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Towards Mapping Place Semantics: A Geosocial Media Data Approach for Geo-Semantic Analysis and Place Similarity Computation

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Abstract:

Place semantics refers to the collective socio-cultural values, experiences, and functions that people associate with specific geographic locations, turning mere spaces into "places imbued with meaning" (Tuan, 1977). Studying place semantics has traditionally spanned several disciplines, including geography, sociology, environmental psychology, and geographic information science, each contributing different perspectives on how places are perceived and valued. The advent of user-generated content platforms, which provide vast quantities of geographically referenced textual data, has opened new avenues for the study of place semantics. Geosocial media data, such as tweets or textual metadata from geotagged images shared on Flickr and Instagram, offers insights into human activities, behaviors, and perceptions, thereby offering new opportunities to extract place semantics and analyze spatiotemporal interactions between people and places. (Purves & Derungs, 2015; Adams & McKenzie, 2013). Nevertheless, processing natural language data at scale presents significant challenges and necessitates the use of efficient text mining algorithms to manage the vast amounts of data involved. Recent advancements in natural language processing (NLP), especially the development of transformer based and large language models, have introduced powerful new methods for efficient information retrieval, greatly enhancing our ability to derive meaningful insights from extensive geosocial media datasets.

The overarching objective of this ongoing study is to model place semantics by leveraging state-of-the-art NLP methods to enable the capabilities of geo-semantic analysis and place similarity computation. The approach to modeling place semantics we propose employs neural topic modeling with BERTopic (Grootendorst, 2022) to extract the collective meaning people attribute to places, which are reflected through sociocultural views, experiences, and activities expressed in over 800.000 geosocial media posts shared on Twitter, Flickr, and Instagram in the city of Dresden. We then aggregate and transform the extracted information into document embeddings using Sentence-Transformers[1] (Reimers & Gurevych, 2019), so that each place is treated as a collection of semantic representations encoded into the high dimensional vector space. We go a step further and create place embeddings by geospatial indexing the document embeddings using hexagonal hierarchical geospatial indexing system (H3[2]). Thus, we are anchoring these semantic representations to a geospatial extent, which allows for the consideration of geospatial granularity and relationships. Just as word embeddings allow for the computation of word similarities in NLP tasks, these geospatially indexed document embeddings (our place embeddings) enable us to measure the semantic similarity between places. This capability facilitates complex geo-semantic analysis where places can be queried not just by physical proximity but also by their thematic and cultural similarities. For example, just as one might search for synonyms using word embeddings, one could also search for places with similar cultural characteristics or activity profiles, calculating the cosine similarity between place embeddings. Thus, by using this analogy, we leverage the established principles of semantic analysis in NLP and adapt them to the spatial domain, offering a novel framework to extract, encode, analyze, and communicate place semantics from geosocial media textual data.

Future work will focus on developing a system that facilitates interactive geo-semantic analysis, place similarity computation, as well as the visualization of place semantics at different semantic and spatial granularities.

[1] https://sbert.net/
[2] https://github.com/uber/h3

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