Mesh based representation of urban areas

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Abstract. *We present a robust and automatic method to generate an idealized surface geometry of a city landscape ready to be meshed for non-viscous flow simulations. The city geometry is idealized and reproduces the topography and the city blocks. Our method needs three main steps. First, a 2D mesh of the cadastre is generated. Second, 2D mesh is deformed to reproduce the topography according to a least-squares criterion. Third, we extrude the city blocks according to the height of the corresponding buildings. Finally, we illustrate the main application of our method by obtaining a surface representation and a tetrahedral mesh for the city of Barcelona in Spain.*

Problem statement

Input

City streets and blocks: Barcelona cadastre

City topography: Barcelona Digital Elevation Model (DEM)

City details: Barcelona Light Detection And Ranging (LiDAR)

Requirements

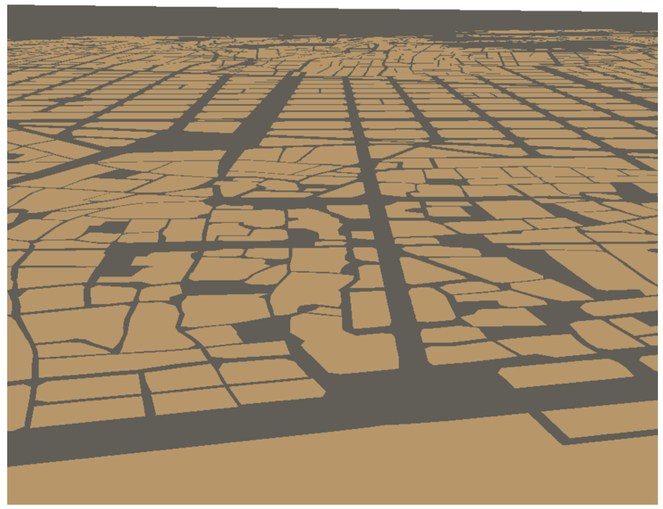
- **Detail removal.** City surface models may contain features such as cars, trees and other elements that have to be ignored by the final mesh.
- **Streets and buildings.** The fluid flow will be determined by the distribution of the city streets, which are defined by the surrounding buildings.
- **Topography.** The slope of the city underlying terrain influences the flow results and therefore, has to be captured by the simulation geometry.
- **Automation.** Reduce tedious, time-consuming and error-prone human intervention.
- **Element count.** Critical in daily operational frameworks, such as air quality forecasts, to deliver simulation results timely.
- **Surface marks.** Features such as urban surface, buildings or pollutant emission inventories have to be marked on simulation geometry.

References

[1] J. R. Shewchuk, Triangle: Engineering a 2D Quality Mesh Generator and Delaunay Triangulator, Lecture Notes in Computer Science, 1148, 203–222, 1996.
[2] H. Si, Tetgen, a delaunay-based quality tetrahedral mesh generator, ACM Trans. Math. Softw. 41(11), 1–36, 2015.
[3] A. Gargallo-Peiró, X. Roca, J. Peraire, J. Sarrate. Optimization of a regularized distortion measure to generate curved high-order unstructured tetrahedral meshes, Int. J. Numer. Meth. Eng. 103, 342–363, 2015.

Methodology and results: Barcelona area

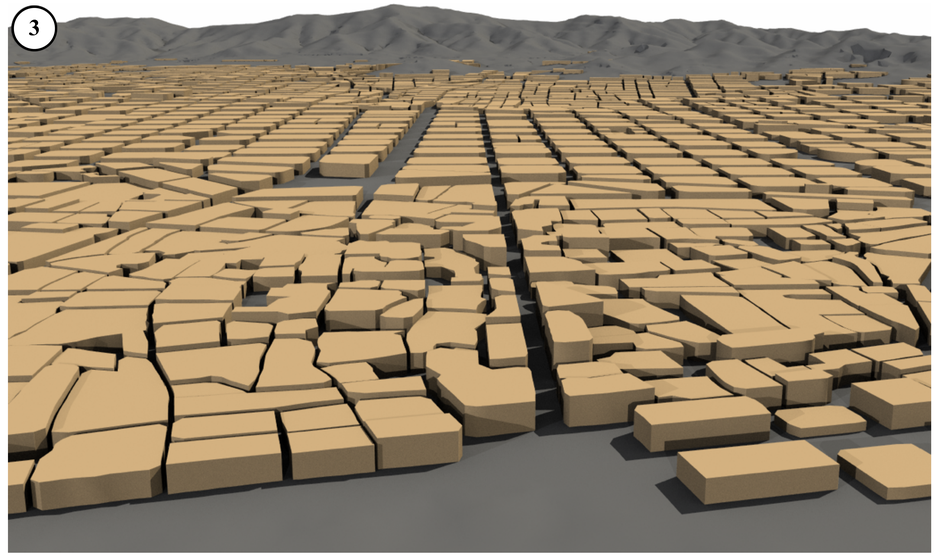
1



Incorporate city block limits (planar mesh):

- Set the desired sizes for the 1D, 2D and 3D mesh entities.
- 1D mesh of the cadastre of desired size.
- 2D planar triangular mesh [1] constrained to the 1D mesh.

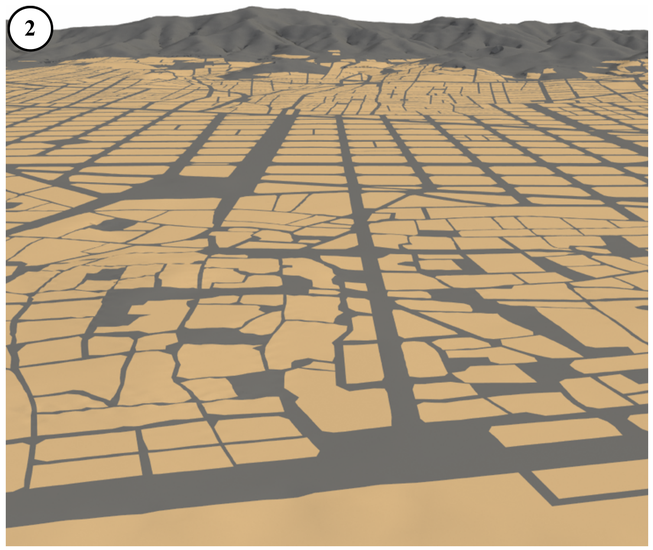
3



Generate the geometry representation of the urban area (surface mesh):

- We duplicate the block boundary nodes to insert city block facades and roofs.
- Roof heights computed as the average block heights from the LiDAR data.
- The output is a surface mesh representation of the urban area geometry.
- Number of nodes: 1M. Number of elements: 2M. Computational time: 113 sec.

2



Incorporate underlying topography (surface mesh):

- Deform the previous 2D mesh to accommodate the topography (DEM) under a least-squares criterion.
- This mesh is conformal with the cadastre blocks.

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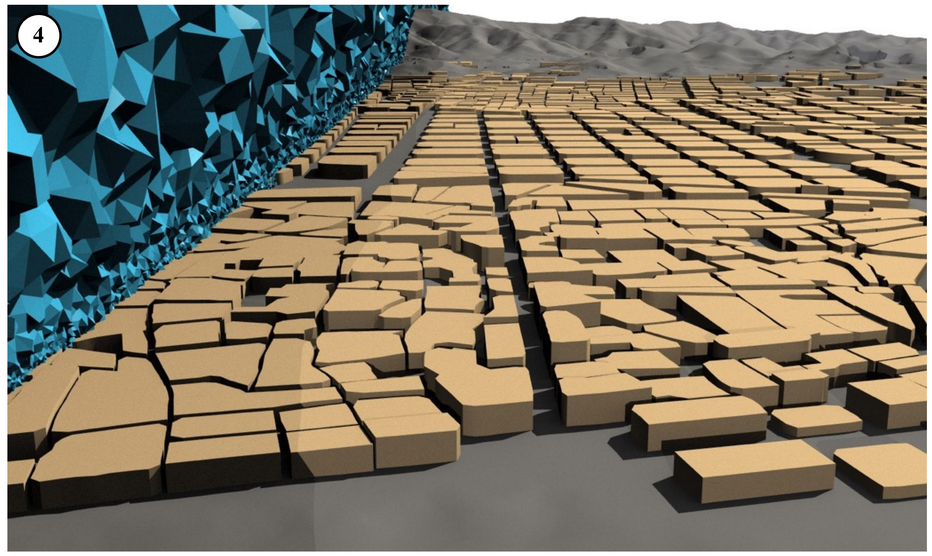

Generate the tetrahedral mesh for non-viscous flow simulation (volume mesh):

- We generate a tetrahedral mesh [2] bounded by our geometry representation of the urban area.
- We check and optimize [3] the quality of the obtained meshes.
- Number of nodes: 10M. Number of elements: 60 M. Computational time: 104 min.