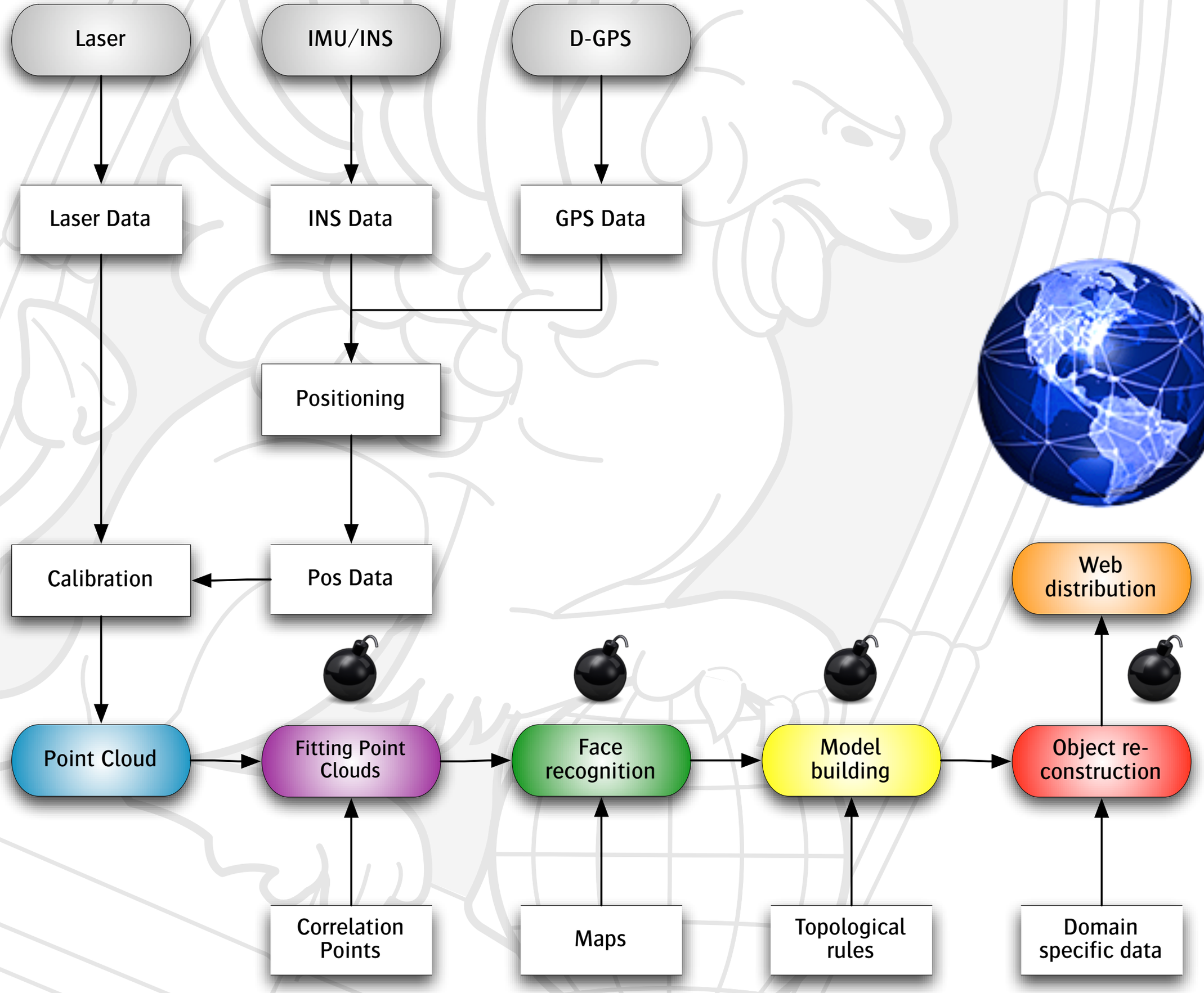
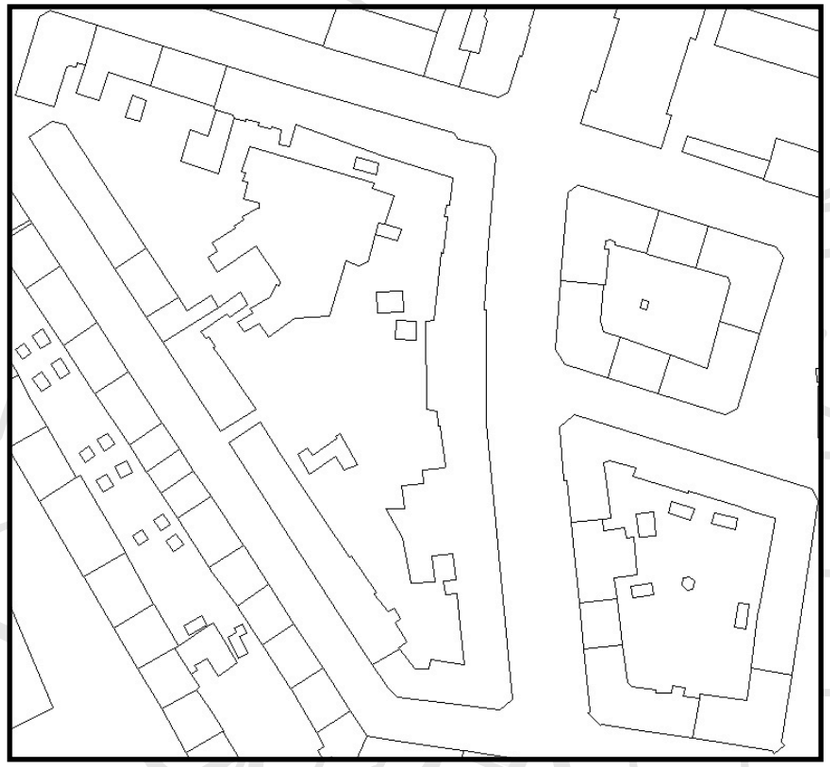

Laser
IMU/INS
D-GPS
Laser Data
INS Data
GPS Data
Positioning
Calibration
Pos Data
Point Cloud
Fitting Point Clouds
Face recognition
Model building
Object re-construction
Web distribution
Correlation Points
Maps
Topological rules
Domain specific data

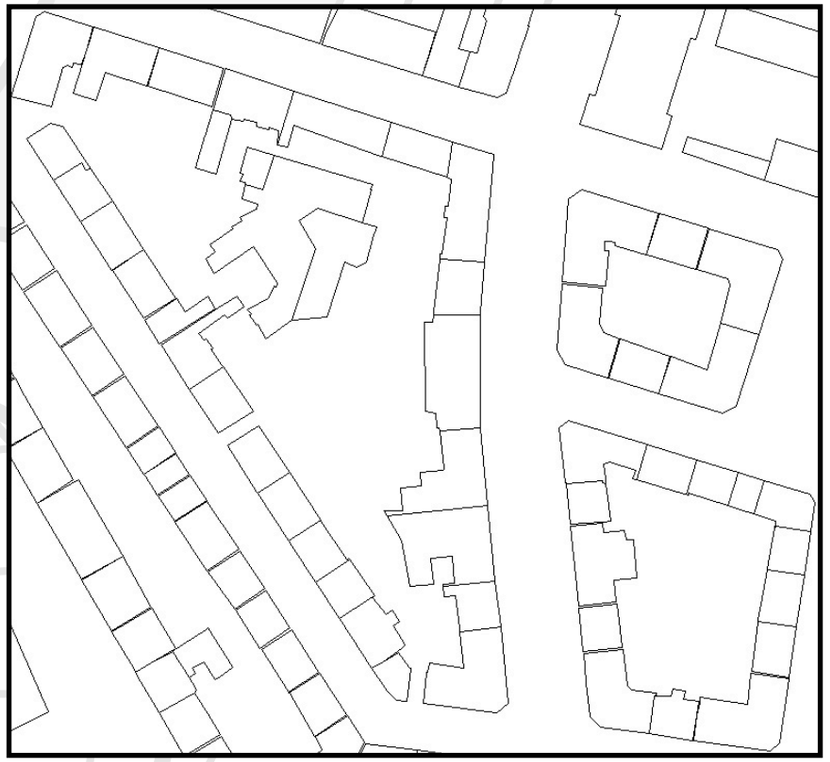
Building Reconstruction

- Available source data:
  - Laser scanning – 1x1 meter grid
  - Ortho photos
  - Footprints of buildings from Technical Map
  - Cadastres from Technical Map
- These are the problems of the source data:
  - Laser scanning is low resolution with only 1 measurement / m^2
  - Laser scanning is interpolated.
  - Ortho photos cannot be used for feature extraction.
  - Footprints often cover groups of buildings.
  - Laser scanning and footprints/cadastres are mutually displaced

Building Reconstruction – preprocessing

- Height jump lines on roofs are difficult to detect. Consequently, it is preferable that footprints as much as possible describe physical building units.
- Solution is to cut footprints by cadastres:

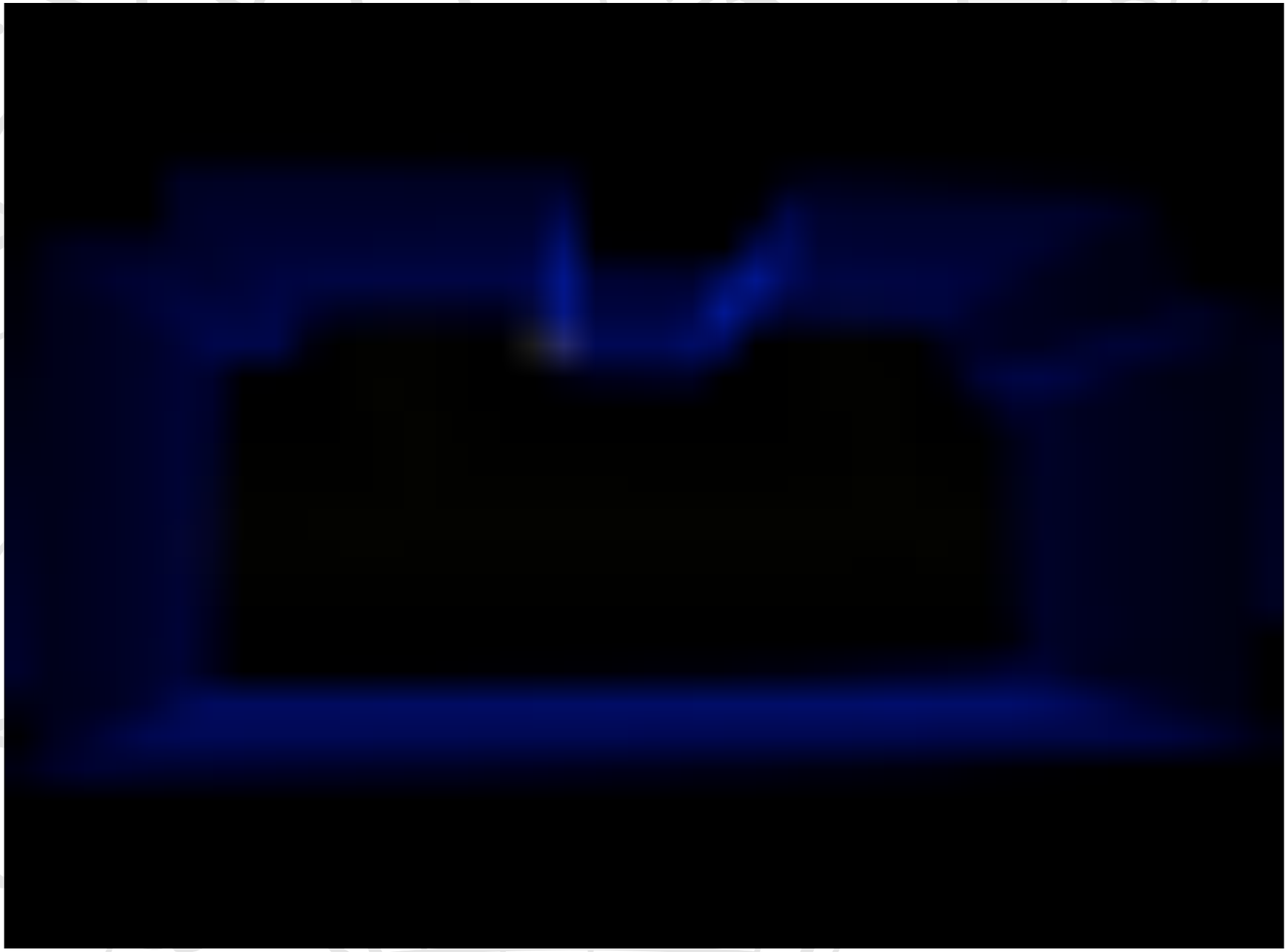




Hough Transform

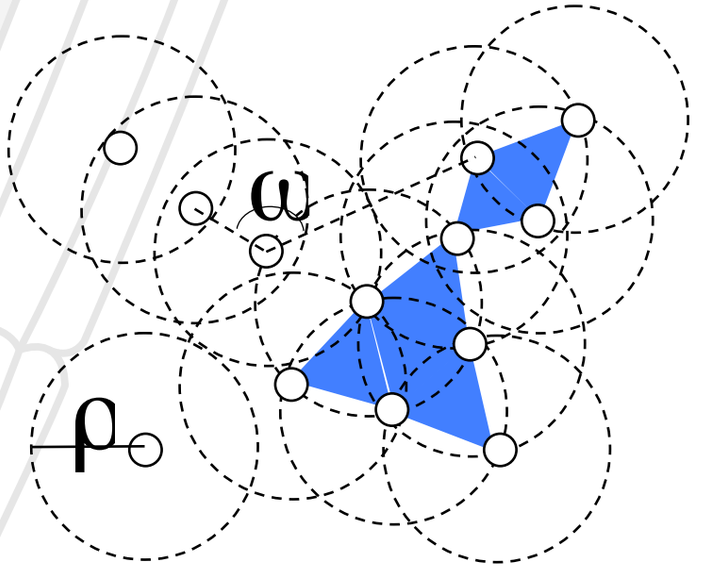
- Originally intended for 2d - easily extendable to 3d
- Widely used in Computer Vision for detection of straight lines and circles
- Algorithm for extraction of general features. Does not have problems with local minima, and thereby considered very robust
- Cannot be used for creating topology - the process of linking extracted features with neighbours
- We use Hough for extraction of 3d planes

Preprocessed Laser Scanning



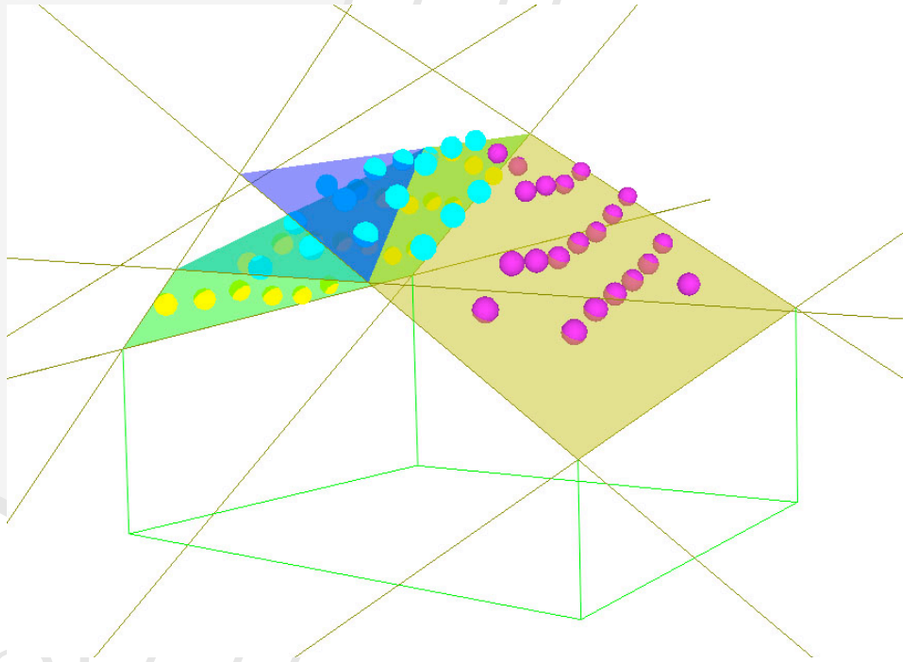
Extraction of planes from Parameter Space

- A huge amount of planes can be extracted from the accumulator cells of parameter space
- Planes can be formed by points originating from different roof surfaces having completely different surface normals
- Erroneous planes are effectively rejected by calculation of projected cluster area

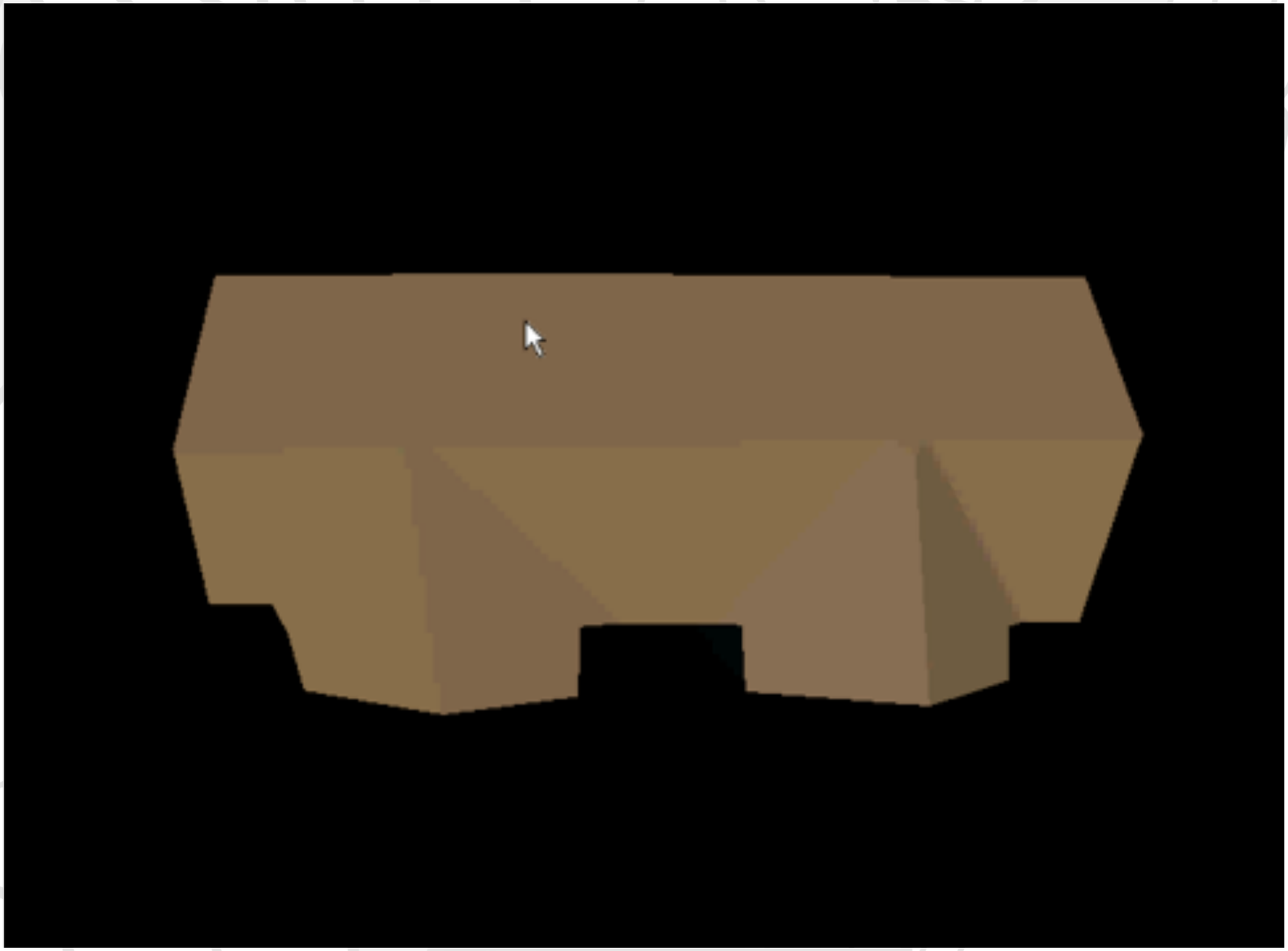


Creating topology

- Cut planes with each other when intersection is within a minimum distance from the point cloud
- Remove bounded faces outside the footprint (projected on XY)
- Overlapping faces are removed if these are not represented by points of the point cloud
- Detect remaining degenerate sections by mesh welding. Edges not allowed to bind more than two faces



Resulting building geometry



Results and next step

- Created 34.000 buildings in two days
- Implemented the 3d city model in GRIFINOR
- Investigate methods for integration of ground-based and air-borne Lidar
- Understand and control the whole black-box proces!

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The end - Thank you!