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Advancing urban analytics through integration of NLP, graphs and GIS

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Abstract:

Contemporary urban development is characterized by increasing complexity, as evidenced by nonlinear growth patterns, interconnected investment decisions, and intricate spatial-temporal relationships. This complexity is highlighted by the findings of Patorniti et al. (2018), who advocate for a sociotechnical systems approach to urban planning, emphasizing the importance of transdisciplinary methodologies to capture the multifaceted nature of urban environments. This viewpoint is supported by Gashenko's (2019) research on pattern recognition in urban planning formations and Vempati's (2024) studies on AI integration in smart cities.

Despite significant advances in urban analytics, integrating various aspects of urban analysis remains difficult. Traditional GIS-based approaches, while effective for spatial analysis, lack the ability to integrate textual data with temporal dynamics in unified analytical frameworks (Zhou et al., 2020). Similarly, Li et al. (2020) emphasize the importance of incorporating multiple data sources to gain a comprehensive understanding of urban dynamics. Graph theory has opened up new avenues for modelling spatial relationships in urban environments, particularly when examining transportation and infrastructure networks (Domingo et al., 2019).

However, previous applications of graph theory in urban studies have primarily focused on spatial aspects, ignoring integration with textual data and temporal analysis. As a result, there are few methodologies for analyzing the semantic content of urban documents, spatial relationships between objects, and the temporal dynamics of development processes all at the same time. In this study, we present an integrated analytical framework that encompasses three dimensions: semantic, spatial, and temporal.

Our objective is to uncover, quantify, and interpret latent patterns and relationships within investment processes in urban environments. The aim of the study is to integrate quantitative, semantic, and graph analyses into a coherent research framework for a better understanding of urban investment dynamics. By integrating these layers, we can reveal complex interdependencies; for instance, components with similar quantitative characteristics may exhibit high semantic diversity and varying complexities in investment activities.

Spatial analysis of the identified process types uncovers distinct patterns of urban development, highlighting the diverse spatial dynamics of the city. The results can provide urban planners and policymakers with tools to visualize development patterns, monitor trends, and assess the compatibility of investment activities with strategic planning goals, thus contributing to the advancement of modern urban analytics.

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