DRISI

Caltrans Division of Research, Innovation and System Information

Research Notes

Transportation Safety and Mobility

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Project Title:
UTC - Analysis and Prediction of Spatiotemporal Impact of Traffic Incidents for Better Mobility and Safety in Transportation Systems. (METRANS, 14-04)

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Analysis and Prediction of Spatiotemporal Impact of Traffic Incidents for Better Mobility and Safety in Transportation Systems

Develop a method to forecast how and when the travel-time delays, caused by road accidents, will occur on the transportation network in both time and space.

WHAT IS THE NEED?

Traffic congestion is major a problem throughout the world. It impedes our mobility, pollutes the air, wastes fuel, and hampers economic growth. While adverse weather, construction zones, physical bottlenecks, seasonal events (e.g., school schedule) can all lead to congestion, a key contributor to traffic congestion is road accidents. Accidents include events that disrupt the normal flow of traffic, usually by physical impedance in the travel lanes. According to National Safety Council (NSC) the total direct costs attributable to car accidents were $276 billion in 2012 [NSC12]. Moreover, National Highway Traffic Safety Administration (NHTSA) reported that motor vehicle accident casualties numbered 2.4 million injuries and 33,561 deaths in the US in 2012 [NHT12].

The above effects combined represent a huge social and economic detriment to the US and pose a serious concern for drivers, law enforcement, and transportation agencies. Hence, reducing the impact of traffic accidents is one of the primary objectives for transportation policy makers. The wealth of data collected from traffic sensors and accident logs offers an unprecedented opportunity to mine and understand the traffic incidents with an aim toward mitigating the consequences of these incidents.

[NSC12] National Safety Council Report,
http://www.nsc.org/Documents/NSC%20MV%20Fatality%20Estimates.pdf

[NHT12] National Highway Traffic Safety Administration Report,
http://www-nrd.nhtsa.dot.gov/Pubs/811856.pdf

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WHAT ARE WE DOING?

The main objective of this research is forecasting how and when travel-time delays—caused by road accidents—occur on the transportation network in both time and space. Toward this end, we will conduct fundamental research through mining and correlating traffic incident information and sensor datasets collected over the past three years and archived in the Integration Media System Center (IMSC) located at the University of Southern California (USC).

Using real-world datasets from the Los Angeles road network archived in the IMSC data warehouse, we will develop machine learning techniques to predict the following:

a) the travel-time delays on the upstream traffic and surrounding streets

b) when and how the delay will occur in the transportation network in both time and space

WHAT IS OUR GOAL?

Our goal is to quantify the impact (i.e., backlog and clearance-time) of road accidents on the up-stream traffic direction and in the surrounding network (e.g., arterial streets) of the accident.

WHAT IS THE BENEFIT?

Quantification of traffic accident data may help increase the efficiency of the transportation system and reduce the significant financial impact and lost time due to traffic accidents. For example, the output from our research may be used by city transportation agencies to identify the proper response for accidents, by drivers to avoid potential congested grid locks, by first responders for effectively dispatching emergency vehicles, or by legislators for long-term policy making.

WHAT IS THE PROGRESS TO DATE?

Progress to date includes completion of the following tasks:

- Literature review on traffic incident impact prediction on road networks
- Creation and population of road network topology data structures
- Directional map matching of accidents to Los Angeles Road Networks
- Detection and correction (or removal) of inaccurate sensor readings and accident records
- Spatial and temporal aggregation of sensor data

In addition, Dr. Liyue Fan attended the 2015 Transportation Research Forum in Atlanta, GA, to present the research direction under this project on displayed on a poster entitled "Discovering Causality in Traffic for Accident Impact Prediction."

In the second period, work was done on implementing the prediction algorithms. In particular, the researchers focused on learning a latent model from accidents, and then make impact prediction from the learned traffic models. The researchers have implemented Granger causality algorithm that identifies cause and effect relationship between sensors. In addition, model spatiotemporal speed variations on sensors both in normal conditions and in case of accidents. During the implementation of the algorithms, it was observed two major (expected) challenges. First challenge is data sparsity in the road network, i.e., most of the arterial segments in the road network are not equipped with sensors and/or sensors are far away to analyze the impact, which in turn deteriorates the learning algorithms. Second challenge is missing sensor data and/or delayed accident reports, which requires significant cleaning effort. The researchers have plans to handle these challenges in the next period.

WHAT IS THE PROGRESS TO DATE, CONT.?

In the third period, the focus was on two major tasks towards implementing the main framework of the research. First, they addressed the problems of the latent model used in our traffic prediction algorithm. In particular, as pointed out in the second period, the algorithms suffered from data sparsity i.e., large number of arterial and highway edges are not equipped with sensors and/or sensors are far away to analyze the impact. As a result, they have developed a locally weighted regression technique to estimate the speed of a highway segments (without a sensor) by using the nearby sensors (both upstream and downstream) in the same direction. To address the data sparsity problem with arterial segments, they partitioned the road network into grid cells and developed a spatial and temporal correlation technique that infers the speed of arterial segments in each cell by using the sensors in the corresponding cells. The experimental results showed that the modifications implemented improved the prediction accuracy by at least 20%. Second, after handling data sparsity, they developed a novel Graph Matrix Factorization (NMF) technique to learn the latent space from the transportation network, which takes into account the topology and segment attributes. The preliminary experimental results show that this technique can learn the traffic congestion in short time but has problems in identifying the immediate changes (e.g. caused by accidents). To address this problem, in the next phase, they will work incorporating a temporal matrix to our baseline method NMF to jointly infer the spatial and temporal behavior of the congestion both in normal conditions and in the presence of sudden changes caused by accidents.