Semantic Embedding for Regions of Interest

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Introduction

We are now collecting geospatial information more than ever; spatial data sources are rapidly growing and diversifying. We can obtain large quantities geopspatial information such as annotated Places of Interest (POIs), check-in comments, geo-tagged microblog comments, and demarked **Regions of Interest (ROIs)**. All these sources interplay with each other, and together build a more **complete picture of the spatial and social dynamics for a region**. To accomplish the objective, we first devised the concept of semantic embedding for ROIs, that captures both the spatial and the semantic components together. We present an effective modeling approach with **a multipart network model (TNE), capturing semantic and spatial features of ROIs** to embed them in a latent semantic space.

Modeling

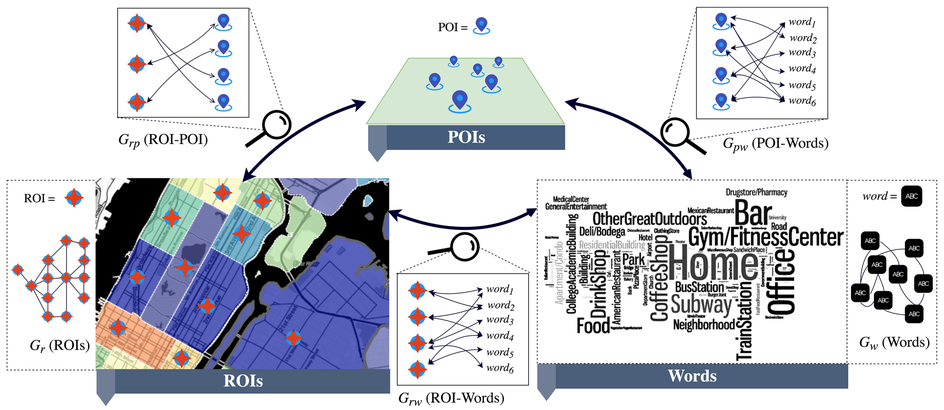


Fig 1. Information Graph Network $\mathcal{G}$, illustrating relations among/within ROIs, POIs and Words with bipartite graphs G_{rp}, G_{rw}, and G_{pw}, and homogeneous graphs G_r, G_w.

Modeling Overview

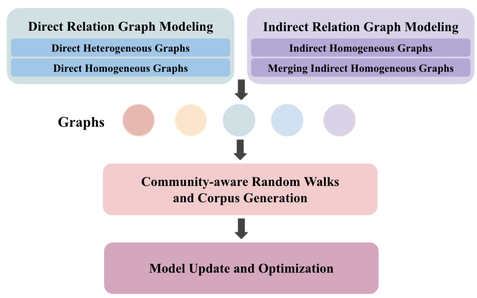


Fig 2. **Tripartite Network Embedding (TNE) modeling** approach overview. First, property preserving graphs are created with direct and indirect graph relation model, followed by community aware random walk and model optimizations.

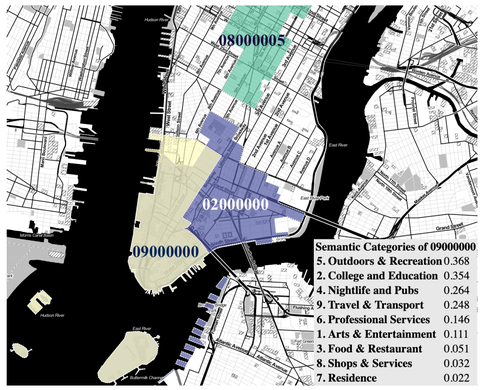


Fig 3. An example ROI from Lower Manhattan, New York City with Semantic Categories information from embedding with two semantically nearest neighbors.

Key Contributions

1. First paper defining the semantic embedding for ROIs capturing spatial and semantic features jointly.
2. The paper proposes a property preserving tripartite network embedding (TNE) that learns low-dimensional latent representations of ROIs.
   (a) TNE preserves transitive relation properties from mergeable indirect graphs.
   (b) TNE's community-aware random walks alleviates moderately connected community problem in graphs.
   (c) TNE proposes a new negative sampling over heterogeneous graphs which enhances learnability.
   (d) TNE is easily extendable to a general multi-partite network embedding problems.
3. Introduced semantic category annotation for ROIs that identifies the feature similarities of ROI with defined categories for semantic understanding. This also helps us to evaluate our ROI embeddings.
4. We present extensive experiments with real-world datasets to show qualitative advantage of ROI embedding with TNE. We compared TNE with state-of-the-art baselines from comparative related works to justify our embedding process through spatial and semantic facets.

Experiments and Results

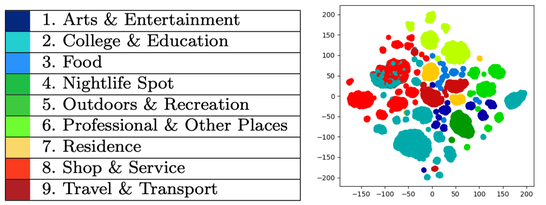


Fig 4. Semantic Categories and POI embeddings t-SNE plot from TNE. This verifies that TNE generates high quality POI embeddings too.

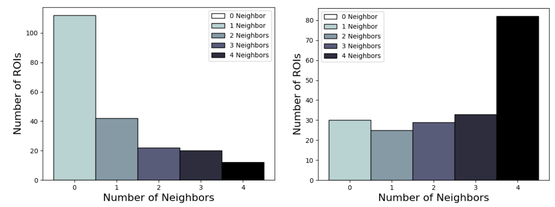


Fig 5. Histogram of spatially nearest neighbor from BiNE (baseline) and TNE(our) embeddings. More nearest neigbors signifies geospatial affinity preserved in TNE embeddings than BiNE embeddings.

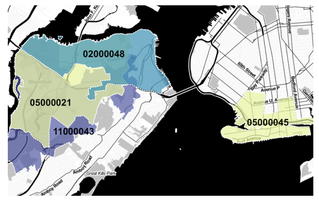
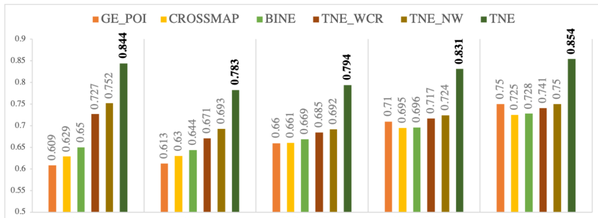
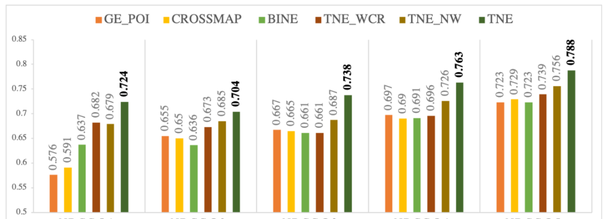


Fig 6. Nearest neighbors of ROI 43 from Staten Island semantically similar to ROI 45 from Brooklyn.



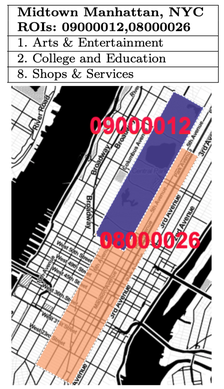
	NDCG@1	NDCG@2	NDCG@3	NDCG@4	NDCG@5
GE_POI	0.609	0.613	0.660	0.710	0.750
CrossMap	0.629	0.630	0.661	0.695	0.725
BiNE	0.650	0.644	0.669	0.696	0.728
TNE_WCR	0.727	0.671	0.685	0.717	0.741
TNE_NW	0.752	0.693	0.692	0.724	0.750
TNE	**0.844**	**0.783**	**0.794**	**0.831**	**0.854**

Fig 7. ROIs semantic category annotation ranking analysis of ROIs based on similarity between ROI embedding and category embedding. Ground truth semantic categories are crowdsourced.



	NDCG@1	NDCG@2	NDCG@3	NDCG@4	NDCG@5
GE_POI	0.576	0.655	0.667	0.697	0.723
CrossMap	0.591	0.650	0.665	0.690	0.729
BiNE	0.637	0.636	0.661	0.691	0.723
TNE_WCR	0.682	0.673	0.661	0.696	0.739
TNE_NW	0.679	0.685	0.687	0.726	0.756
TNE	**0.724**	**0.704**	**0.738**	**0.763**	**0.788**

Fig 8. Semantic category ranking analysis of ROI pairs with contrastive features. The map shows Midtown Manhattan, NYC has top three contrastive features from Central Park on Arts Entertainment, Education and Shops Service categories.



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