Intersection Congestion Pattern and Traffic Bottleneck Identification in Cities

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Project Introduction

❖ What we do and why?

Traffic congestion is a severe issue in every big city that have wide influences. Our project aims at:

- **Recognizing and describing different congestion patterns among all the intersections.**
- **Exploring the spatial clusters of congested intersections in city to identify traffic bottlenecks.**

Compared to previous work researching congestion on abstract road segments, the project focus on real entities in road network: intersections. Meanwhile, we identify several set of traffic bottlenecks in Atlanta on the intersection level, which would be useful for government improving congestion optimization.

❖ Dataset in Project

- Get from Kaggle, **~850k rows of records**; describes the hourly intersection congestions states in Atlanta, Chicago, Boston and Philadelphia
- Aggregated by time slots (e.g. Morning Busy Hours, Evening Busy Hours) for further analysis

Approaches, Related Experiments and Results

1 Recognize Congestion Patterns

❖ Gaussian Mixture Model

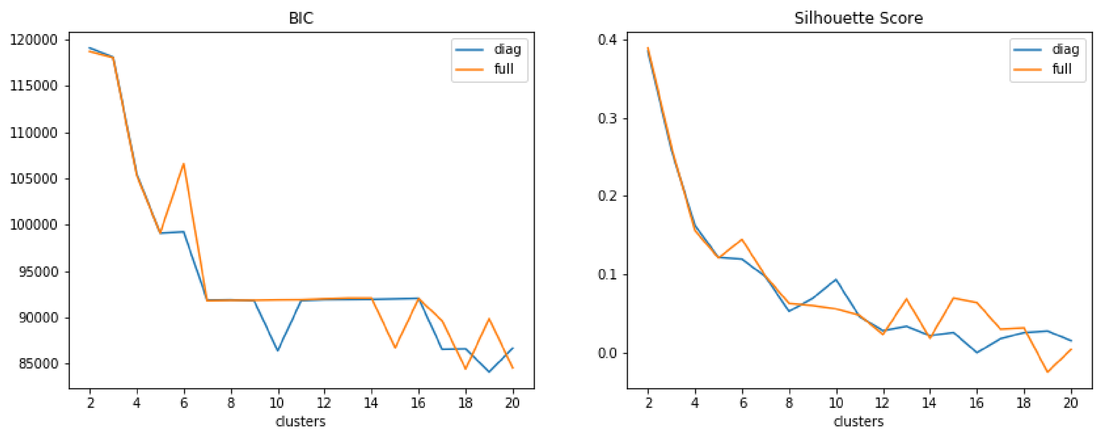
We use **Gaussian Mixture Model (GMM)** to cluster intersections based on the congestion time of left-turn, right-turn and going-straight at each intersection.

- Expectation-Maximization approach
- **More robust for multi-modal distribution**
- **Fit oblong, stretched-out clusters**

❖ Analytics Experiments

- Hyperparameter tuning on covariance type and number of clusters
- Metrics: **Bayesian information criterion (BIC) and Silhouette Score**.

Example: GMM Experiments for Weekday Evening Busy Hours



❖ Congestion Patterns Results

Described by two dimensions: **the degree of congestion and the difference congestion state among driving routes**.

Example: Congestion Patterns during Weekday Evening Busy Hours

Cluster Interpretation	Average Waiting Time of Clusters			Counts
	Left	Right	Straight	
Mild left and right turn congestion	24.6	17.9	0.0	1143
Median all way congestion	55.7	39.3	35.6	1224
Severe left turn congestion	113.0	55.4	70.6	104
Mild all way congestion	21.2	32.4	16.0	798
Mild left turn and go-straight congestion	32.2	8.0	17.6	1162
Severe right turn congestion	70.3	143.1	39.8	48

2 Spatial Clustering

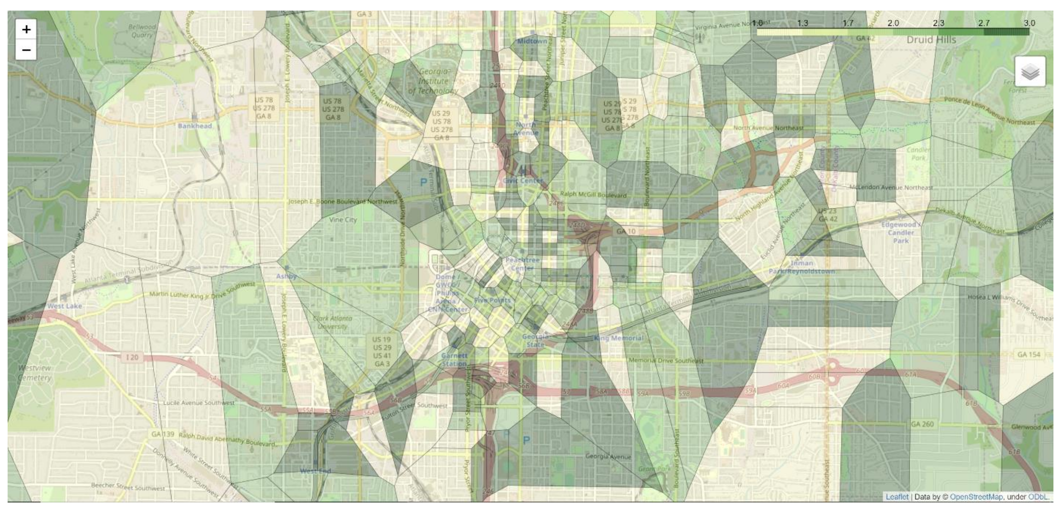
❖ AMOEBA Algorithm

AMOEBA is a spatial clustering method. Reasons for choosing AMOEBA:

- Not as sensitive as the traditional clustering methods to spatial distance. The similarity on other attributes can be reflected.
- Support the identification of irregularly shape of spatial clusters.
- Achieve spatial contiguity among spots

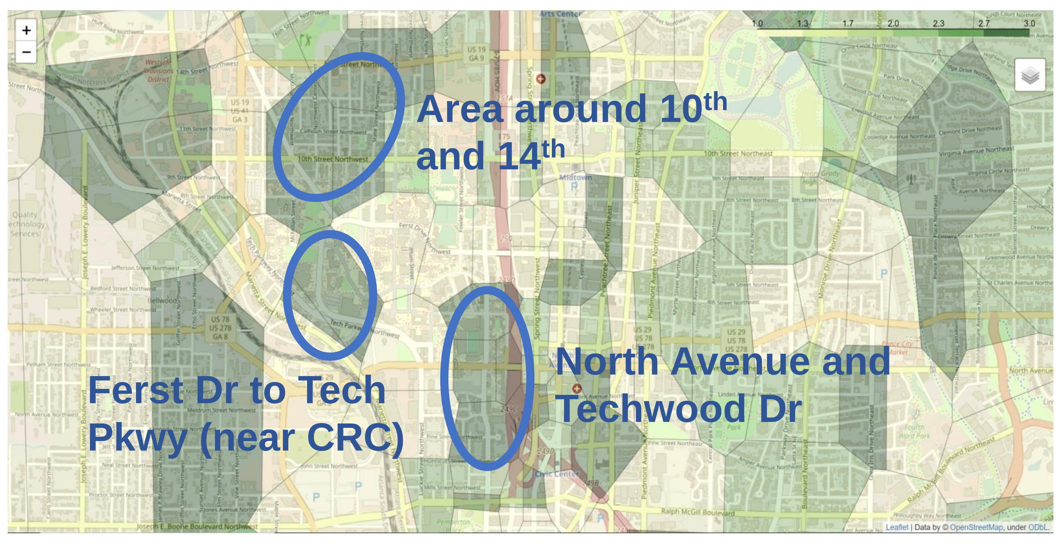
❖ Analytics Experiments

- Generate Voronoi polygons around intersections to achieve spatially contiguous.
- Clustering results not only identify which cluster the spot belongs to, but also represent the relative degree of congestion state.



❖ Traffic Bottleneck Identification

The typical set of bottlenecks we identify from the analysis is **the main entrance and exits around Georgia Tech**.



3 Web-based Visualization

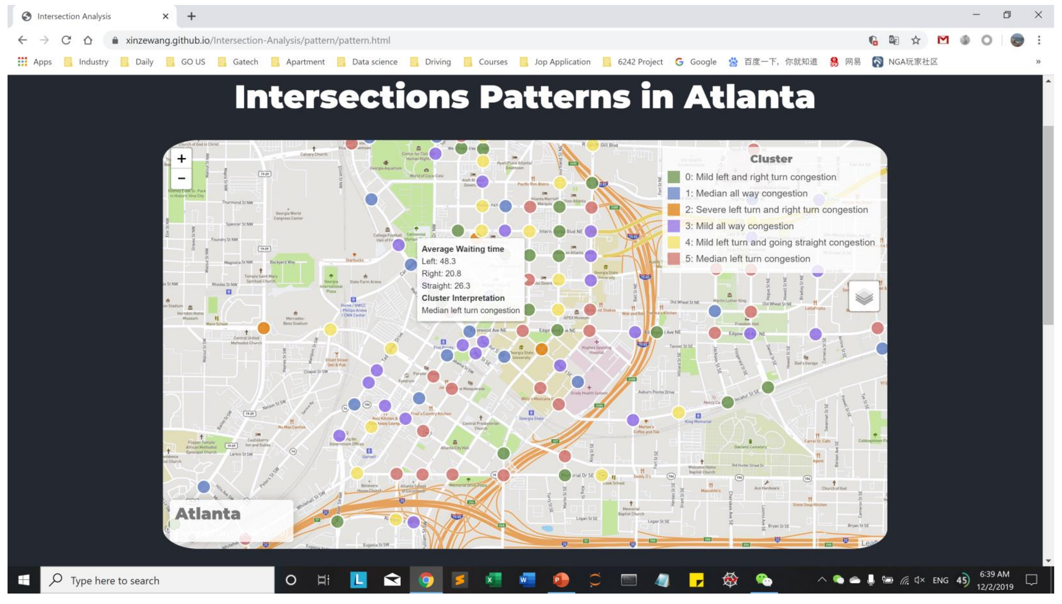
❖ GIS-based Website

A high-level overview of congestion patterns and spatial groups of intersections on the map.

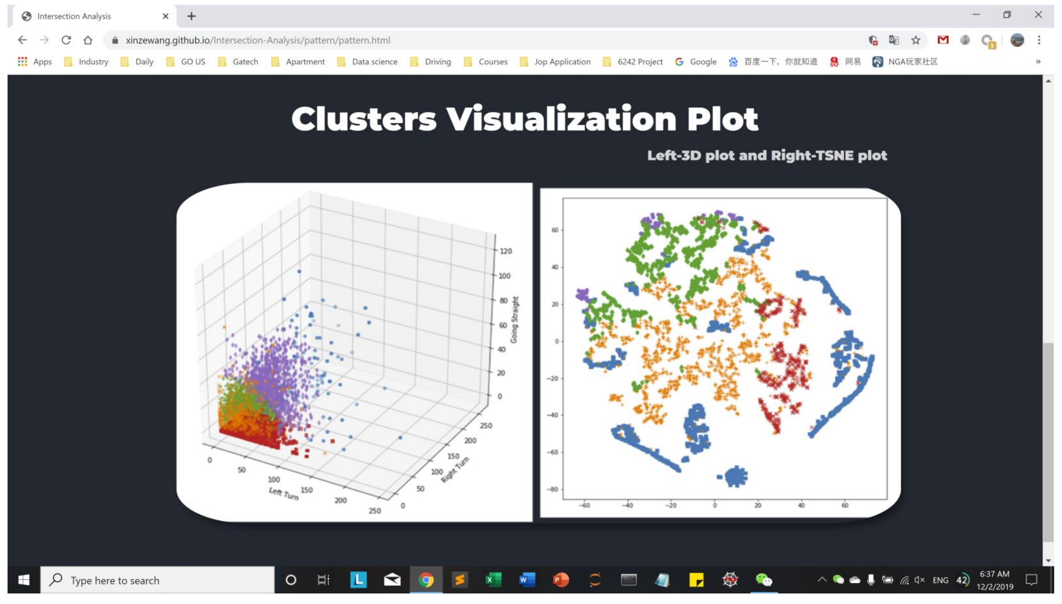
- HTML and CSS, with responsive web design using Bootstrap framework and interesting symbols from Font Awesome
- Use jQuery to manipulate styles, animations and customizations
- Open-source JS library Leaflet for city map

❖ Website Interface Illustration

Congestion Pattern with Tooltips



Congestion Pattern Clusters t-SNE Plot



Spatial Clustering with Navigation Bar