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AI-Prompted Workflows for Building Footprint Extraction from LiDAR Data: A Comparative Analysis with Traditional GIS Methods

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Abstract:

Automated extraction of building footprints from LiDAR data represents a fundamental task in the fields of remote sensing and geoinformatics, particularly in the context of large-scale spatial data processing and urban mapping, and the creation of cartographically suitable building datasets. Despite the availability of advanced tools implemented in commercial platforms such as ArcGIS Pro and widely used open-source GIS software such as QGIS, a research gap persists in the systematic use of generative artificial intelligence—specifically prompt-driven programming using artificial intelligence (AI)—for the development of reproducible, flexible, and scalable geospatial workflows. Existing methodologies are often implemented as opaque “black-box” solutions or require significant domain expertise for efficient parameter adaptation and tuning. Furthermore, comprehensive evaluations comparing AI-assisted approaches with conventional GIS-based methods remain limited.

This study presents the design and implementation of a semi-automated workflow for extracting building footprints from classified LiDAR point clouds, developed through iterative, prompt-based interaction with large language models (LLMs), namely ChatGPT (OpenAI) and Claude (Anthropic), used for the generation, refinement, and documentation of geospatial processing workflows. The proposed methodology integrates standard geospatial processing techniques, including point cloud rasterization, morphological filtering, and raster-to-vector conversion, followed by adaptive regularization, geometric generalization, and orthogonalization of the extracted building footprints. The regularization process is performed with adaptive tolerances depending on building size, point density, and geometric complexity. To improve geometric consistency and cartographic quality, building footprints are iteratively adjusted through edge alignment, orthogonalization, and, where necessary, rotation. The rotation is optimized to preserve dominant building directions, agreement with the original point cloud, and the position of the building centroid. This enables the generation of geometrically regularized footprints while minimizing deviations from the source data. The workflow was created iteratively through prompt engineering, where successive prompts were used to generate, modify, test, and refine individual processing steps and algorithm parameters based on intermediate results. A multi-scale processing strategy is also incorporated, enabling the analysis of spatial data at multiple resolutions and thereby improving the detection and delineation of buildings with varying spatial extents and geometric characteristics.

The effectiveness of the proposed workflow is evaluated through a comparative analysis with outputs generated using established tools within ArcGIS Pro, QGIS, as well as a custom Python program utilizing available librariesas (Ďuračiová et al., 2026). Quantitative evaluation is conducted using an aggregated shape similarity index (Ďuračiová, 2023), combining set similarity, boundary distance, and differences in area, perimeter, and number of vertices, complemented by a cartographic assessment of geometric fidelity performed in GIS software. Particular attention is paid to the geometric quality, regularization, and cartographic usability of the resulting building footprints. Representative examples of the resulting building footprints and their comparison with reference data and conventional GIS-based approaches are presented in Fig. 1.

The results indicate that AI-assisted, prompt-driven workflows can achieve a level of geometric accuracy comparable to traditional approaches while offering increased adaptability and reproducibility. In addition, the explicit representation of workflows through prompts contributes to improved documentation and methodological clarity. However, certain limitations have been identified, particularly in terms of the robustness of geometric regularization, sensitivity to input data quality, and the processing of large data volumes. At the same time, the investigated task benefits from the fact that

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the resulting building footprints can be readily verified through visual inspection and comparison with reference data. This reduces the risk of unnoticed errors in the generated workflow and results. Such straightforward validation may not be possible for all geospatial analyses, where AI-generated errors can be more difficult to detect and assess. Furthermore, not all buildings were represented with the same level of geometric quality. The most problematic cases were geometrically complex structures and buildings characterized by a lower density of LiDAR points, for example due to partial occlusion by surrounding vegetation. Nevertheless, the integration of generative AI into geospatial data processing workflows represents a promising direction for the development of automated building footprint extraction and regularization. The combination of AI-driven methodologies with established GIS techniques has the potential to enhance efficiency, reproducibility, methodological transparency, and the production of cartographically consistent building datasets for spatial analysis and mapping applications.

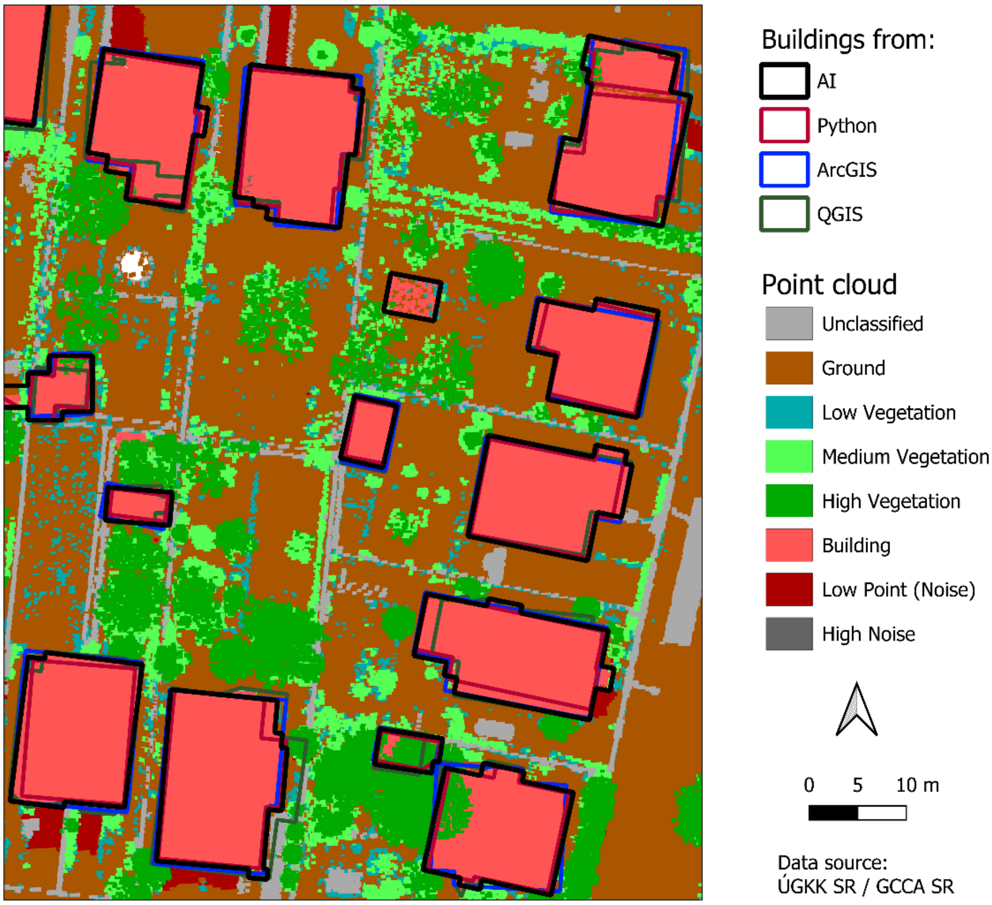

Figure 1. Comparison of building footprints extracted using the proposed AI-assisted workflow, ArcGIS Pro, QGIS, and a custom Python program. Source LiDAR data: Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA SR).

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