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Urban Building Footprint Extraction using Graph Neural Networks and Assessed OpenStreetMap Data with Sentinel-2 Imagery

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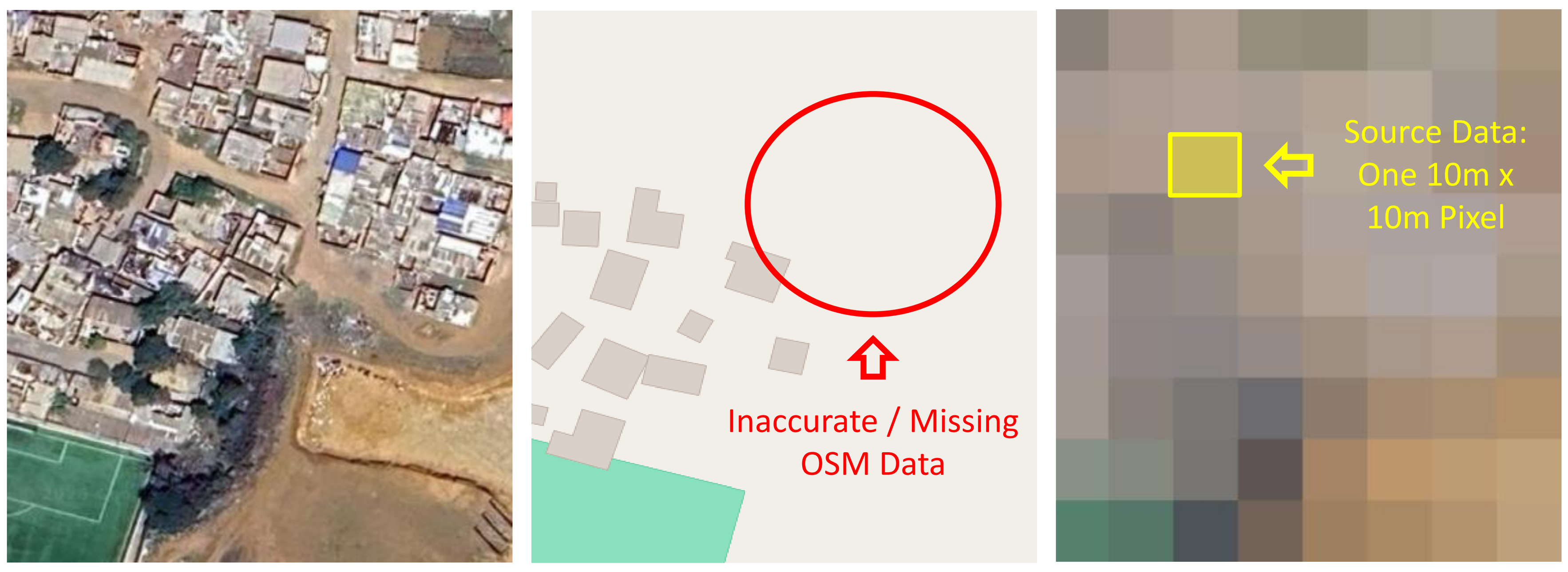
INTRODUCTION & AIM

Accurate building footprint data is critical for sustainable urban planning (SDG 11) and disaster management. However, automated extraction is hindered by a two-fold challenge: the inconsistent quality of crowdsourced OpenStreetMap (OSM) data used for training, and the technical difficulty of modeling complex urban shapes from medium-resolution Sentinel-2 imagery. This study aims to overcome these challenges by introducing and validating a novel, data-centric framework for robust building footprint extraction.



(a) Ground truth (b) Inaccurate OSM (c) 10m Sentinel-2

Figure 1: Comparison of High-Resolution Ground Truth and Sentinel-2 Imagery, Highlighting Data Inconsistencies in OpenStreetMap

METHOD

Our data-centric method consists of two main stages. First, a high-confidence ground truth dataset is generated by cross-validating three open data sources (OSM, Google Open Buildings, Overture Maps) and applying a temporal stability analysis to filter errors. Second, Sentinel-2 imagery is transformed into a graph structure by segmenting it into superpixels, which serve as graph nodes. Our proposed UrbanGraphSAGE model is then trained on this graph to classify each node as 'building' or 'non-building' by learning from both spectral features and spatial context.

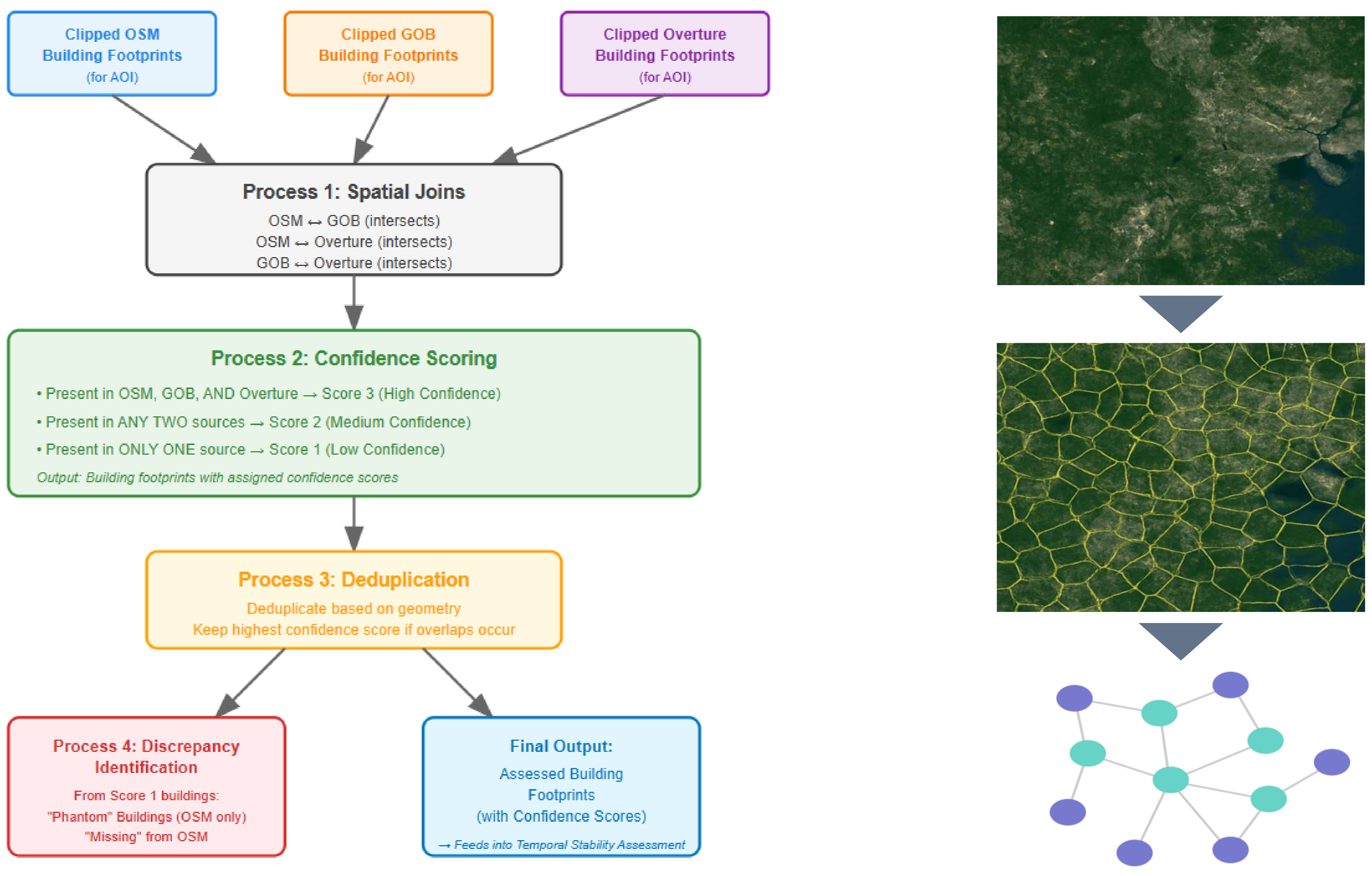
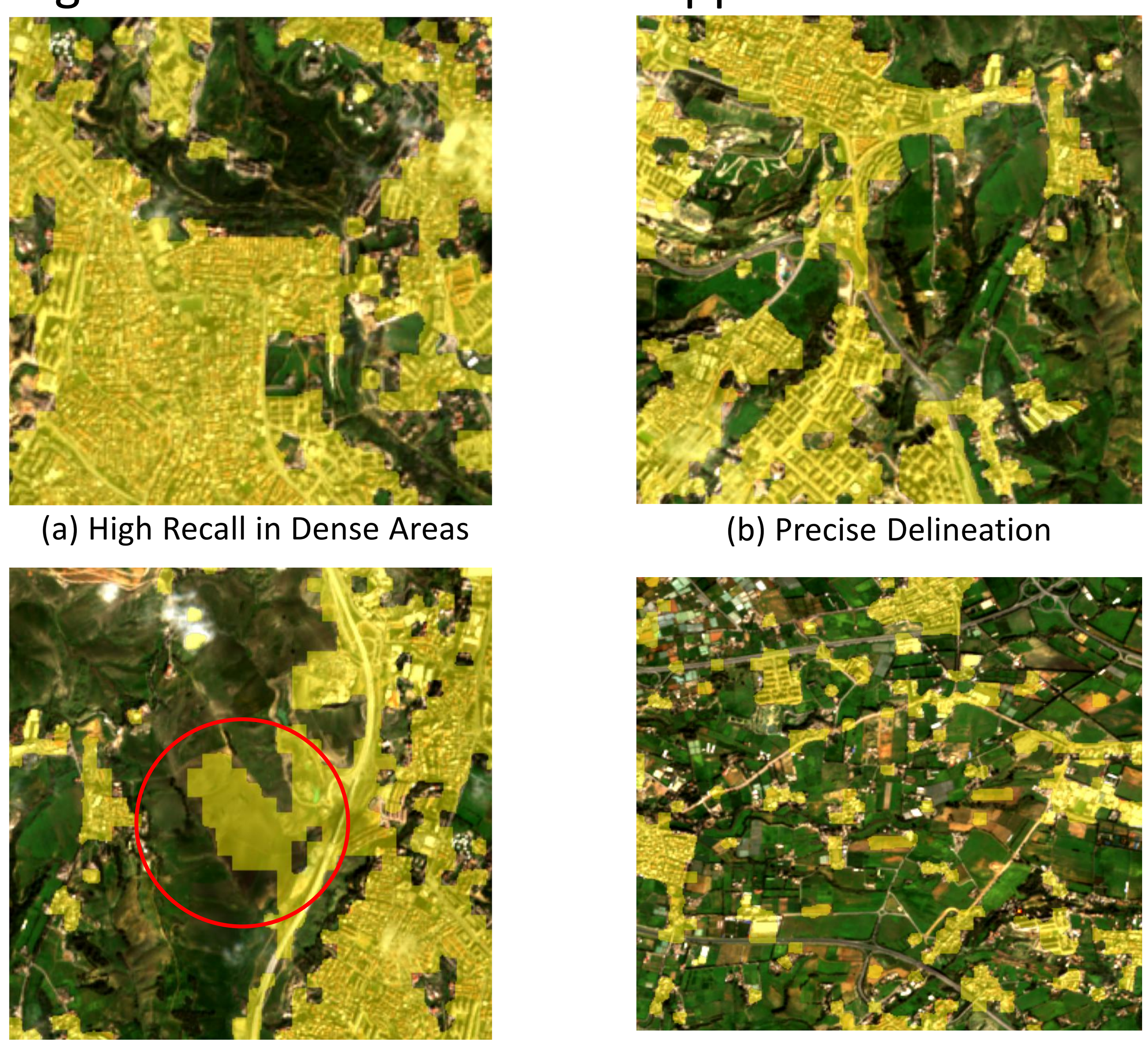


Figure 2: Flowchart Illustrating the Proposed Data-Centric Method for Building Footprint Extraction

RESULTS & DISCUSSION

Our data-centric framework demonstrated robust performance on the complex urban test set of Algiers. The final model achieved a strong F1-Score of 0.76 and a particularly significant high recall of 0.92, confirming its effectiveness at minimizing the omission of existing buildings. Analysis of the results highlights the GNN's ability to delineate buildings in dense areas, but also reveals challenges related to spectral confusion with non-building surfaces like bare soil, which is a persistent issue with medium-resolution imagery. Overall, the findings validate that a rigorous data assessment pipeline is foundational to achieving reliable results in GeoAI applications.



(a) High Recall in Dense Areas (b) Precise Delineation

(c) Spectral Confusion (d) Small Structures

Figure 3: Qualitative Results of UrbanGraphSAGE Building Footprint Prediction

CONCLUSION

This research validates a novel, end-to-end framework integrating a rigorous data-centric pipeline with a Graph Neural Network. The model achieved a high recall in Algiers, proving its effectiveness for creating comprehensive urban inventories. The methodology provides a scalable, low-cost, and replicable tool for planners and disaster managers, leveraging the power of open data.

REFERENCES

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