Interactive Multiscale Visualization of Mobility Networks

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Abstract

Nowadays, thanks to the advancements in communication technologies and IoT we have access to huge amounts of structured and unstructured mobility data which could be utilized for analyzing the dynamics of mobility networks. One way to make the most out of this huge data is using interactive visualization techniques. One of the main building blocks of this research is to exploit visualization techniques to increase the stakeholder engagement and give the freedom of data analysis in an interactive environment which enable them to have a seamless and consistent transition between different scales like network-level, region-level, corridor-level.

We start from network-level to visualize several aggregated measures based on speed, flow, vehicle loss hours and also performing a spatiotemporal clustering based on the traffic congestion patterns in each province in the Netherlands. Then, in the next step in region level (can be selected by the user) by utilizing machine learning techniques we detect the anomalies in the transport networks or in the traffic. The basic approach would be performing classification on the congestion patterns that we get from the COSI API. In this line we can examine wide variety of classifiers like K Nearest Neighbors (KNN), Support Vector Machines (SVM), Convolutional Neural Networks (CNN) which all of them have their pros and cons in terms of precision, implementation complexity, and time complexity. Thus, to measure and compare their performance, we use performance metrics such as Precision, Accuracy, AUC, sensitivity, and specificity. Finally, we can pick the best model as our default model for our visualization tool.

The anomaly detection here could be beneficial for traffic managers to make on-demand plans to manage the traffic and prevent the congestion spread to the neighboring roads.

Going down to the corridor level, we investigate the regularities in the traffic congestion patterns. To determine the degree of regularity of the congestion pattern, for a specified corridor and a specified time of day, we calculate the average and the standard deviation of the congestion area based on the COSI data in order to find the degree of regularity of the congestion pattern of a specified corridor.

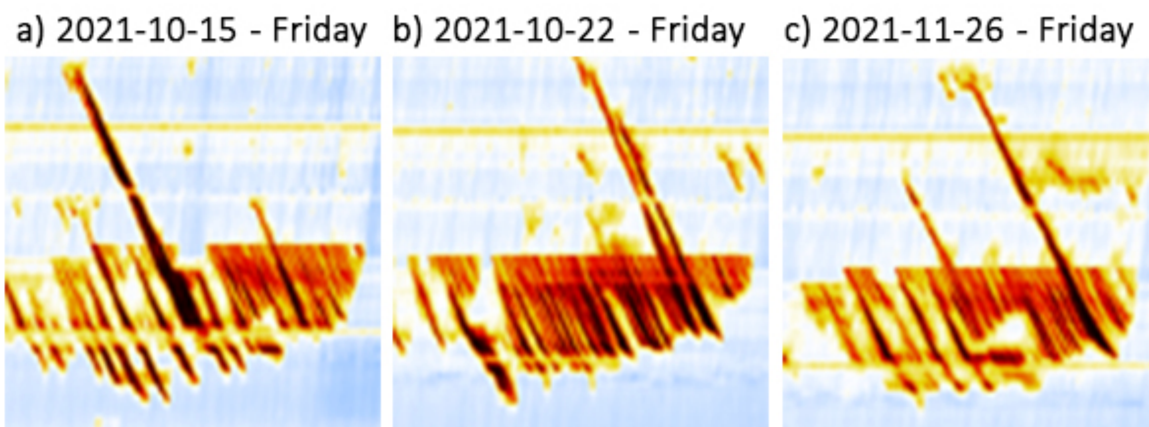

Figure 1: Congestion patterns for a same workday of week with arbitrary time distance. ***The horizontal and vertical axis represent time and locations respectively.***

We have two ways to select the time periods for calculating the degree of regularity; 1- We can select a specific time window of n consecutive days (e.g., 20 workdays). 2- We can pick n consecutive time windows in one day (e.g., 8:00 to 18:00 – every 1 hour).

Figure 1 shows a small example of congestion patterns for three Fridays with 1-week and 1-month distance. In the first glance, we notice the resemblance of the congestion patterns of these three days. So, we can tell there is a regularity in traffic congestion on Fridays.

Also, we can extract the main area of the congestion patterns for each day – as highlighted with yellow in Figure 2 – and calculate their average to get the overall pattern for this specific day (regular congestion pattern). Then for each new congestion pattern in future we can calculate the degree of irregularity based on the distance of the new congestion pattern from the regular pattern.

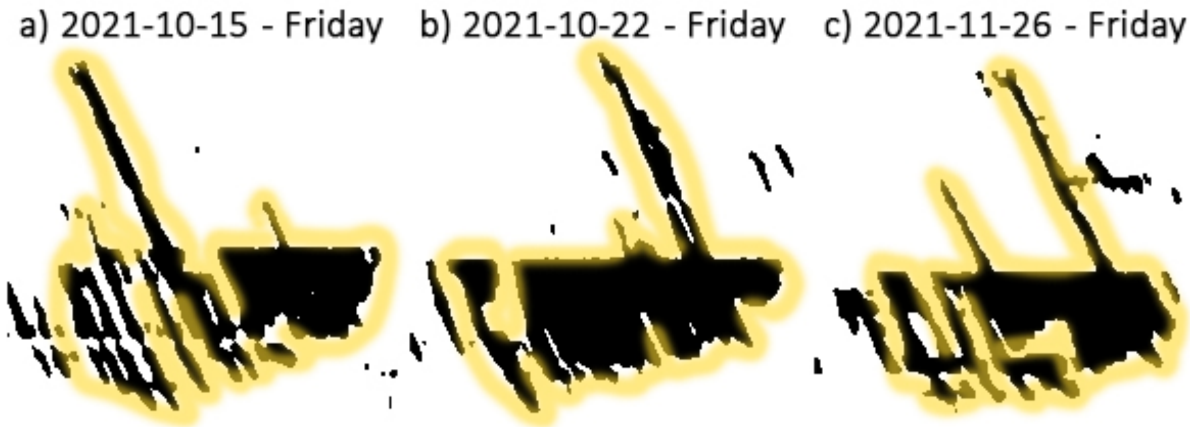

Figure 2: Binary images of congestion patterns for a same workday of week with arbitrary time distance. ***The horizontal and vertical axis represent time and locations respectively.***

Finally, we unite all the tools and techniques developed by addressing the previous challenges and bring them into one interactive visualization tool which follows the Information Seeking Mantra (ISM) "Overview first, zoom and filter, then details-on-demand". The ISM is a well-known guideline in the traffic data visualization. Based on this guideline, the final tool for this research would be an interactive visualization tool in which at first gives an overview of the data, then let the user apply some filters on the data or seamlessly have a transition between different scales while at the same time provides detailed information for each subset of data. Moreover, we analyze the stakeholder behavior by tracking their actions while they are working with this product and collecting their feedbacks using questionnaires to enhance the UX and increase the user engagement.