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GIS Investigation of Crime Prediction with an Operationalized Tweet Corpus

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Abstract: Social media as the de facto communication channel is being used to disseminate one's diurnal self-revelations. This profound discovery often contains double-talk, peculiar insights, or contextual information about real-world events. Natural language processing is regularly used to uncover both obvious and latent knowledge claims within disclosures published amid the complex environment. For example, a perpetrator with first-hand knowledge of their criminal incident uses social media to post critical information about it. A geographic information system (GIS) is capable of large-scale point data analysis and possesses methods that enable dataset processing, evaluation, and automatic spatial visualization. Such an artifactfused with traditional environmental criminology theory and social mediaerects guidelines, tools, and models for substantive construction and evaluation of GIS crime analysis solutions. Provided the social media stream is timely and correctly processed, corrective action can be taken. The construction of a natural language processing social media annotation pipe identifies latent indicators extracted from a social media corpus and is an integral part of societal mishap prediction. Spatial visualizations and regression analyses were used to describe and evaluate project artifacts. As a result, a social media corpus was operationalized, and subsequently used as a proxy for a traditional environmental criminology risk layer in construction of a social media GIS crime analysis artifact. Using such multi-domain collaboration, the artifact was able to increase the predictive crime incident outcome with an overall R-squared increase of 21.94%. This result is the state-of-the-art; there are no other results to compare it to.

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Introduction

Social media (e.g., tweets) are the de facto communication channel to disseminate one's diurnal self-revelations. This profound phenomenon contains double-talk, peculiar insight, and contextual data or information about real-world events. Amid such complex and personal expose, natural language processing (NLP) techniques uncover both obvious and latent knowledge claims published within.

A geographical information system is capable of large-scale data analysis and possesses methods that enable dataset processing, evaluation, and spatial visualization. When fused with traditional research theory—such an artifact defines guidelines, algorithms, and models for substantive and predictive investigation.

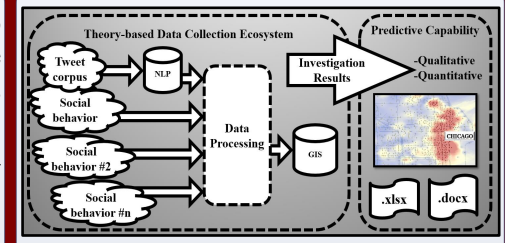
Objectives

Despite a tweet's sparse content, NLP makes their use in a predictive GIS artifact feasible. For example, subsequent to processing, useful tweets are able to:

- **Predict the validity of a real-world event only recorded by observation of social media eyewitness; or**
- **Predict real-time trends by amalgamating social media with traditional social behavior variables.**

Thus, inquiry explores GIS outcomes when consuming "useful" or "not useful" tweets as identified via NLP techniques. In addition, a research framework illustrates social media being coalesced with other behavior variables and subsequently used as a social behavior GIS proxy layer.

Research Framework

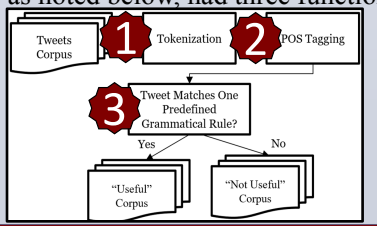


The research framework defines a process and exposes opportunity to fill the gap between sparse text social media and its representation of real-world events by examining meaningful tweet content and purging useless structures. That is, some tweets are so sparse they cannot represent the real-world context in which they exist; hence, a "Not Useful" tweet (illustrated in the table below). However, some tweets are "Useful" but require extra processing.

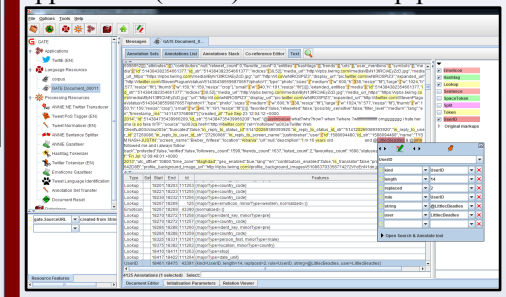
Useful	Not Useful
I'm at Old Navy in Chicago IL https://t.co/lczpu9NLF	balllooonnsss ??? http://t.co/mjhuKyH7DM
My Phone Die So Fast	WAYYOHANDSIDETOOSI
David Bowie is... my favorite! @ David wie is At Mca Chicago	Funniest
I aint gta stunt on nobody...trust me Yo LoL!	#CuppyCoffee!!!!!!!???
I can't wait to see lora tomorrow	@_lorShane ????

Tweets & Natural Language Processing

Operationalizing "useful" or "not useful" tweets was accomplished via the General Architecture for Text Engineering[1] (GATE) NLP suite of tools. The NLP pipeline built, as noted below, had three functions.

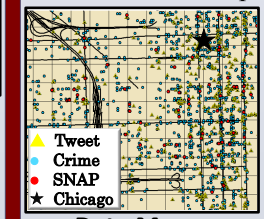


Therefore, it tokenized, part-of-speech tagged, and applied custom grammar rules to each tweet. A custom GATE NLP application (below) executed the pipeline.

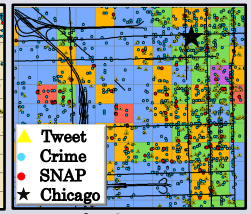


GIS Analysis

Association between features of a tweet, e.g., acronym use and its grammatical structure, and its potential usefulness were operationalized via NLP preprocessing. GIS capability examined both quantifiable and meaningful qualitative results; each are required in data analysis, information dissemination, and predictive artifacts.



Data Map



Solution Map

The maps represent the area of downtown Chicago with a fishnet spacing of 750 feet. Tweets,[2] crime,[3] and SNAP[4] locations are the variables displayed. The Data Map is a visualization of the data. The Solution Map represents the results of a GIS grouping analysis tool used for exploratory variable analysis; the attributes are combined and cell shading represents latent structures.

Discussion and Conclusion

With a novel NLP pipeline tweets were processed and used to measure the change in performance of an ArcGIS[5] 10.4.1 artifact. A 1,000 tweet sample was hand tagged and compared to a baseline model, and to an innovative social media grammar applied by a rule-based social media NLP pipeline. GIS evaluation tools answer the question, prior to content analysis of a tweet, does a method exist to support identifying a tweet as "useful" for subsequent GIS processing? Indeed, "useful" tweet identification via NLP returned precision of 0.9256, recall of 0.6590, and F-measure of 0.7699; consequently, exploratory GIS processing of a social media variable increased 0.2194 over baseline.

Predictive capability potential of a GIS artifact implementing social media's latent behavior attributes is vast. Yes, preliminary results are encouraging but future research is important and needs to identify its value.

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