Modeling Spatiotemporal Patterns for Next-POI Recommendation: A Unified Approach Using Graph Embedding and Self-Attention

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***Abstract*—In recent years, the development of social media has made self-guided travel more convenient. However, the overwhelming amount of social media information has also made travel planning more challenging. Thus, point-of-interest (POI) recommendation systems have received increasing attention, particularly those leveraging users' historical check-in records. Despite notable advancements, existing approaches face several key limitations. First, most models concentrate on individual user trajectories, overlooking complex inter-POI relationships. Second, although temporal dynamics are considered, prior work emphasizes short-term variations while neglecting broader periodic patterns. Third, spatial dependencies are frequently oversimplified, with insufficient attention to specific geographic zones. Fourth, while deep learning methods have improved predictive performance, they still struggle to capture cyclical temporal trends. To address these challenges, this study proposes a next-POI recommendation system that integrates graph embeddings to model complex and interactive relationships among POIs. In addition, the system encodes user activities, considering both short-term and long-term temporal behavioral patterns. Moreover, we enhance spatial representation by employing a UTM (Universal Transverse Mercator) grid-based method, which more effectively captures geographic dependencies than traditional GPS coordinates. Finally, a transformer-based approach with a self-attention mechanism analyzes user check-in sequences, capturing complex behavioral patterns for more accurate and personalized recommendations. Experimental results demonstrate that incorporating graph and grid-based spatial features substantially improves prediction accuracy. Additionally, the proposed system outperforms both sequential and non-sequential baselines across multiple evaluation metrics, confirming the benefits of the proposed next-POI recommendation system.**

***Keyword*—POI Recommendation Systems, Graph Embedding, Temporal Features, Grid-based Spatial Encoding, Transformer.**

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