Towards detailed building typology by urban-scale 3D building decomposition

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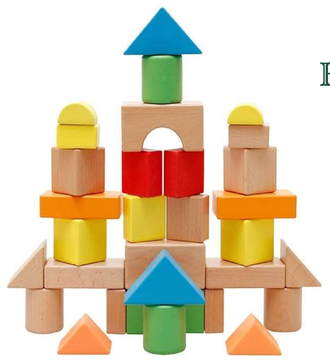
1. Introduction

- Urban-scale building shape analytics is crucial for identifying building functions, analyzing urban morphology, and understanding how building shapes and their distribution affect microclimate and energy consumption.
- However, both traditional building shape analytics based on 2D footprints and exploratory studies on 3D building models describe building shape as a whole, i.e., a polygon in 2D or a polyhedron in 3D. It fails to capture the shape primitives composing a building and obscures the building massing customized for functionality and performance.



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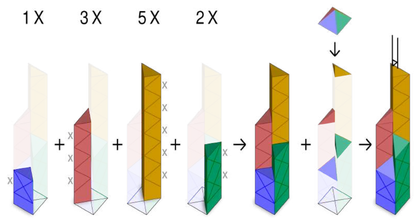
Building as parts?

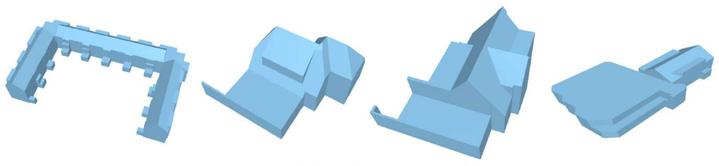


src: Wikipedia-Bank of China Tower

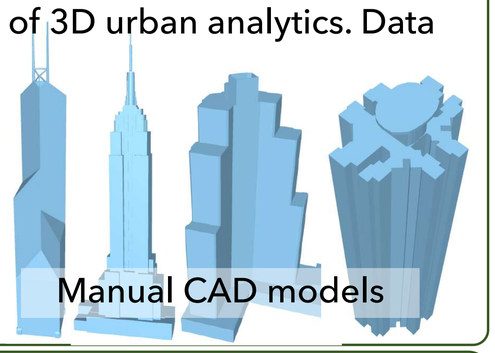
- We transfer the classic task of **shape decomposition** from the field of computer graphics into urban analytics to address this limitation.
- Building shape analytics then separates a building into smaller primitive parts. Adjacency between parts derives a graph for shape characterization. We then can use this graph to identify and cluster the shape typology of buildings.

2. Data

Advances in reality capture technologies, such as LiDAR scanning and photogrammetry, have significantly improved the accessibility and detail of 3D building models. Recent developments in 3D reconstruction, including neural radiance field (NeRF) and Gaussian splatting, further broaden the potential for the widespread adoption of 3D building models on urban and global scales. 3D building models are expected to become a fundamental data source for a broad range of 3D urban analytics. Data used in this study include:



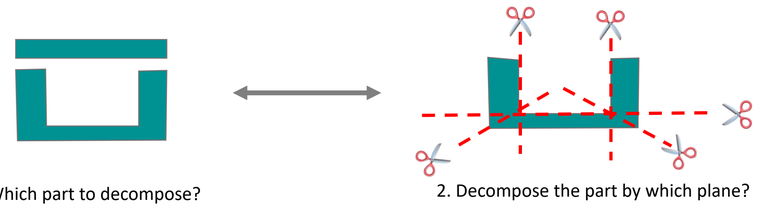
Reconstructed lightweight models
(from point clouds or photogrammetry meshes)



Manual CAD models

3. Method: BuildingCut

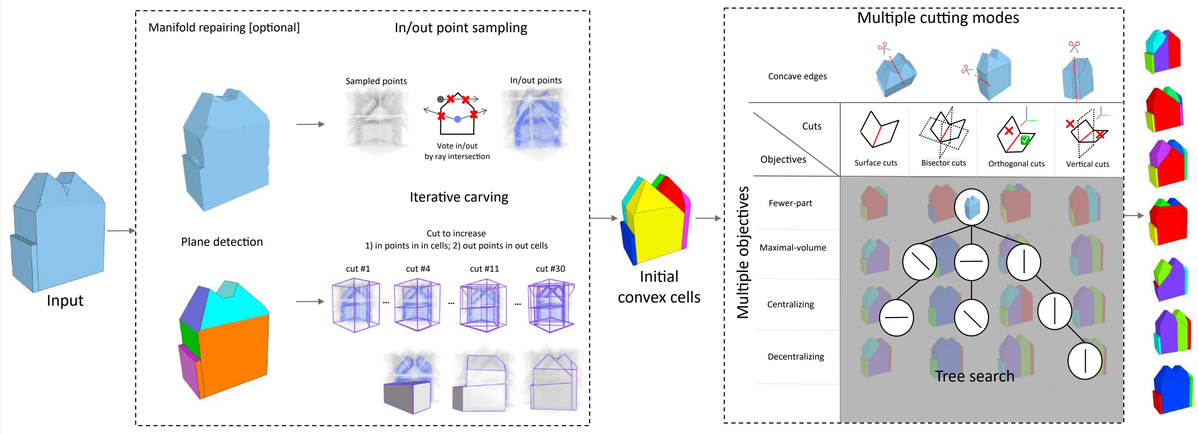
Atomic 2 steps to decompose a shape



1. Which part to decompose?

2. Decompose the part by which plane?

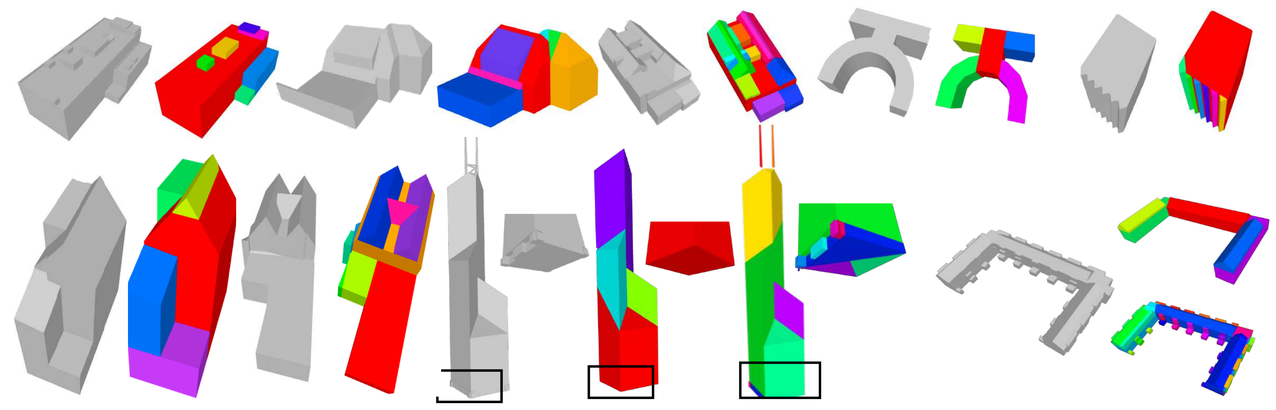
Framework of BuildingCut



Stage 1: Preprocessing

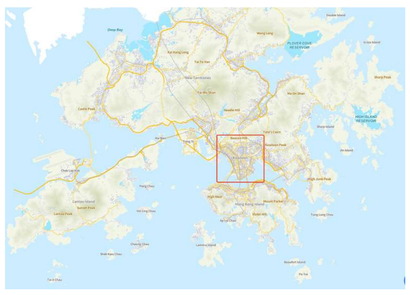
Stage 2: Decomposition framework

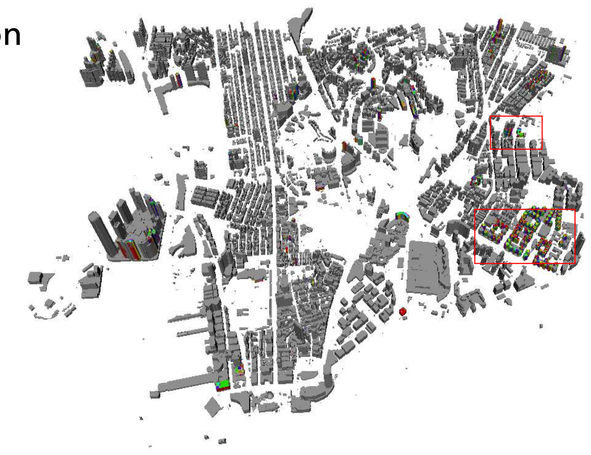
4. Result gallery



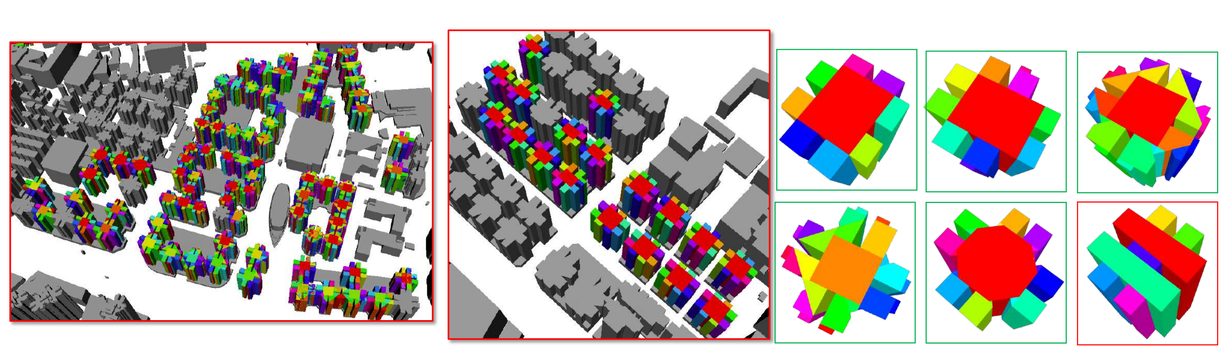
5. Urban-scale experiment

Experiments have been conducted on more than 8,000 buildings in Hong Kong.

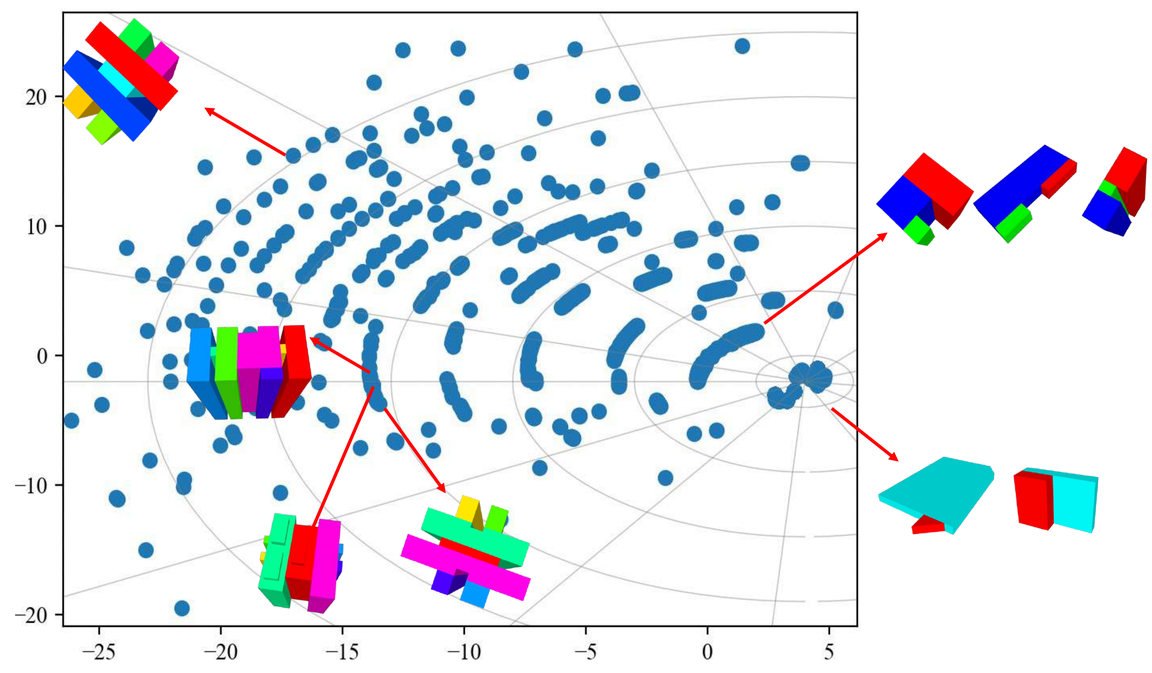




Our method successfully detected the typical 8-wing buildings of Hong with precision and recall above 90 %.



The visualization of multidimensional scaling on pairwise similarity between the decomposition graphs of each building displays a distinct layering of the complexity of building typology.



6. Conclusion

Our pilot results validate the feasibility of using 3D building decomposition for more detailed building typology. The experiments also demonstrate a strong potential for scaling our method to urban-scale 3D building shape analytics to empower future applications with rapidly expanding 3D building models.

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References

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Nan & Wonka. 2017 Polyfit: Polygonal surface reconstruction from point clouds. (ICCV)

Will be Open! Our method and test samples will be released at https://github.com/eiiijiiiy/ after paper submission (Perhaps by Dec. 31 2024!)

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