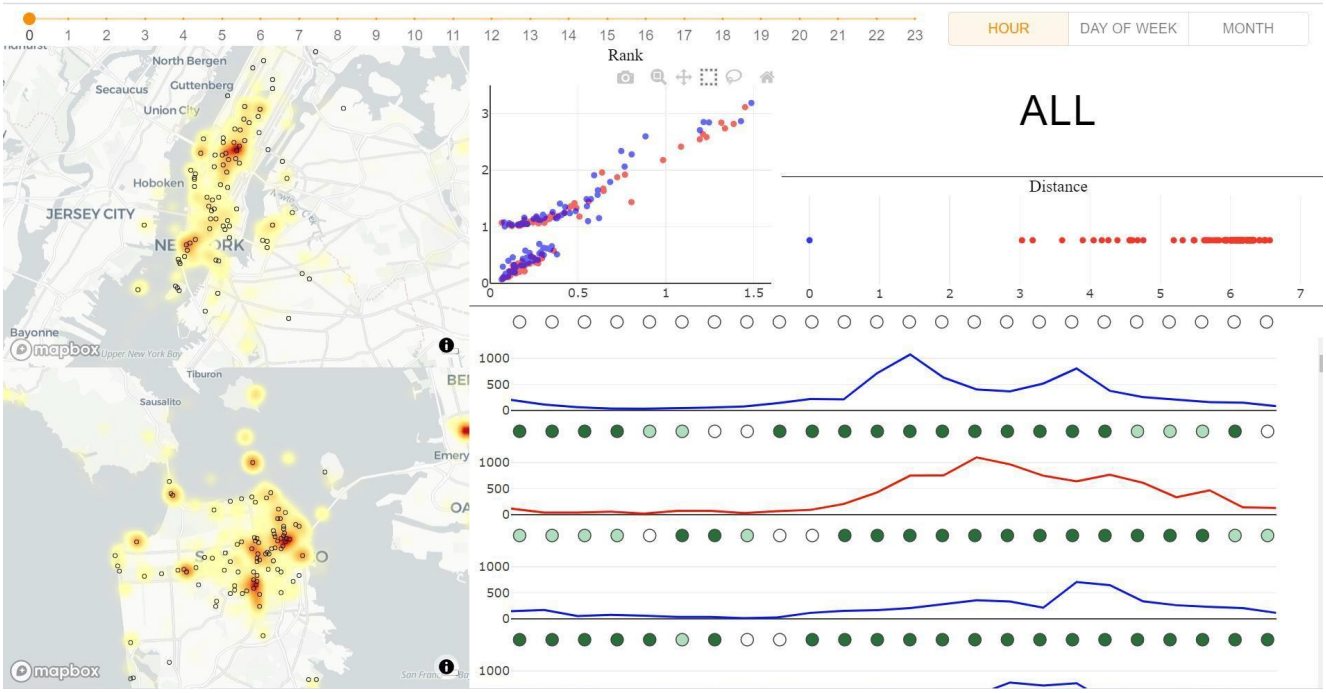
Paper Reproduce: Urban Pulse - Capturing the Rhythm of Cities

Final Project | sl9404 | 2021 Fall CS-GY 6313/CUSP-GX 6006 Information Visualization

GitHub: http://losiyu.github.io/paper-reproduce-urban-pulse



About Paper

The paper purpose a concept of “urban pulse,” which captures the Spatio-temporal activity in a city across multiple temporal resolutions in the context of numerous urban datasets.

PDF Link: https://fmiranda.me/publications/urban-pulse/tvcg-2017-urbanpulse.pdf
Demo: https://github.com/VIDA-NYU/urban-pulse

Related Work

Urban pulse uses the photo uploaded on Flickr, including the location and date metadata for research. Similar media include Sina Weibo [1] and Facebook [2]. Except for media data, government data is another good choice. The US government transparency program published many datasets from the department, which is valuable and reliable [3]. After acquiring the data, the second step is data analysis. "Beyond Transparency: Open Data and the Future of Civic Innovation" is a book that introduced a framework for using data [4]. Shadbolt’s paper shows how to search, categorize, and analyze government data [5]. The Density map is the best way to describe human activity flow for the urban dataset. Telcovis introduce a new density map to visualize human activity [6]. Scheepens introduces MANet, which performs well in human movement and has a smaller MSE [7]. Wang publishes a tool to visualize the traffic data[8]. The Mesoscopic simulation models, which combine the properties of both macroscopic and microscopic simulation models, have high performance when visualizing high volume density data[9]. Analysis of geometry social media data massive research has been done to exploit social media data to infer and predict people's spatial and temporal behaviors. For example, Geotags are used to improve situation awareness in emergency response [10, 11], disease control [12], and to understand cities [13, 14].

Problems and Difficulties

1. Find the data

Flickr data published by Yahoo contains metadata for research. I successfully found the processed data on the VIDA lab. Because the data has been cleaned, we can only see three columns, including longitude, latitude, and timestamp, and only in NYC and SF. The size of the dataset is around 600K. The pre-calculated critical points dataset I used is also in their lab database contains approximately 100 points.

2. Density Function

The Density map is one of the essential features in the visualization dashboard. The intensity of the color was calculated by using a Gaussian weighted sum.

$$f(p) = \sum_{x_i \in N(p)} e^{\frac{-d(p,x_i)^2}{\varepsilon^2}}$$

However, I could not find the framework using the same function for rendering, so I chose deck.gl heatmap layer to visualize the human activity. Deck.gl uses the Gaussian kernel function to calculate the color intensity. This step took the most time in my project. According to the paper, it needs 18 minutes to calculate using a regular PC. So the demo sometimes lags for a few seconds while rendering.

3. Topological persistence

The paper uses topological persistence to evaluate the urban pulse. The author pairs the global maximum with the global minimum. The efficiency of this method is O(nlogn).

4. Urban Pulse Location

Urban Pulse Density function evaluates the human activity based on the mesh of 600K points. Euler distance to calculate the pulse strength in the range of each point (Figure 1). Even though the author has improved efficiency using pre-calculated areas, it still takes a while to get the rank.

5. Urban Pulse beats

Capturing the urban pulse is the core concept of the paper. The question is how we can identify it after getting the activity curve over time. The author determines it based on significant beats, Maxima Beats, and Function Beats.

Significant Beats are 0/1 sequence to indicate the absence/presence of a persistent high maximum at the location. Maxima Beats the absence /presence of a maximum at the location over the different time steps. These parameters record the activity around the significance beat. Function Beats stored the scalar function of variation of scalar function (Figure 2). The line chart is based on the functional beats, which show human activity. The green circle is based on the Significant Beats, which shows the urban pulse rhythm.

Figure 1

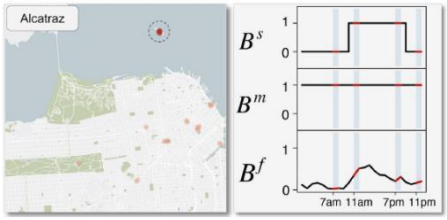


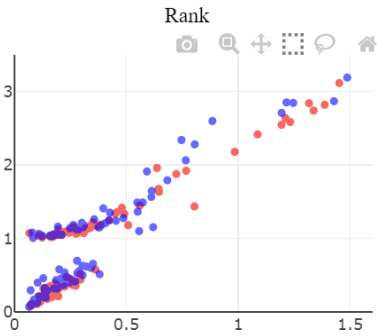
Figure 2

Implementation

1. Geo Map

Algorithm: Gaussian weighted sum
Interaction: zoom, pan
Framework: Mapbox, Deck.gl
Code

2. Rank Scatter plot

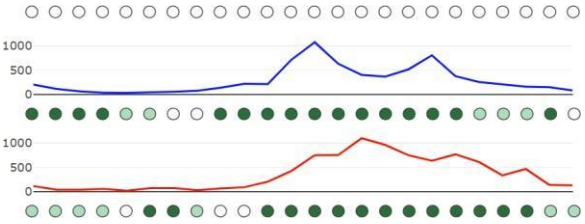


Algorithm: Root mean square of significant, maximum and functional beat
Interaction: regular and lasso select, zoom, pan
Framework: Plotly.js
Code

3. Distance Chart

Algorithm: Euclidean distance between time series
Interaction: highlight, zoom
Framework: Plotly.js
Code

4. Pulse Chart



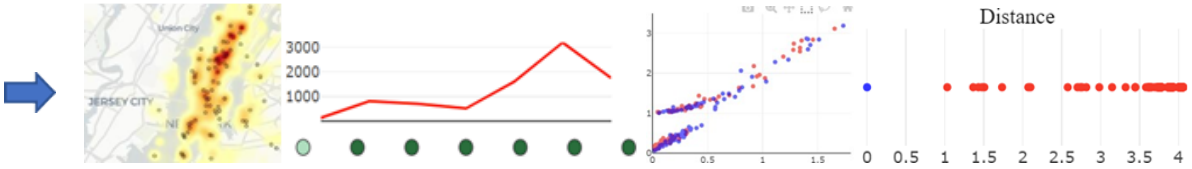
Algorithm: Frequency of image take
Interaction: zoom, select
Framework: Plotly.js, d3
Code

Stories

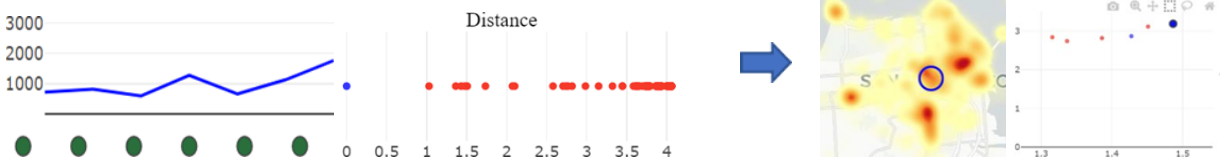
1. Focus on a part of critical points - Select in rank scatter plot

2. Change the date - Select a different time or cluster method

Ex. All the plots will calculate critical point and density based on the day of the week rather than the hour



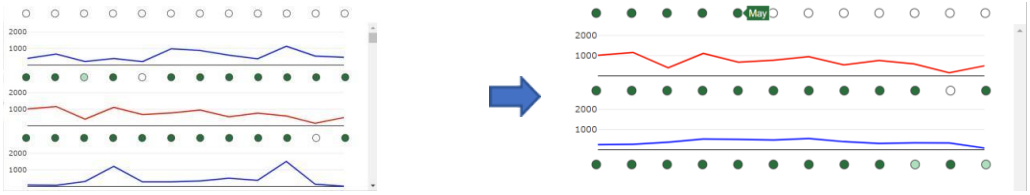
3. Highlight the location on the map and rank chart by - Hover on a specific pulse chart



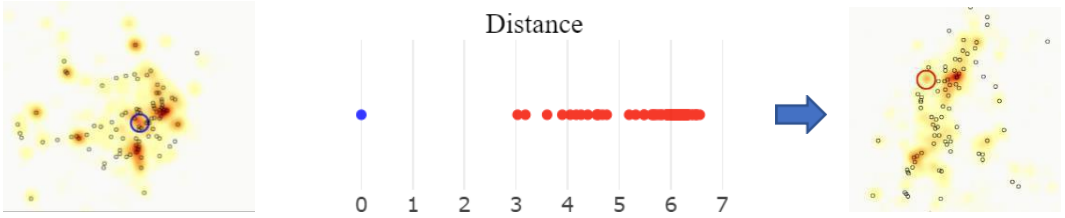
4. Select the location want to focus on and show critical points only in an area - Select a location or an area

5. Filter the location with the pulse time - select the date, weekday, or month

Ex. Show locations have a strong pulse all the time from January to May.



6. Find a similar urban pulse in another city - Hover on the point in the distance chart



Works Cited

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