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QUALM: Quick, Unconstrained Approximate L-Shape Method

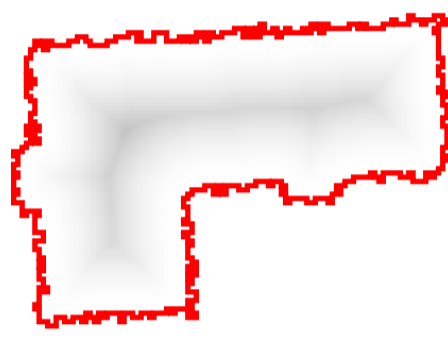
K. Edum-Fotwe^{1,2}, P. Shepherd¹, M. Brown¹, D. Harper², R. Dinnis²

1) University of Bath, 2) Cityscape Digital

1 → Introduction

What → a simple, fast 2D shape approximation method for rectilinear building footprints.

Why → approaches based on a skeletal representation are sensitive to sensing noise at shape boundaries [1].



Advantages, Applications & Benefits →

- compact footprints for 2D map-updating.
- automatically vectorises airborne laser-scans.
- data-driven, efficient and easy to implement.
- works on structured or unstructured input.

2 → Approach

Step 1 → compute minimal area bounding box (MABB) of input. (Hough-Transform)

Step 2 → for each vertex in MABB: **eat-away** a corner by reducing the distance to the input.

Measuring Geometric Error

The Hausdorff-Distance Error Measure

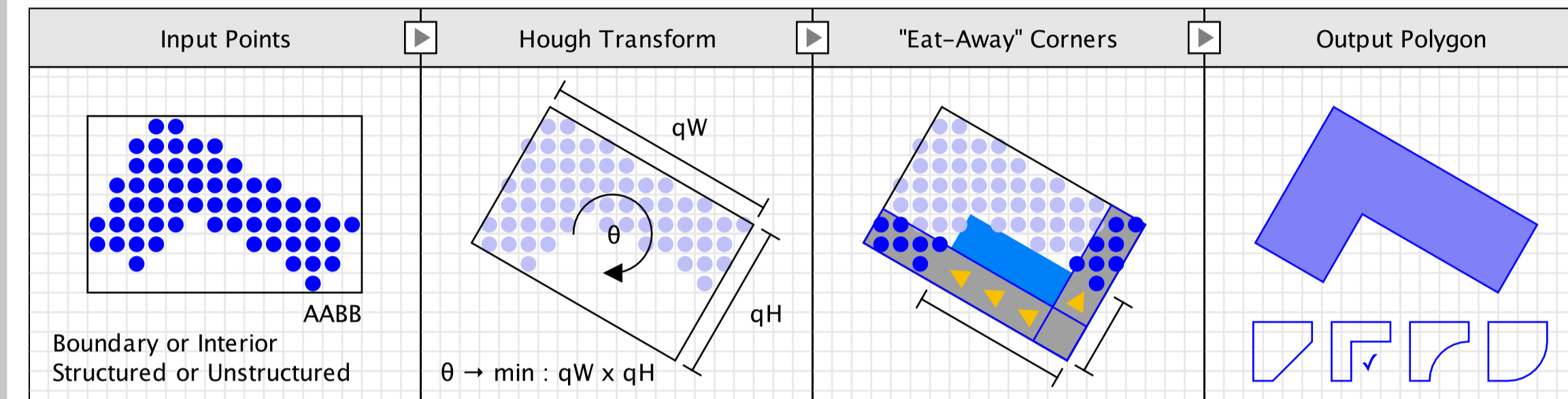
$$f(A,B) = \max(\|A_i - (B_j, B_{j+1})\| \forall i \in A : \forall j \in B)$$

The Intersect-over-Union Error Measure

$$(A \cap B) / (A \cup B) > \omega : \omega \in [0 : 1]$$

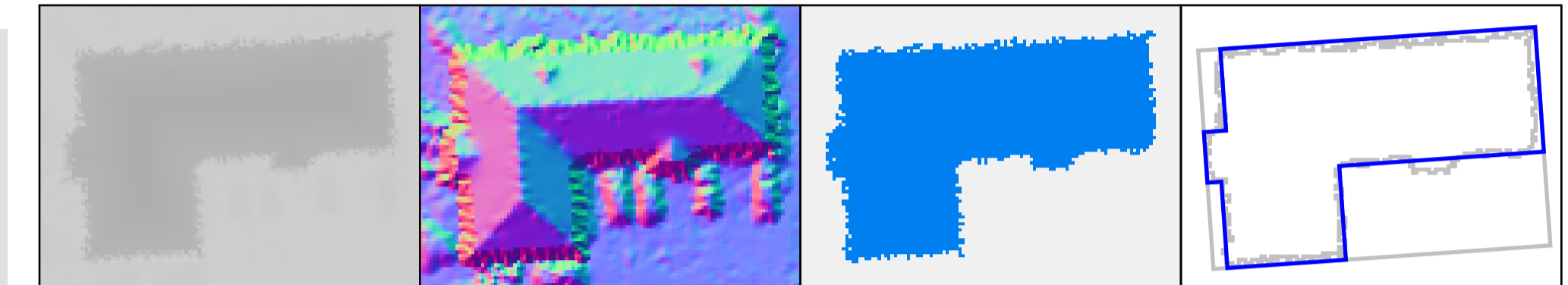
As this is a heuristic shape approximation method, it is vital to be able to measure the geometric accuracy of each generated polygon relative to the original input-points. For this two measures are used. A discrete maximum **point-to-edge distance** and a continuous normalised **shape-to-shape-overlap ratio**.

3 → The QUALM Algorithm Illustrated



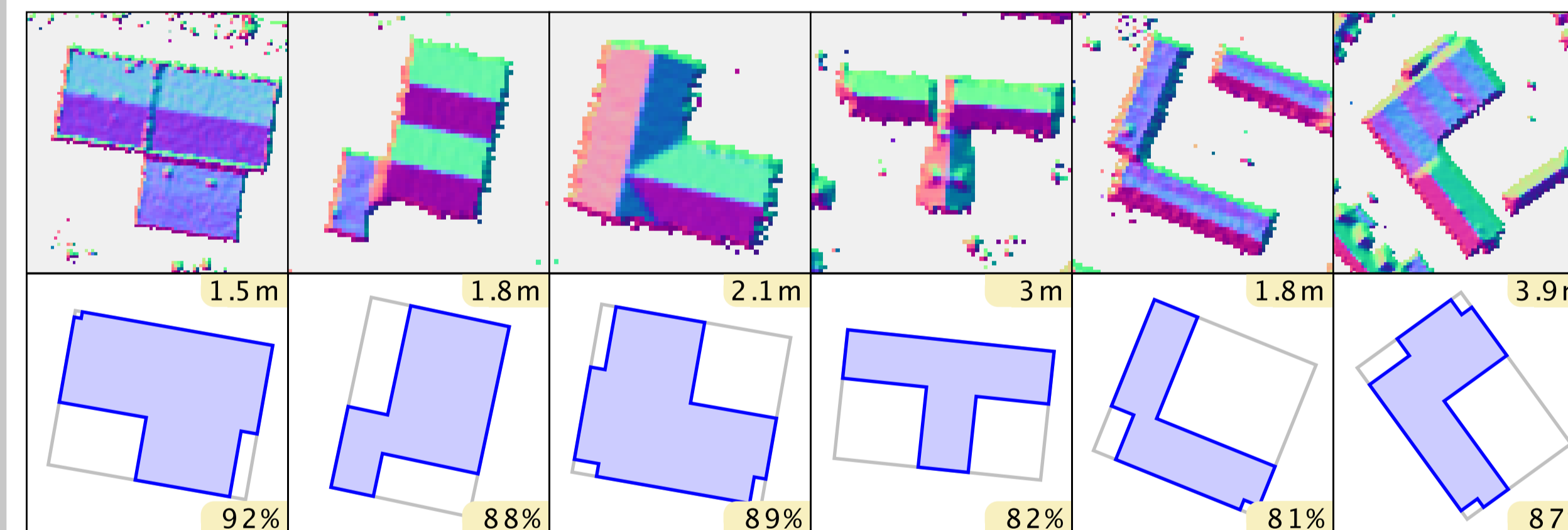
The Key Idea

intuitive, data-driven, deterministic.

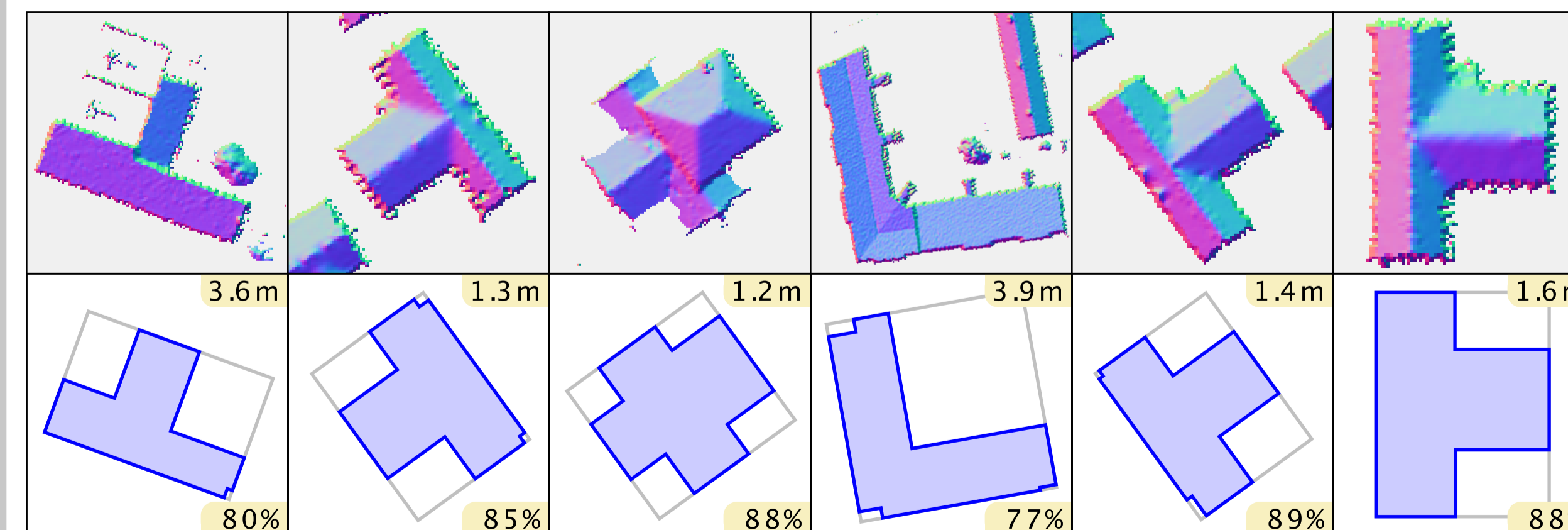


a real-world example from the 50cm point-spacing city of London dataset (from left to right) input-range-points, normals, difference of elevation building segment, resulting automatic L-shape footprint (scan-converted boundary in gray, eat-away hull in blue)

4 → Experimental Results



building footprints automatically recovered from 1m point-spacing airborne range scans of the City of Bath, UK - input (top-row) and output (second-row) with error-measures



building footprints automatically recovered from 25cm point-spacing airborne range scans of the City of Manchester, UK (with error-measures shown for each polygon)

5 → Further Research

- Optimise** → nearest-neighbour and point-inside-polygon tests using sweep-line for faster detection.
- Optimise** → efficiency of initial Hough-transform for MABB, using convex hull and or recursive evaluation.
- Extension** → to 2.5D parallax building masses.
- Extension** → to full 3D Mahanttan style buildings.
- Extension** → generalisation from the Hough transform quad to 'eating-away' at the convex hull.
- Extension** → via the inclusion of alternative corner types such as those illustrated in the output polygon cell of the overview - and further eating-away at edges.
- Evaluation** → relative to open-street map data.

6 → References

- 1 → SZELISKI, R. 2010. Computer vision: algorithms and applications. Springer.
- Research funded by: Cityscape Digital and EPSRC. Airborne range scans of the cities of Bath, Manchester and London courtesy of the Environments Agency.