UNSW AUSTRALIA

A semi-automatic approach to building boundary extraction from airborne lidar data

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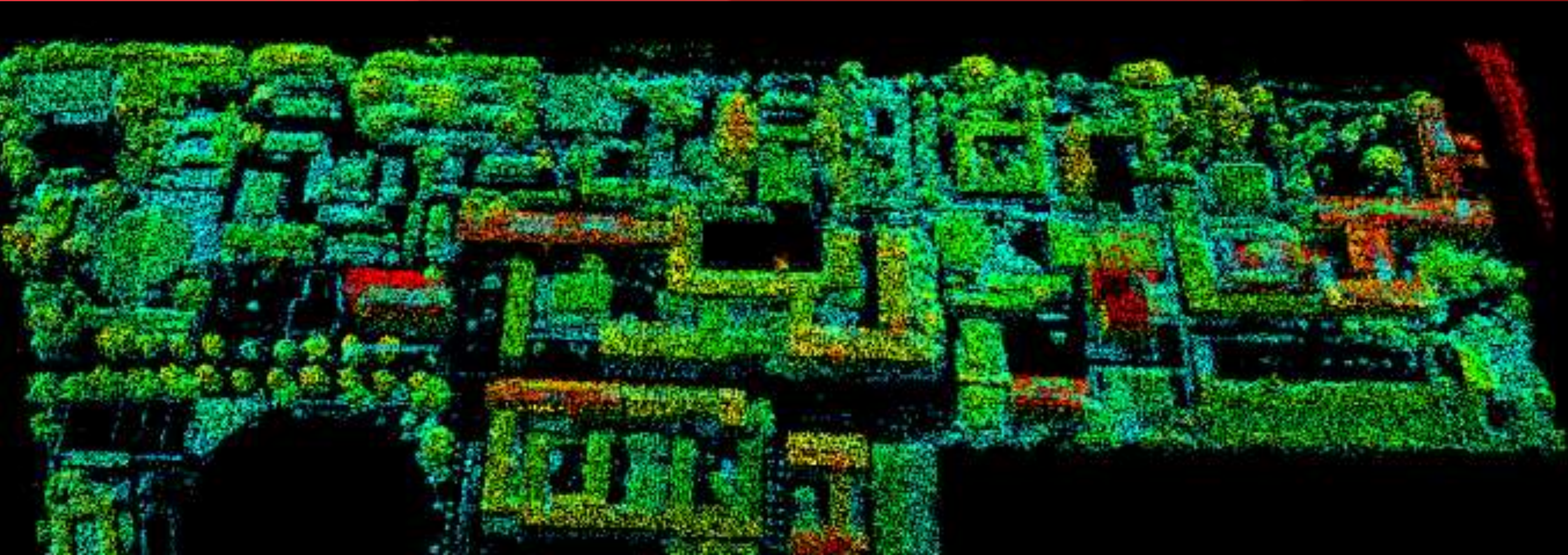


Research objectives

<u>Most filtering algorithms require *rasterization* of lidar data</u>

- Additional computing overhead
- Loss of information
- Increase of uncertainty

<u>Proposed method</u>

- No rasterization
- Adaptive window size
- Adaptive morphological filtering
- Normal difference vegetation index
- Hierarchical clustering and thresholding
- Delineated based on alpha-shape and Douglas-Peucker algorithms

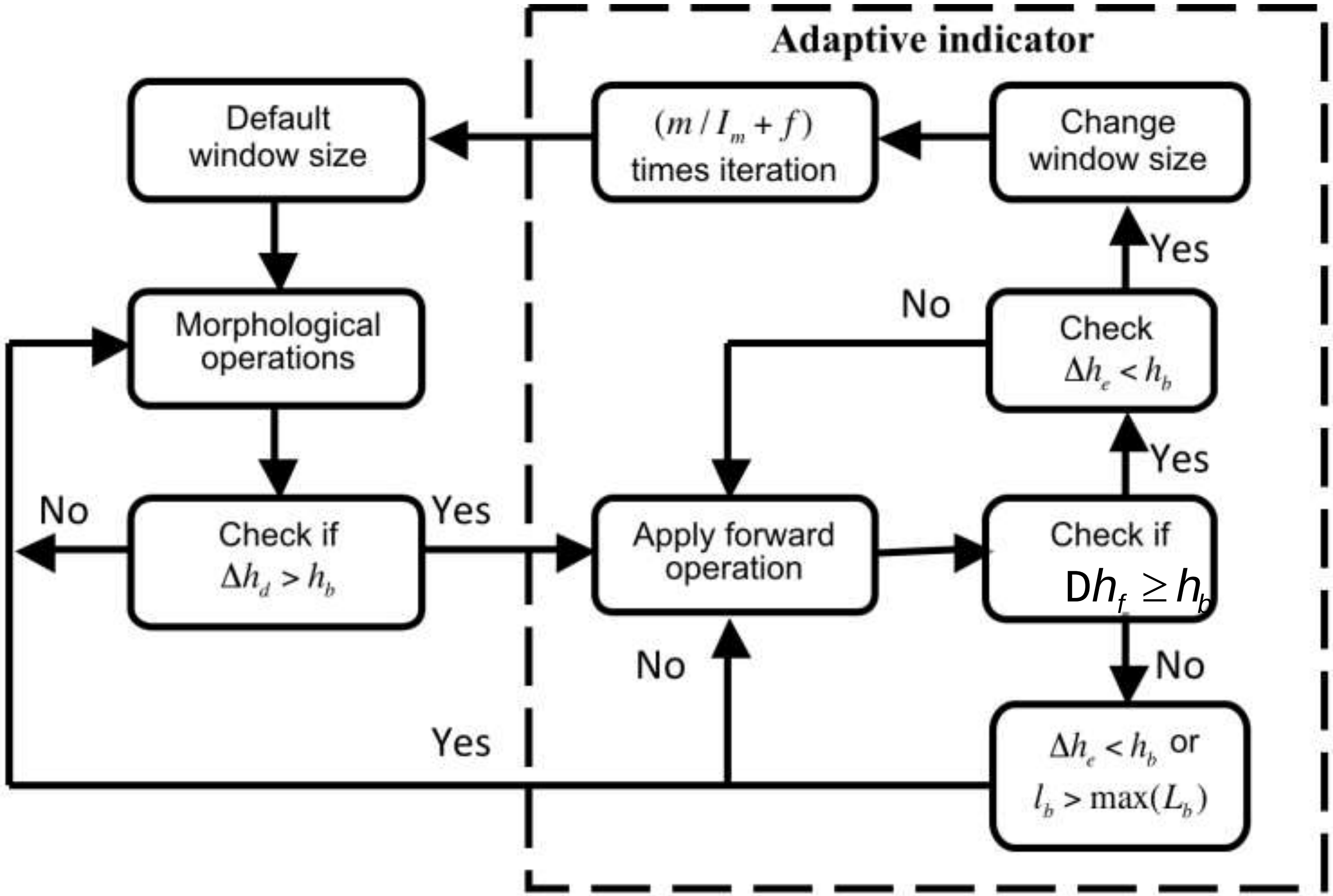
Filtering out ground points

- ✓ A large window size increases the omission error (false negative), and a small window size increases the commission error (false positive).
- ✓ A progressive morphological filter repeats the process several times by gradually increasing the window size, but the choice of the assigned weights can still be an issue.
- ✓ We added an adaptive function that can automatically detect a size of the above-ground features and change the window size accordingly.

Proposed adaptive filtering

- ✓ Use dilation and erosion to find the maximum or minimum within the window.
- ✓ An adaptive window size indicator is developed to detect building rooftops and modify the window size automatically.
- ✓ An approximate size of a building can be detected by measuring the elevation rise and fall, and therefore the window size can be changed accordingly.

Adaptive filtering (Workflow)



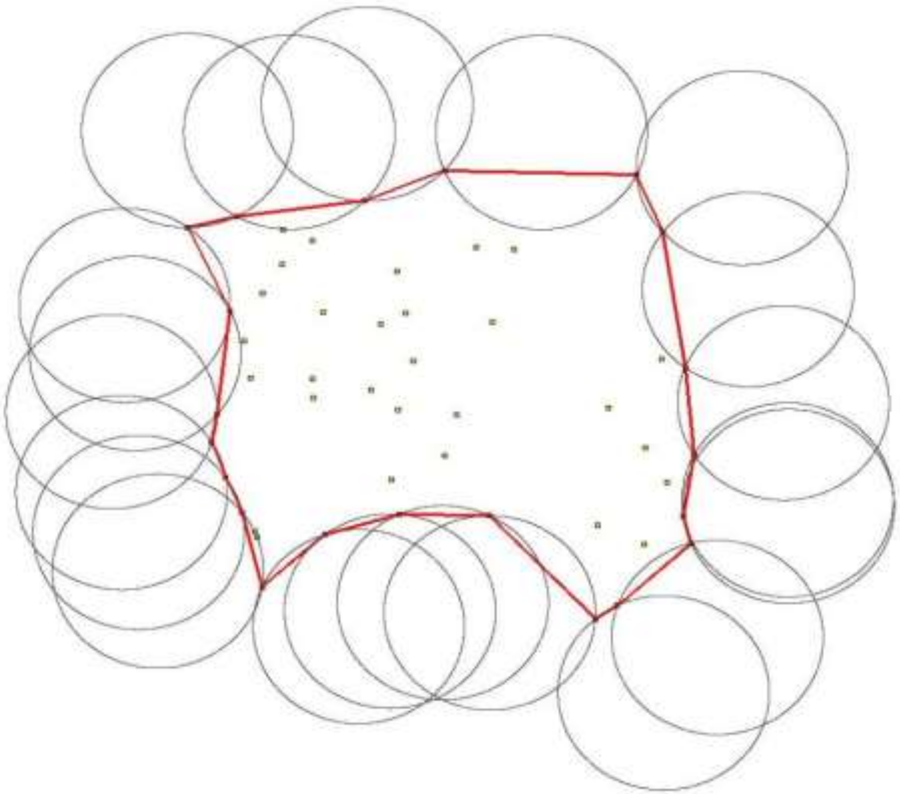
Vegetation removal

- ✓ NDVI alone may not produce a reliable accuracy if the threshold is not appropriate.
- ✓ We used a progressive approach after applying NDVI to remove the residuals as well as other unwanted small features.
- ✓ Hierarchical clustering based on Euclidean-Distance is performed to the points.
- ✓ Based on height, area and the number of points, thresholds were optimized step by step to remove the clusters of non-building points.

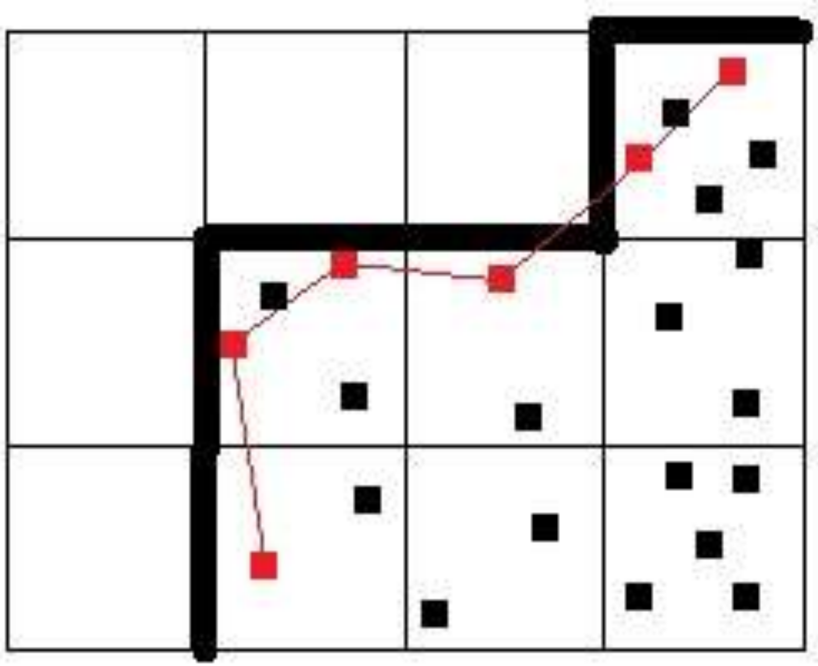
Approaches to building edge detection

- ✓ Alpha-shape to form building outlines
- ✓ Grid-based algorithm
- ✓ Modified convex hull algorithm
- ✓ Fine-tuning with adjustable parameters to remove small residuals

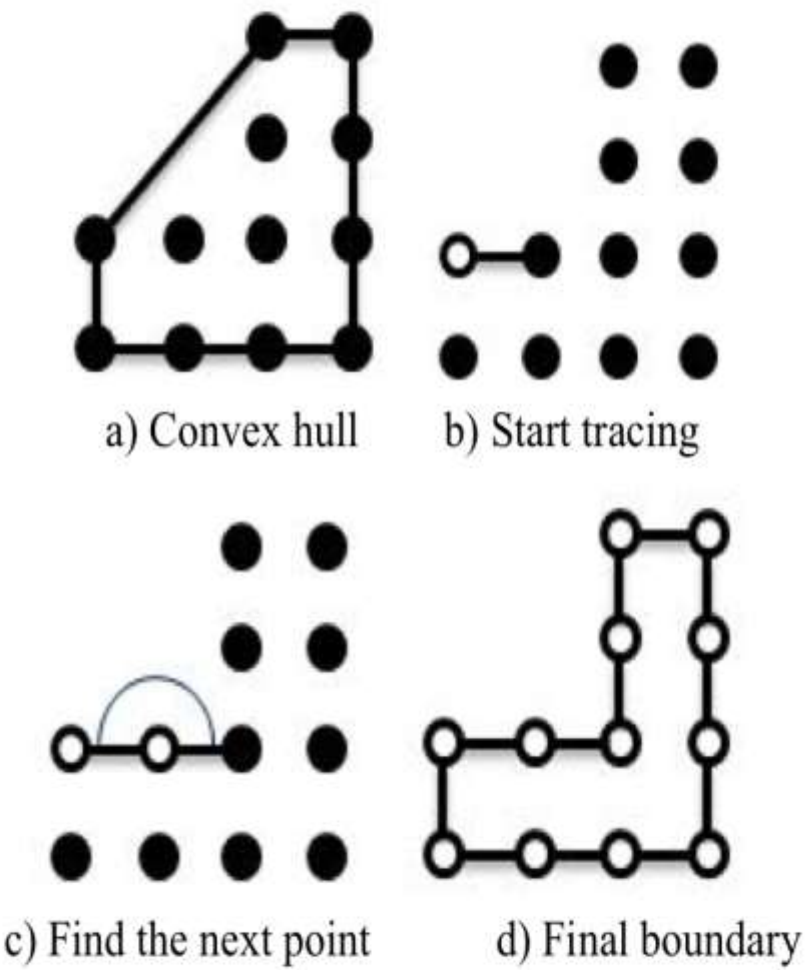
Alpha-shape algorithm



Grid-based algorithm

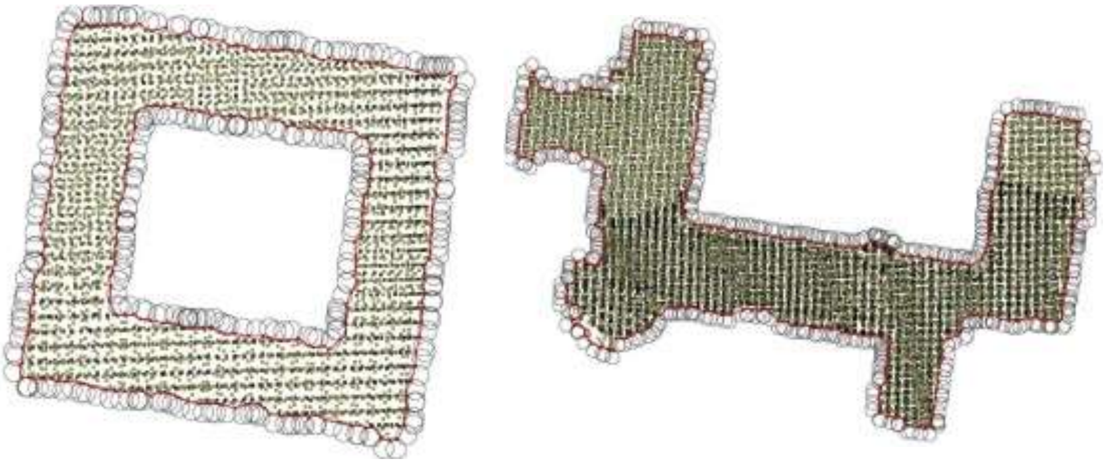


Modified convex hull algorithm

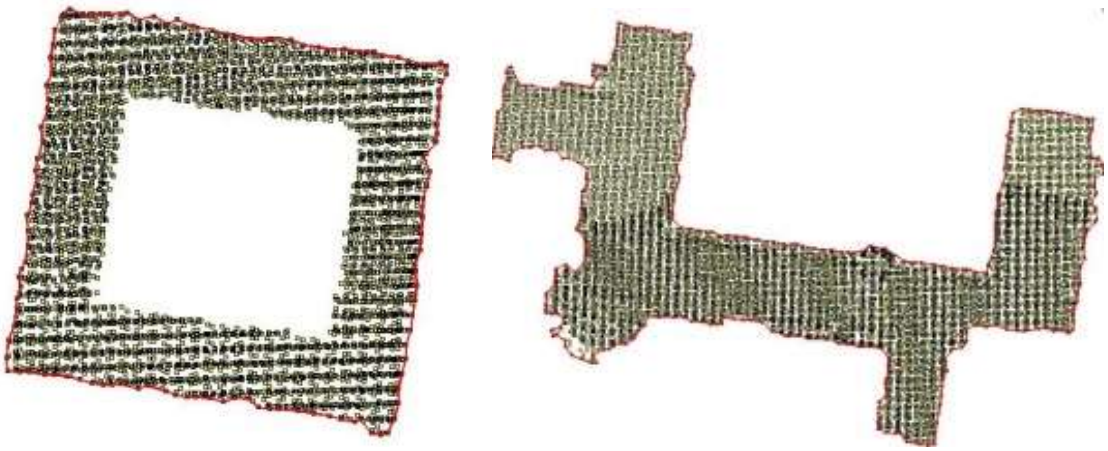


Boundary Extraction (1/2)

- Alpha-shape

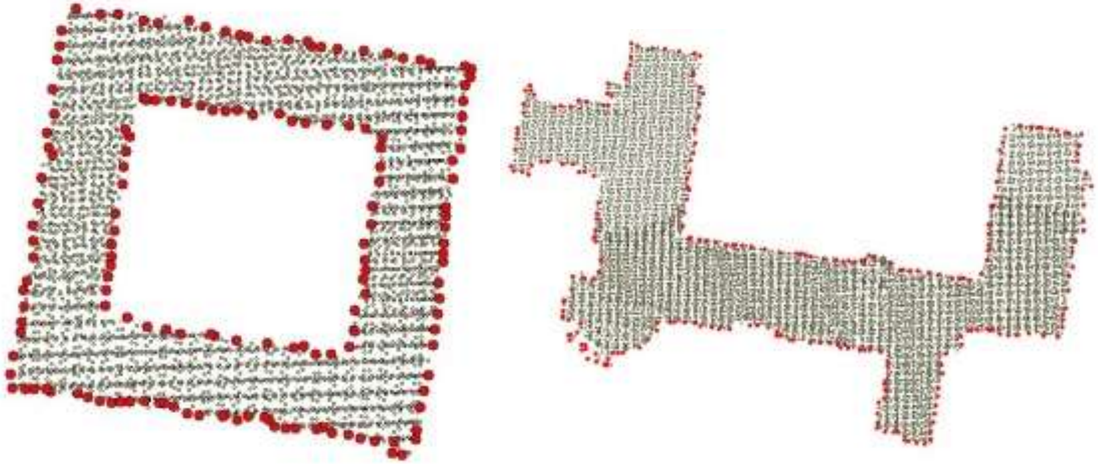


- Modified convex hull



Boundary Extraction (2/2)

- Grid-based



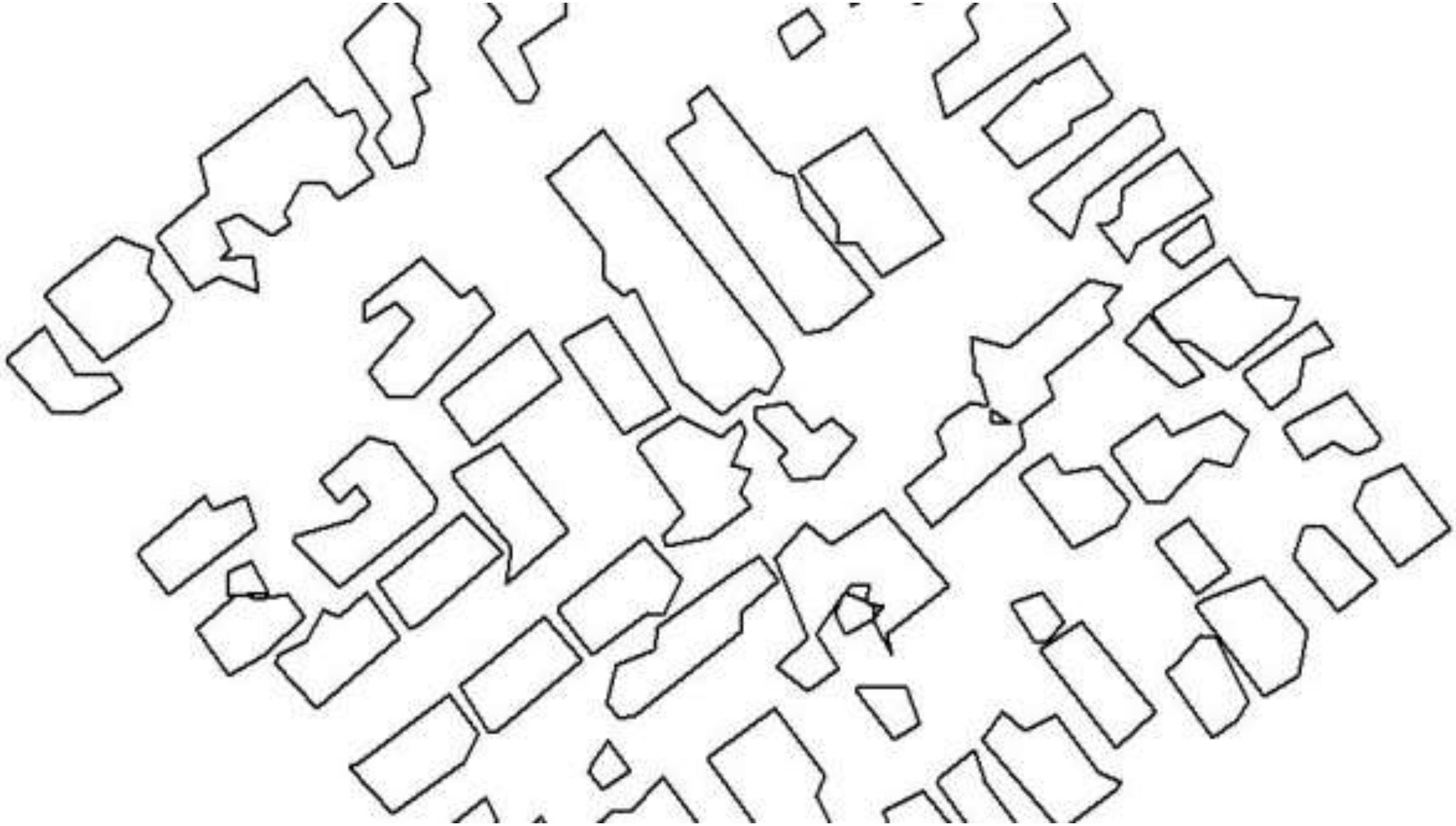
Datasets

- ✓ Lidar data were acquired with Leica ALS50-II on 20 April 2011 over Bathurst, New South Wales, Australia.
- ✓ The data contain up to 4 returns per transmitted pulse.
- ✓ Multiple returns usually occur on the edge of buildings or trees that allow the laser beam to penetrate.
- ✓ The horizontal accuracy and vertical accuracy of the lidar data are 0.8 m and 0.3 m, respectively, with an average point density of 1.57 points per square meter.
- ✓ The aerial ortho-image was obtained on 10 April 2013.
- ✓ Reference building polygons are digitized from this image and are used to assess the test results.

Test Data A: ortho-photo

Test Data A: digitized polygons

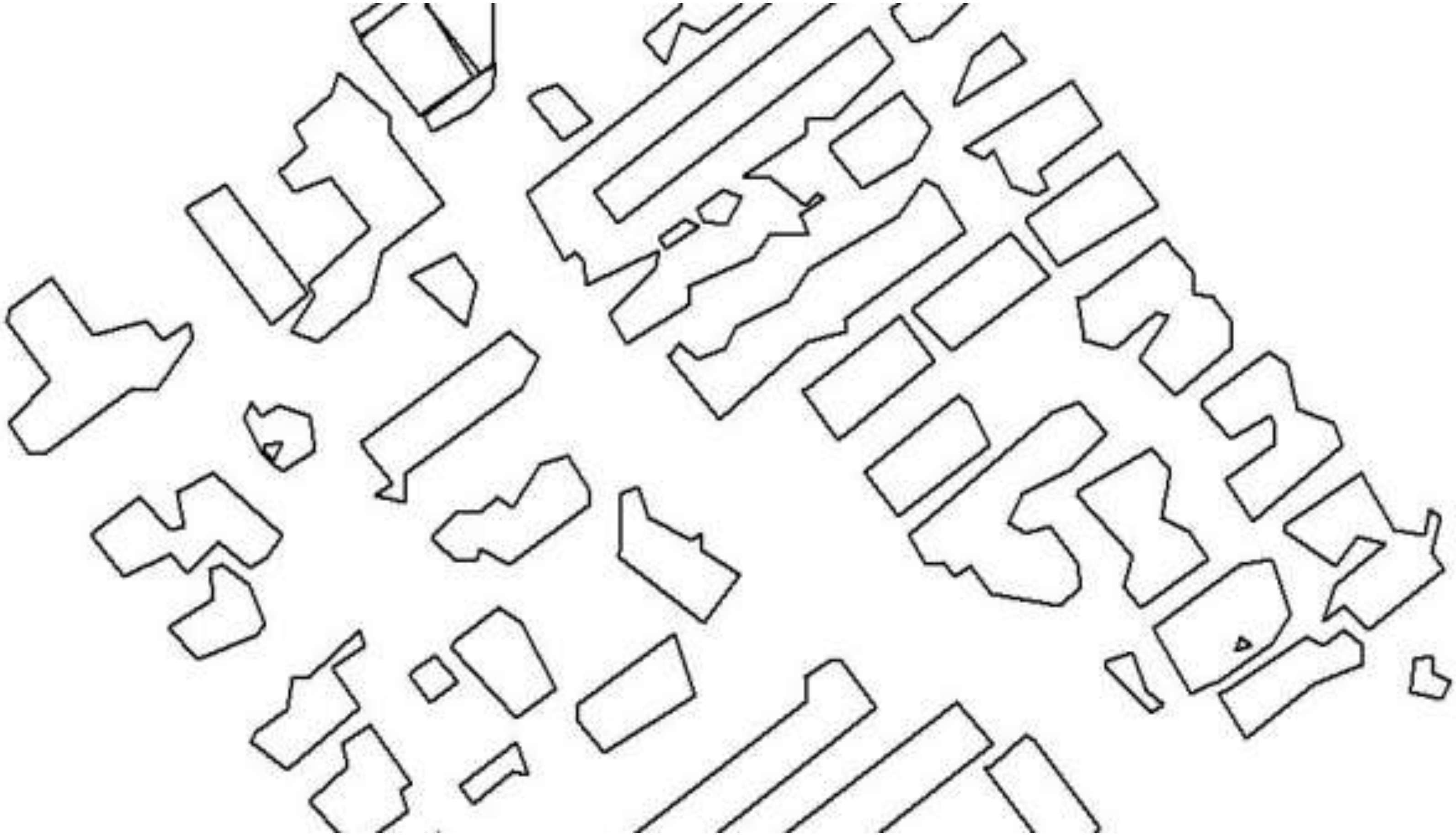
Test Data A: extracted polygons



Test Data B: ortho-photo

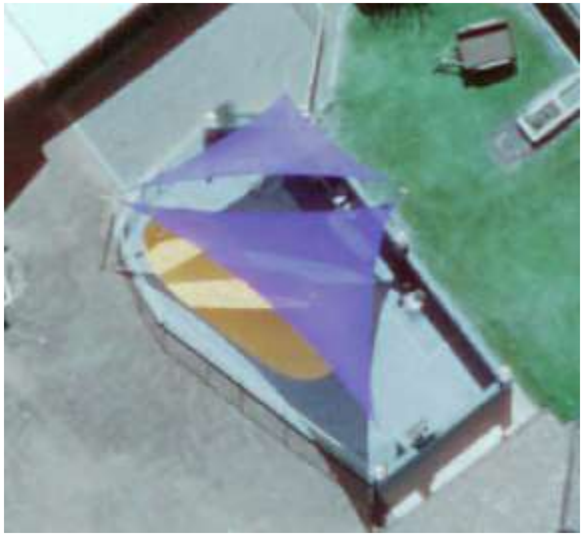
Test Data B: digitized polygons

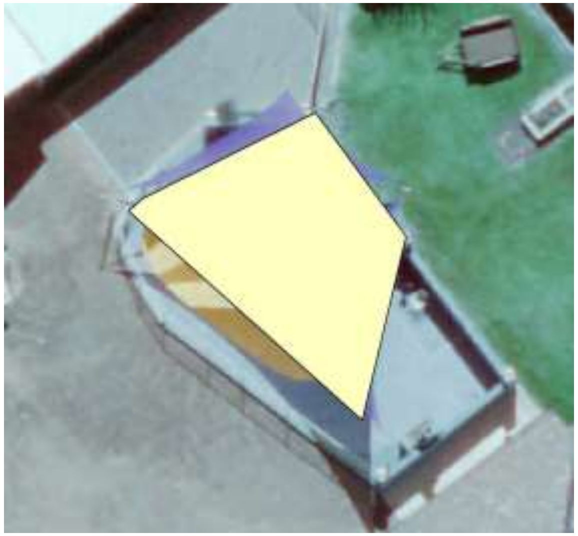
Test Data B: extracted polygons



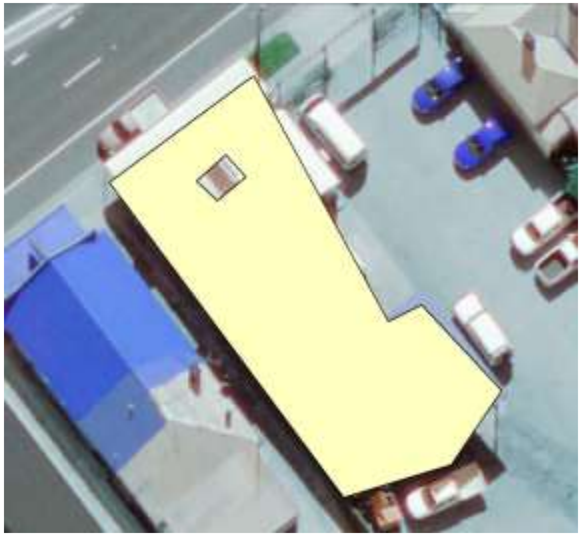
Incorrect detection (1/3)

Incorrect detection (2/3)





Incorrect detection (3/3)



Object-based evaluation (1/3)

- ✓ Completeness C_m

ratio between the number of correctly matched polygons and the total number of polygons, both in the reference

- ✓ Correctness C_r

ratio between the number of correctly matched polygons and the total number of polygons, both in the extraction

- ✓ Quality Q_i

$Q_i=(C_m* C_r)/(C_m-C_m*C_r+C_r)$

Object-based evaluation (2/3)

✓ Fusion rate F_u

percentage of polygons where a single polygon in the extraction must be in fact multiple polygons.

✓ Fission rate F_i

percentage of polygons where multiple a set of polygons in the extraction must be in fact a single polygon.

Object-based evaluation (3/3)

Object-based	***Cm***	***Cr***	***Qi***	***Fu***	***Fi***
Site A	96.34%	98.46	94.91%	21.95%	4.62%
Site B	94.29%	92.73%	87.80%	21.43%	0.00%

Area-based evaluation (1/2)

- ✓ Completeness (C_{ma})
- ✓ Correctness (C_{ra})
- ✓ Quality (Q_{ia})
- ✓ Area omission error (E_{ro})
- ✓ Area commission error (E_{rc})

Area-based evaluation (2/2)

Area-based	***Cma***	***Cra***	***Qia***	***Erc***	***Ero***
Site A	88.28%	91.35%	81.47%	8.65%	11.72%
Site B	86.32%	88.83%	77.87%	11.17%	13.68%

Concluding Remarks

- ✓ The proposed algorithm is suitable for urban areas with varying building dimensions.
- ✓ The required parameters of the proposed algorithm can be automatically determined.
- ✓ The test results show that the proposed algorithm is able to classify ground points with a vertical accuracy of 36 cm, a horizontal accuracy of 75 cm.
- ✓ Multi-rooftop buildings are difficult to detect, but the dual-direction process can improve the result.