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Graph-Based Modeling of Village Infrastructure Development

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Introduction

This study introduces a framework for village classification, quality benchmarking, and infrastructure enhancement strategy formulation using clustering and grouping techniques. It aims to achieve next objectives: creating a computationally efficient method for village analysis, establishing a classification system for village infrastructure quality assessment and implementing Graph Convolutional Networks (GCN) to evaluate village infrastructure quality based on descriptive graph analysis.

Data and Method

This study uses geospatial data from OpenStreetMap (OSM) to evaluate village infrastructure quality. Key indicators include locations and descriptions of various infrastructure elements such as cities, parks, banks, churches, educational institutions, hotels, kindergartens, libraries, medical facilities, and shops. The data is represented in two forms: tabular identifiers (distances to infrastructure objects) and descriptive graphs with parameterized connectivity. Constraints are applied to the graph data, limiting distances to 50km or 30km for different infrastructure types and setting a maximum of five objects per type. After that data is being categorized and processed with clustering and deep learning techniques.

Results

The main result of this study is the methodology for computing villages' infrastructure development level using graph data engineering. This method clusters villages in Ukraine by infrastructure quality and identifies imbalances in local amenities like schools, clinics, and shops. The model is applicable to various countries and infrastructure indicators, enabling the identification of areas for improvement across different development stages. In the research, we have proven that in Ukraine, libraries are less accessible than kindergartens, while shops, medical facilities, and educational access are comparatively similar.

Conclusion

The method has been tested and works well for evaluating village infrastructure using easily accessible geospatial data. The advantage of graph-based deep learning approach is its ability to be customized to local conditions and expanded to incorporate new data types. Future studies will include the cost-effectiveness of the recommended improvements to village infrastructure.

Keywords

Spatial Data Analysis, Machine Learning, Clustering, Graph Convolutional Networks, Geoinformatics, Village Classification