Multi-ray photogrammetry: A rich dataset for the extraction of roof geometry for 3D reconstruction

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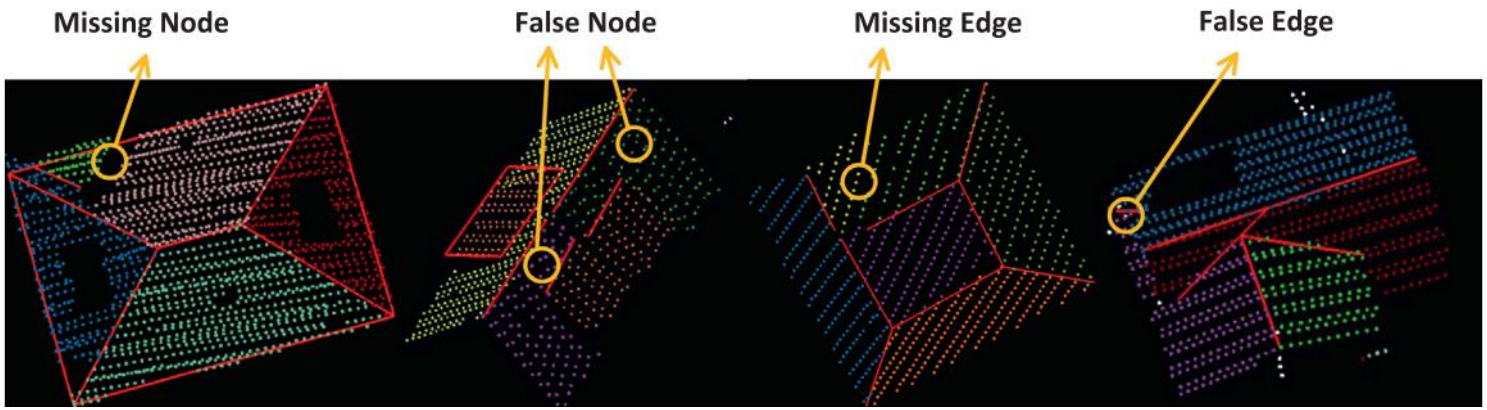
Background

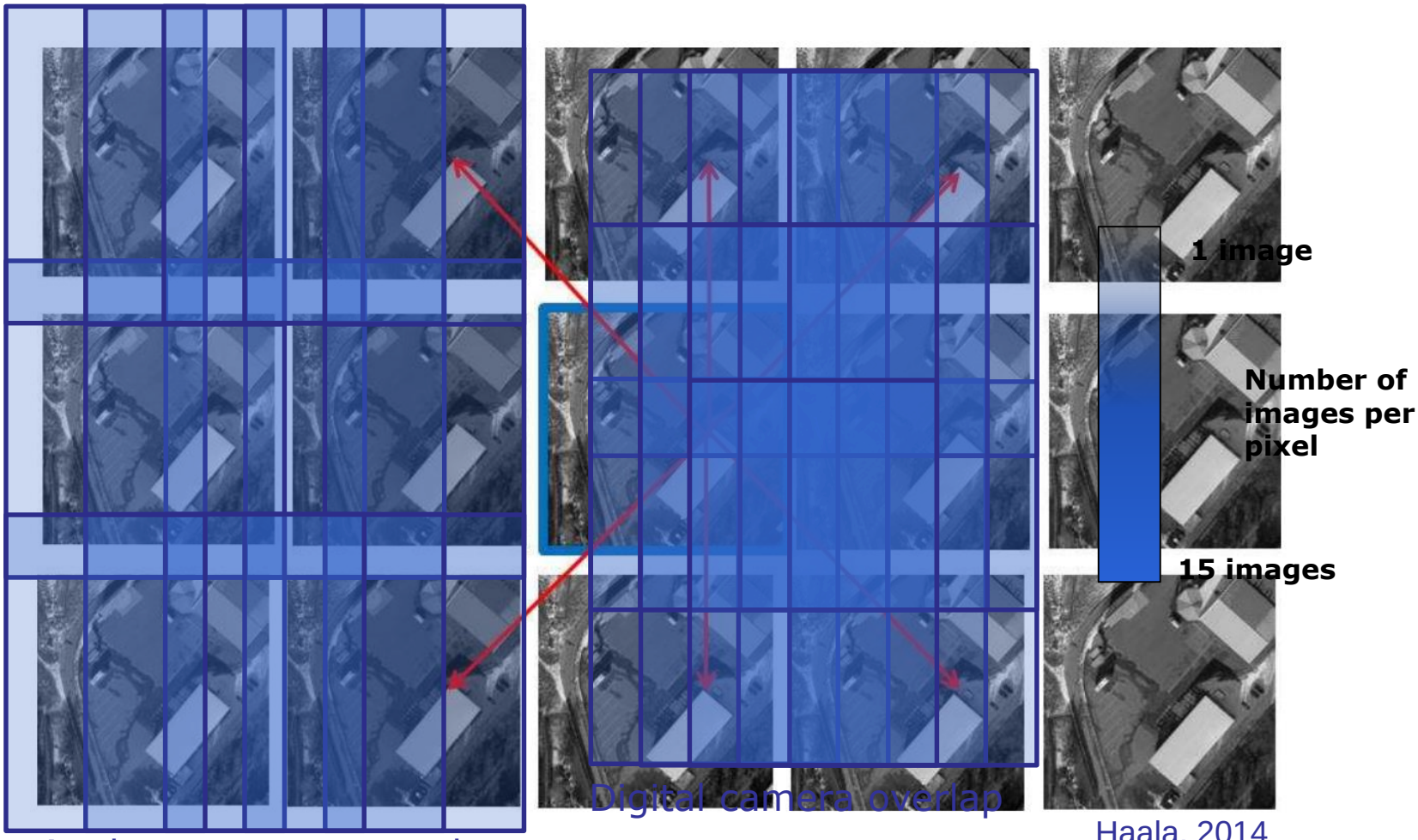
Approaches used in latest ISPRS benchmark on 3D reconstruction:

- 10 methods using original ALS
- 1 method using DSM from ALS
- 2 methods using imagery
- 1 method combined ALS and imagery (Rottensteiner et al, 2014)



Xiong et al, 2014

Multi-ray photogrammetry



Aim & Objectives

The aim of this project is to use data produced from multi-ray photogrammetry to automatically extract and reconstruct LoD 2 3D building models, with accurate geometry of roof vertices:

- Investigate current methods used for building modelling and rooftop extraction, examining their strengths and weaknesses;
- Develop an automated procedure for the extraction of 2D and 3D rooftop vertices from the datasets created from multi-ray photogrammetry;
- Integrate and refine the extracted data from Objective 2 to create a 3D roof model and then integrate with a LoD 1 building model to create the final LoD 2 building model.
- Validate and refine the developed methodology, delivering appropriate metrics on accuracy and reliability.

Test Site

- Newcastle upon Tyne, UK
- Imagery captured using UltraCam XP camera in November 2010,
- Data processed in UltraMap 3.0
  - Raster DSM
  - Image based point cloud
  - True Orthophoto

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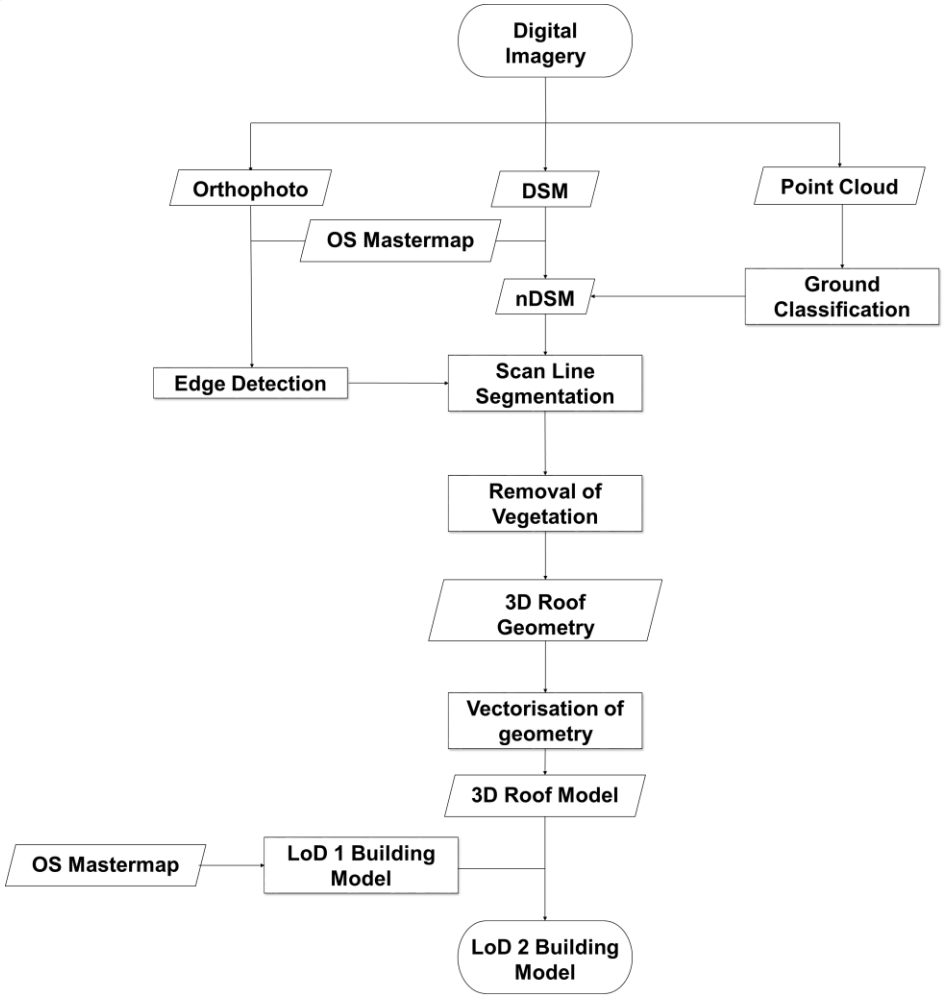
Workflow & Test Site



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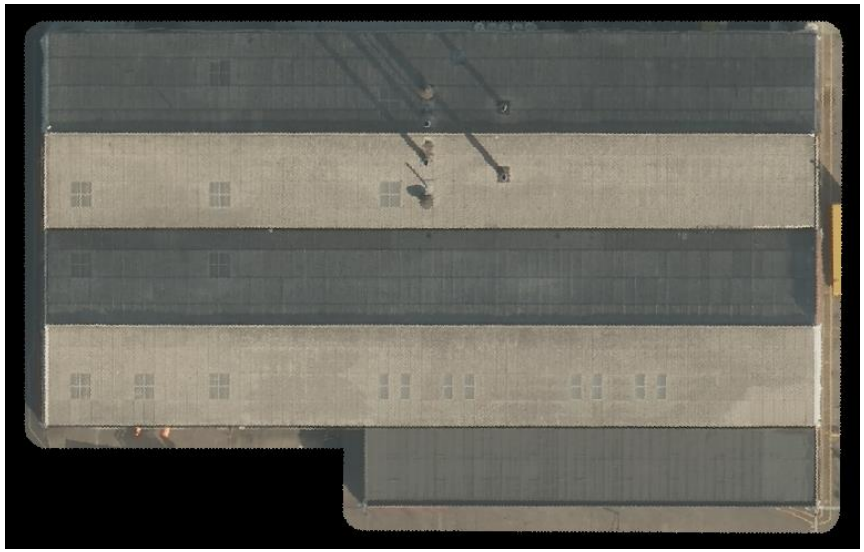
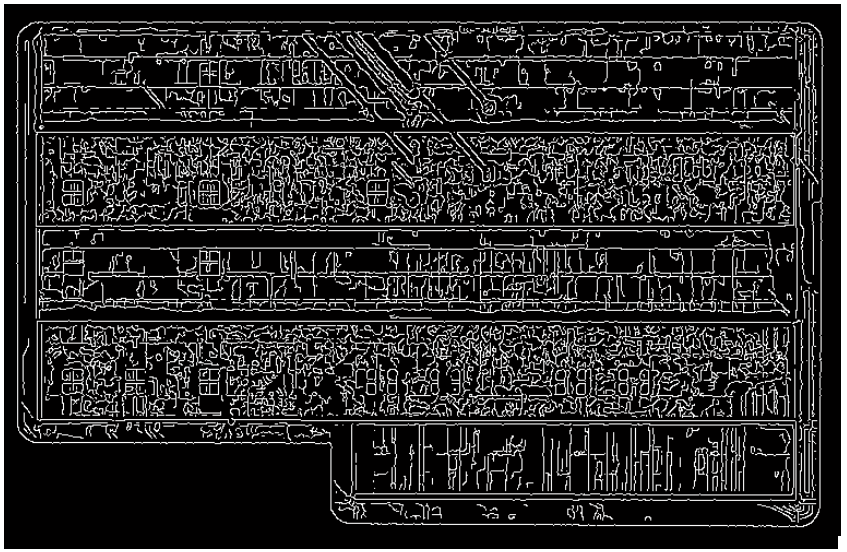
2D: Edge Detection

- Building extracted using OS Mastermap data.
- Investigation of common edge detectors
- Canny edge detector to extract perimeter of roof, ridge and valley lines
- Also extracts noise from roof texture and shadow



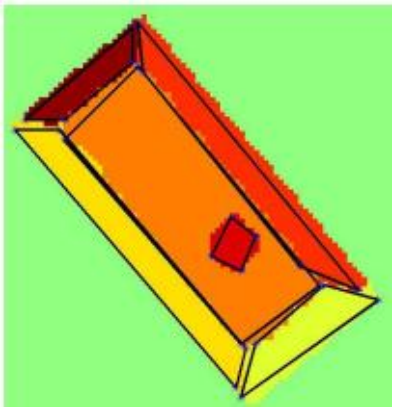
Roof extracted from orthophoto

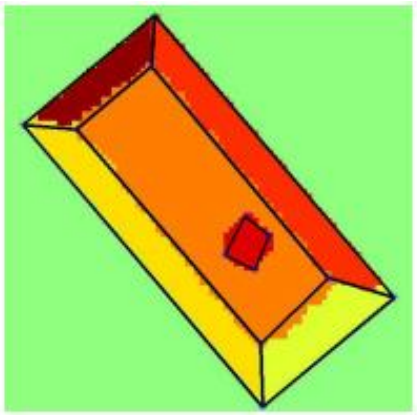


Canny edge detection

3D: Scan line segmentation

- Originally proposed by Jiang & Bunke (1994) for segmentation of close range imagery.
  - Classify cross sections of an image into lines then perform region growing to merge neighbouring lines and form planes.
- Investigated by Alharthy & Bethel (2004) for 3D reconstruction of buildings from lidar
  - Limitations from point cloud spacing and polygon extraction moving the nodes from true position.



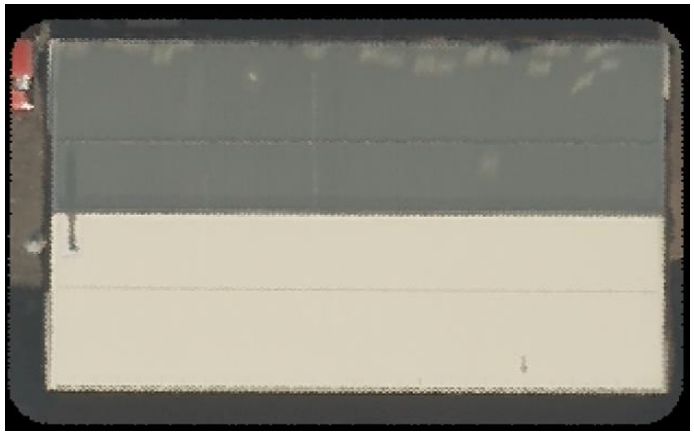


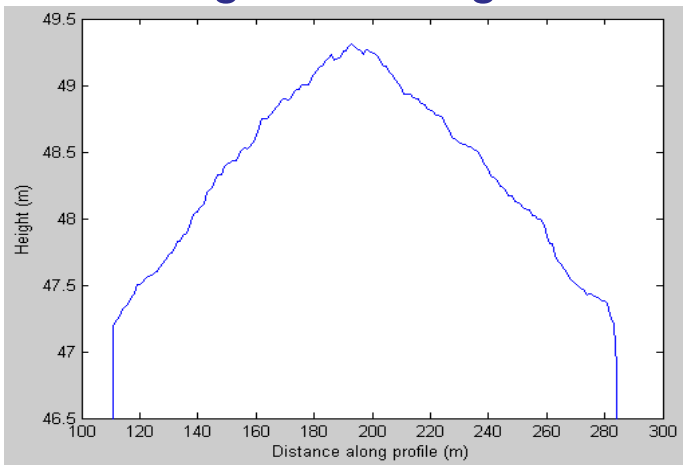
Alharthy & Bethel, 2014

Scan line segmentation – Gable roof

- Detection of breakpoints based on a change in the sign of the slope

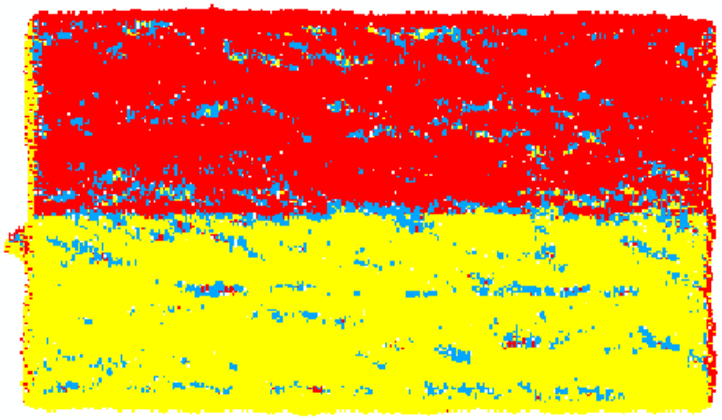
Ortho extraction

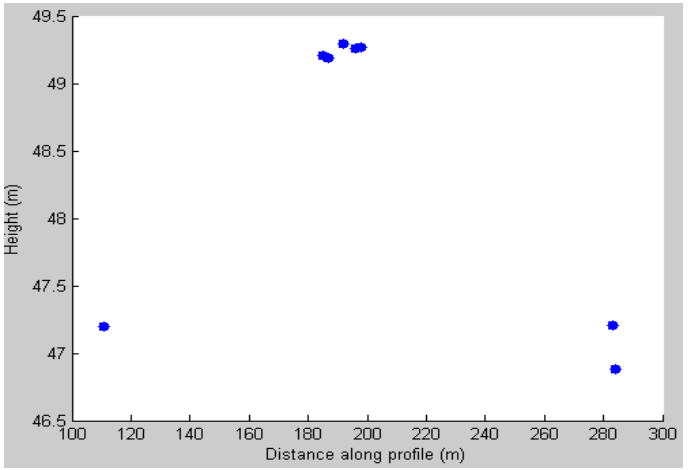




nDSM profile

Scan line segmentation



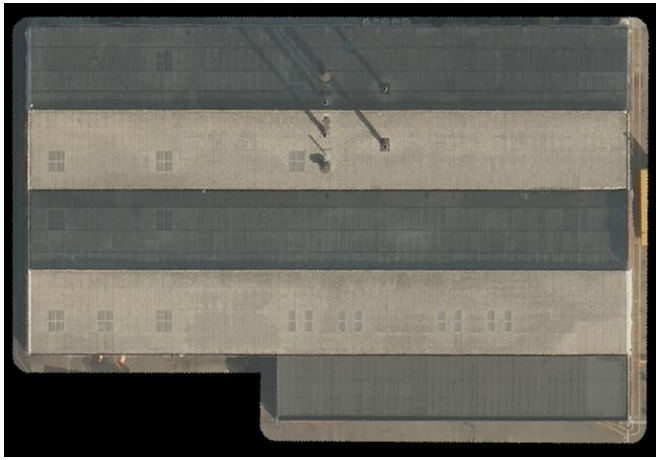


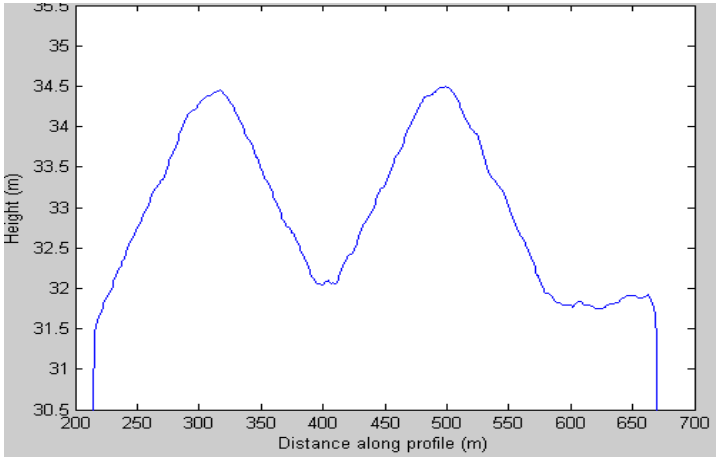
Profile of detected breakpoints

Scan line segmentation – M-Shaped roof

- Detection of breakpoints based on a change in the sign of the slope

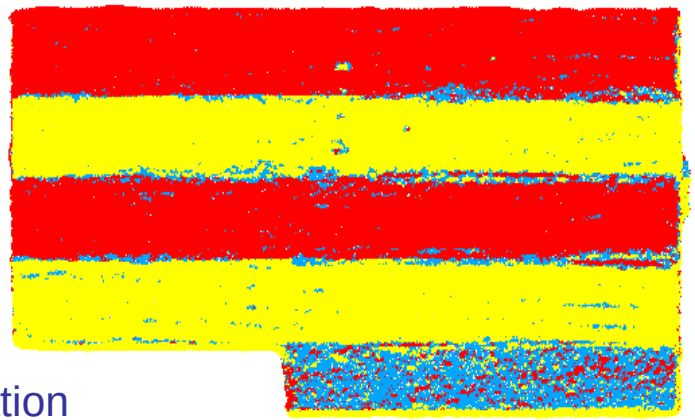
Ortho extraction

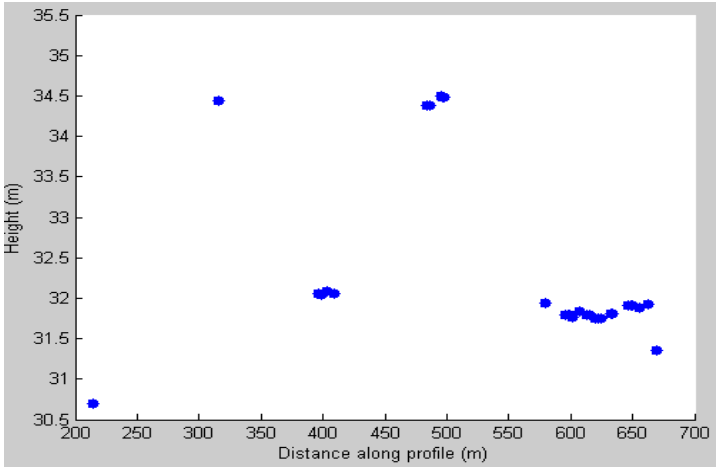




nDSM profile

Scan line segmentation

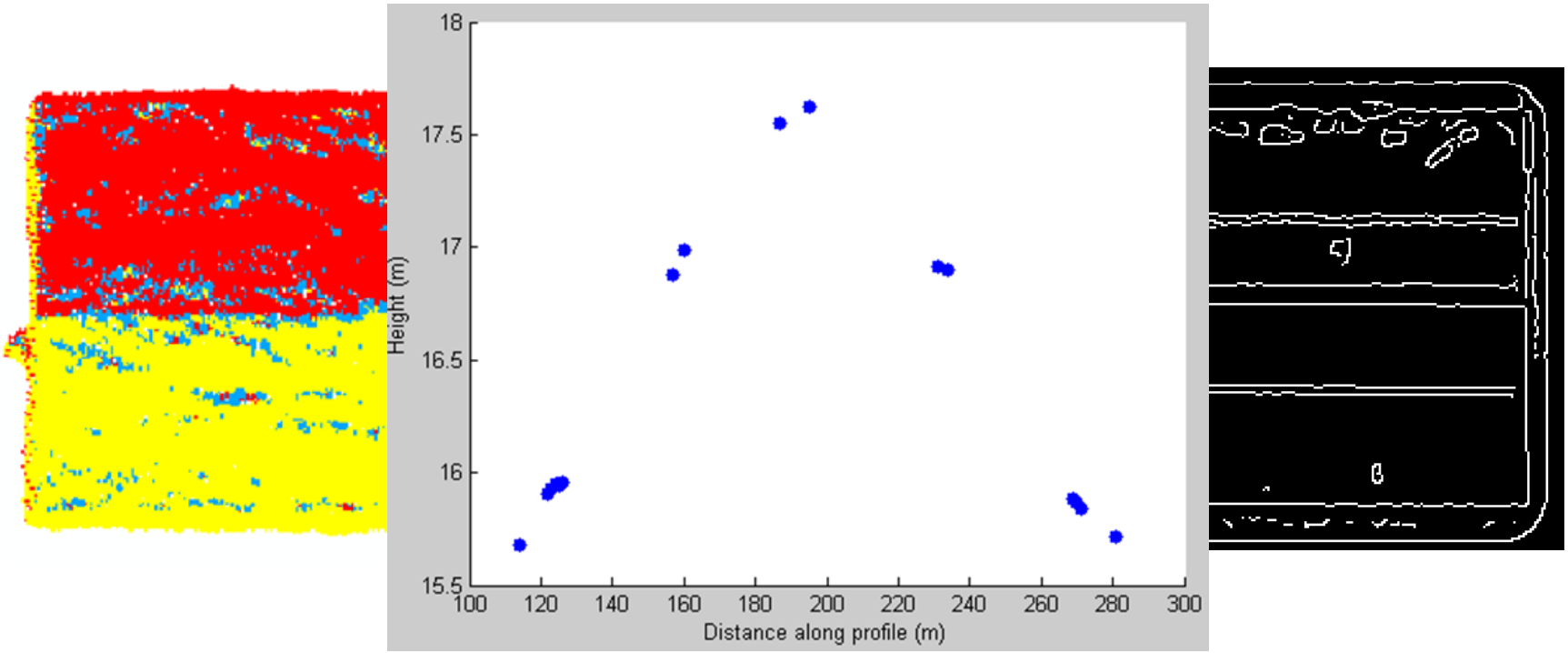




Profile of detected breakpoints

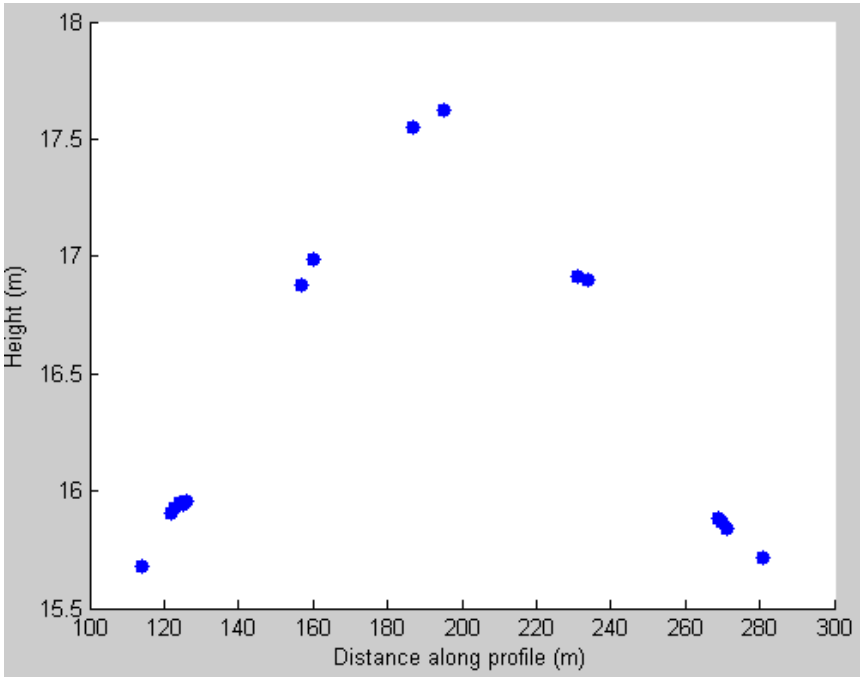
Integration of datasets

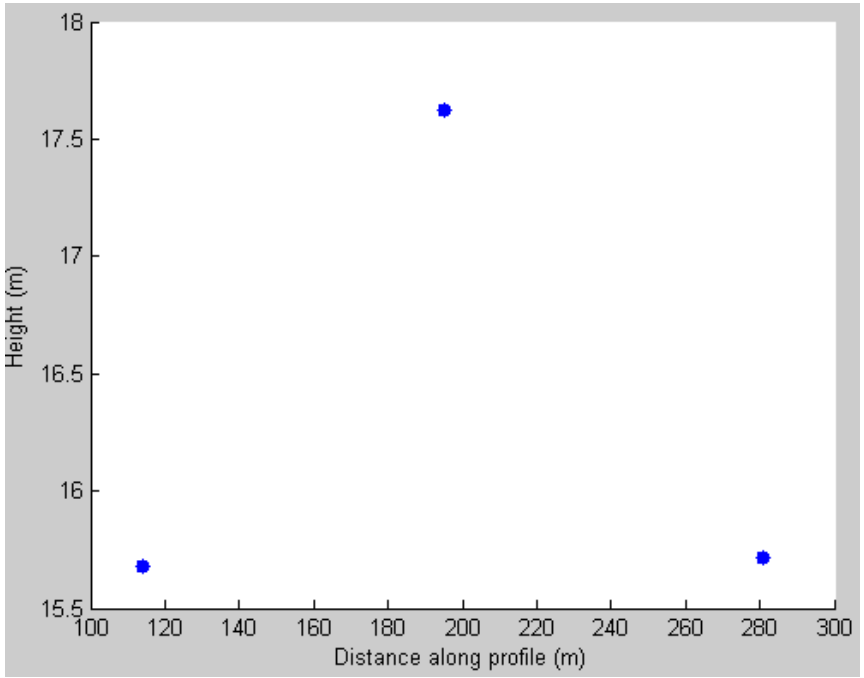
- Canny edge detection extracts accurate location of roof edges but also extracts false positives from roof planes
- Scan line segmentation can be used as part of a process to extract planes but does not extract accurate location of roof edges



Scan line segmentation with edge detection

- Linear Regression of detected Canny edges incorporated into
- Iteratively fit line through data points and remove edges based on residuals of the fit





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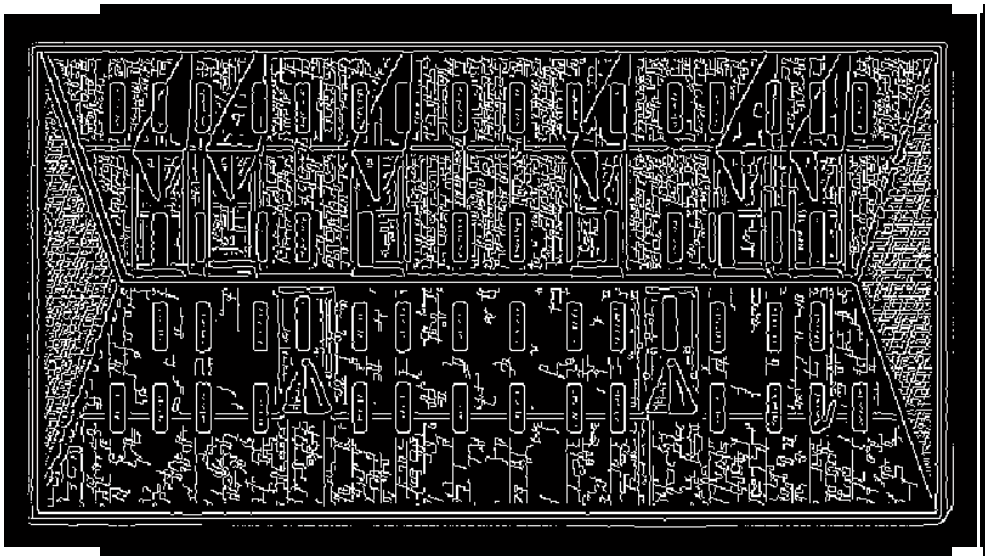
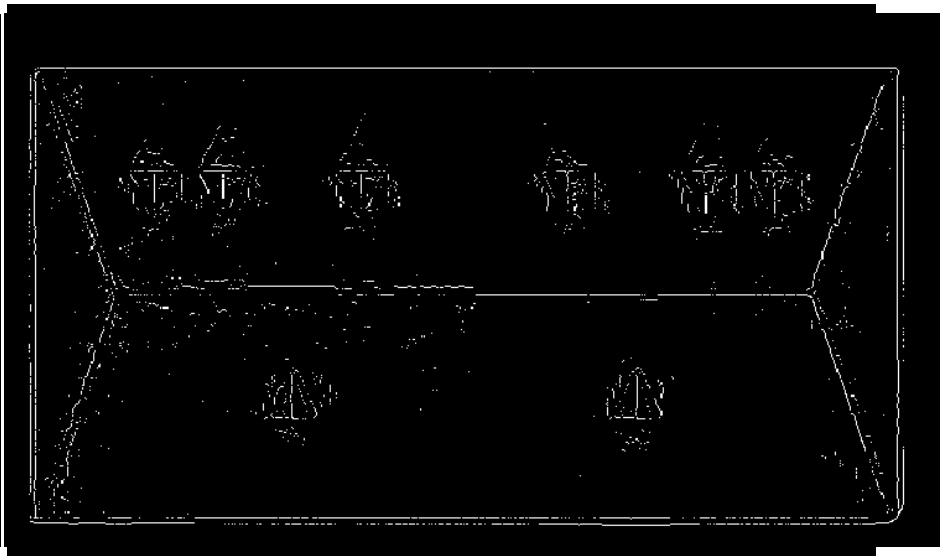


Canny edge detection



Roof breakpoints from scan line segmentation

Conclusions & Future Work

Conclusions

- Multi-ray photogrammetry offers an abundance of dense data that can be used for roof geometry extraction;
- Canny edge detection and scan line segmentation have their individual strengths which can overcome weaknesses for extracting roof geometry;

Future Work

- Exploring threshold sensitivity of canny edge detection and linear regression
- Vectorising of extracted breakpoints
- Developing scan line segmentation approach for removal of vegetation

Thank you for listening

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