3D building extraction from aerial LiDAR enhanced by fusion with cartographic data: a case study

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Abstract. The continuous advancements in technologies such as Light Detection and Ranging (LiDAR) enable automated solutions for various urban studies. Airborne LiDAR technology generates detailed three-dimensional (3D) maps of terrain, directly measuring the Earth's topography to create 3D point clouds over vast areas. This study focuses on Rimini and utilizes LiDAR for 3D building extraction at different levels of detail and compares open source and commercial software. Specifically, it examines the fusion of LiDAR data with cartographic data to enhance model accuracy by addressing challenges like irregular building shapes, incomplete datasets, and varying point densities. The results highlight significant improvements in 3D models when integrating cartographic data with LiDAR, demonstrating the potential for accurate urban modeling in applications like urban planning and disaster management.
Key Words: LiDAR, 3D Building Extraction, Urban Modeling, Data Fusion

This paper explores the integration of Light Detection and Ranging (LiDAR) airborne data with cartographic information to enhance the accuracy of three-dimensional (3D) building extraction for a city. The case study is the city of Rimini, Italy. LiDAR scanners emit laser pulses that permit to determine the 3D coordinates of terrain and objects (buildings, vegetation, …), based on the time delay of pulse reflections and integration with GNSS and IMU sensors [1, 2]. The study compares open-source and commercial software for 3D modeling of buildings, emphasizing the benefits of data fusion for overcoming challenges such as irregular building shapes, incomplete datasets, and varying point densities. The results demonstrate significant improvements in model accuracy and detail in comparison to the use of just LiDAR data with low point’s density. Rimini, located along Italy's Adriatic coast, blends historical richness with modern structures, making it an ideal location for urban modeling studies [2]. The study utilizes LiDAR data from Rimini's municipality, comprising two datasets with varying point densities and coverage areas. These datasets, which are at a fairly low density, are merged to enhance spatial coverage and data completeness, essential for accurate 3D modeling [3].

The paper explores 3D building extraction techniques at different Level of Detail (LoD1 and LoD2) using both free (LAStools and QGIS) and commercial (ArcGIS Pro) software. At LoD2, the study focuses on roof structure representation while for LoD1 a simple 3D model of building is generated. Methods involve:

- Data Processing: Noise removal, ground/non-ground classification, building classification, and height determination using the LiDAR data.
- Building Extraction: Building height and footprint extraction from the LiDAR point cloud and cartographic datasets.
- Model Generation: Extrusion of building footprints to create 3D models.

The study's findings emphasize the critical role of data fusion in enhancing 3D building models' accuracy and detail. Integration with cartographic data (which are 2.5D data, i.e., containing the building footprints and heights data) improves height determination and resolves challenges like multiple roof levels and irregular building shapes. **Fig. 1** illustrate comparative results of 3D models generated solely from LiDAR data and those enhanced through fusion with cartographic data.

Advanced software tools like ArcGIS Pro and LASTools, and open-source solutions such as QGIS, facilitate comprehensive urban modeling but require careful consideration of data quality and processing techniques. Future research should focus on optimizing automated pipelines and developing algorithms to further improve urban modeling applications.

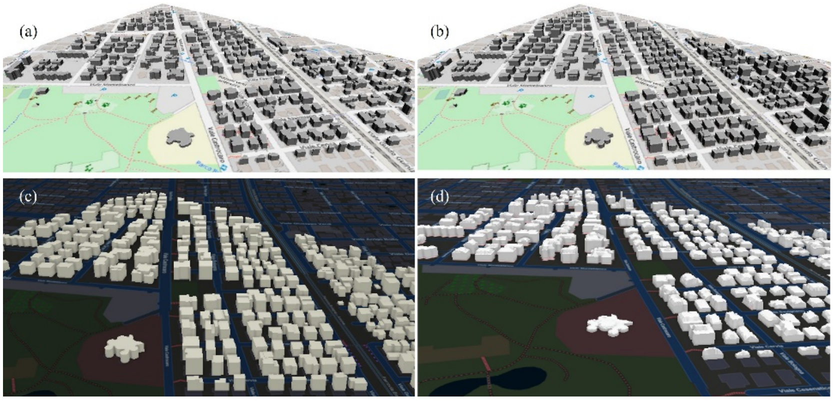

Fig 1. *3D building model; (a) from LiDAR data, processing by LASTools and QGIS, LoD1, (b) from fusion of LiDAR and cartographic data, proc. by LASTools and QGIS, LoD1, (c) from fusion of LiDAR and cartographic data, proc. By ArcGIS-Pro, LoD1, (d) from fusion of LiDAR and cartographic data, proc. by ArcGIS-Pro, LoD2*

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