Data-Driven Prediction of Regional Incidents and Flooding for TSMO

Michigan Department of Transportation， AECOM

Background

The Michigan Department of Transportation's (MDOT) Southeast Michigan Transportation Operations Center (SEMTOC) serves as a center of incident and mobility mangement for the state-owned roadways in Metro Detroit region, in coordination with first responders including the Michigan State Police (MSP), local police departments, fire departments, and towing companies. With three work shift a day and 24/7 operation, it has been critical for SEMTOC and first responder agencies to response to incident and congestion events in a timely manner, especially ahead of special events, such as sports, parades, and incremental weathers events. A few minutes of improvement in response time could save a life or reduce delay significantly. SEMTOC is also a central hub for collecting, analyzing and disseminating valuable traveler information, and maintains multiple databases for internal and external data.

To advance Transportation Systems Management and Operations (TSMO) innovation for MDOT, and enhance the data-driven operations capability, SEMTOC is piloting an advanced incident and flooding prediction tool using different internal and external data sources and advanced statistical models since 2016.

Model Development

The prediction tool, developed by AECOM, provides an estimate of future incidents and high-impact events handled by SEMTOC, by shift and per day for the prediction period. A second functionality of the tool is to forecast hourly probabilities of flooding on the state trunkline highways in the metro region for the same period of time. Note that an incident is defined here as any event that impacts or has the potential to impact traffic flow. In addition, high-impact incidents refer to any incident that causes more than 50 percent of lane closures and significant delay of traffic on highways.

In this tool, incident prediction is performed based on the development and utilization of a neural network (NN) model, which is a self-learning algorithm that captures and represents complex input/output relationships by mimicking the human brain in performing a particular task or function of interest.

Historical weather and incident information was used to train and test the NN model. More than seven years of historical weather-related data from January 2011 to Apr 2018 were gradually obtained from Meteorological Terminal Air Reports (METAR) at the Coleman A. Young Municipal Airport in Detroit as the training data set. This weather station is located within Detroit's city limits to provide a base estimation of the Metro Detroit region's weather. The historical occurrence of incidents for the same time frame as the weather data was utilized within the model development. The historic incident and high-impact data are obtained from two of MDOT's in-house incident database systems maintained at SEMTOC, Advanced Traffic Management System (ATMS) and the Call Tracking system,

The prediction of flooding probabilities is a separate module in the prediction tool, which is based on the development of a Logit model, and uses historic

flooding data and weather forecast data to estimate the probabilities of flooding on freeways in Metro Detroit region.

Weather forecast data, obtained from a meteorological website (www.intellicast.com), is applied to the model, to create a prediction for the future timeframe, which includes the total number of incidents and high-impact incidents for each shift/day, and hourly flooding probablities, for the next ten days including the current day.

Tool Overview and Application

The compiled program user interface of the tool is illustrated in Figure 1, which includes incident prediction module, flooding prediction module, and historic data plots module. Figure 2 shows some prediction outputs of the tool, where Figure 2a shows the weather forecast for the prediction period from the meteorological website mentioned above, and Figure 2b, 2c and 2d shows the prediction results for the incident, high-impact and flooding, respectively, for the prediction period of next ten days. It can be observed that the incident prediction is broken down into the three work shifts (morning, afternoon and night), and the daily total number of incidents is also plotted. The dotted red line in Figure 2b and Figure 2c indicates the historic average number of incidents and high impacts, as a benchmark. The flooding prediction shows 100% of flooding probability in the evening of September 11, 2019, which has been verified by the historic flooding events during that evening.

Prediction reports are generated with the tool on a daily basis, and shared with the stakeholders, including MDOT, first responders, and local transportation operations centers (TOCs). Then, staffing and resources could be better planned prior to any last-minute changes being required. This proactive staffing is of high importance to incident management, especially during severe weather events, such as heavy rain and snow storm in Michigan.

Figure 1. User Interface

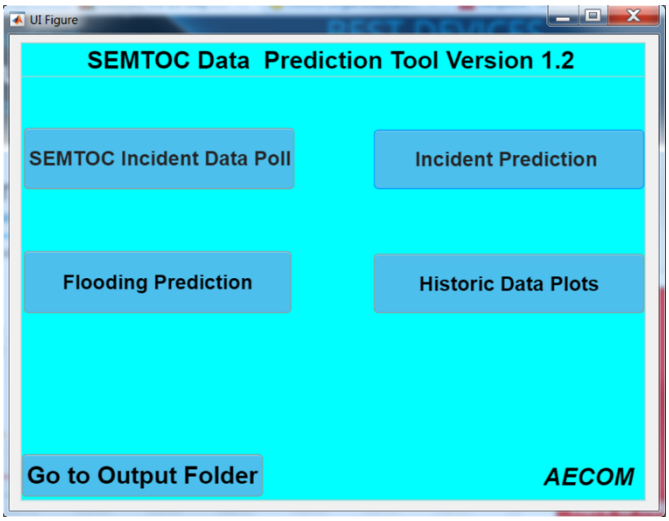
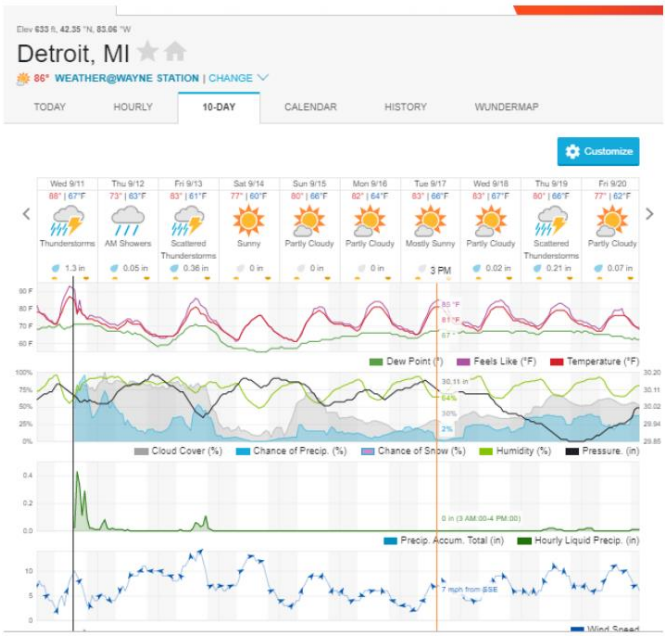
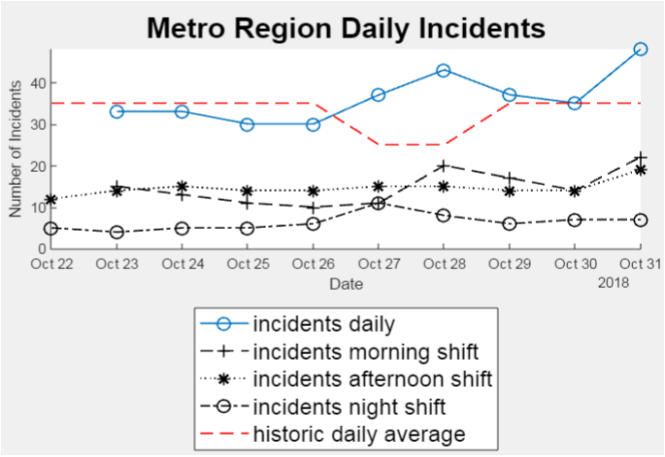


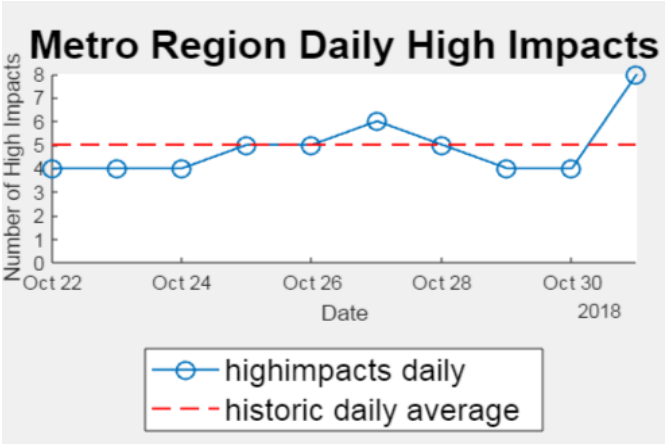
Figure 2. Output Plots



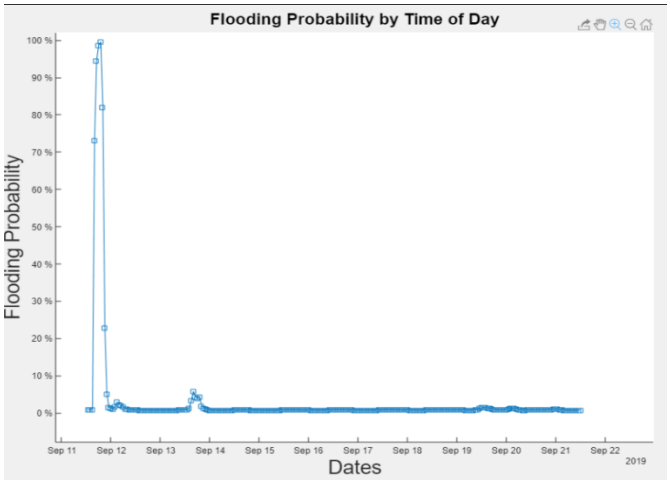
(a)



(b)



(c)



(d)

Outcomes, Benefits, and Learnings

Since 2017, the AECOM control room management team has built the predictive analysis into one of the routine tasks at SEMTOC, and applied the prediction tool to generate incident and flooding prediction reports for situational awareness, and evaluate and adjust their planned staffing resources against predicted incident levels on a daily basis. The evaluations allow the management team to increase staffing levels in advance of periods for which increased incident activities are predicted, while also proactively supporting MDOT in preparing SEMTOC systems, devices and first responding partners.

The historic results show that the prediction tool is a promising tool for the prediction of incidents and flooding events in the Metro Detroit region, with an accuracy rate ranging from 70 to 90 percent. In some instances, the accuracy rate has exceeded 90 percent. Ongoing post-analysis comparisons between incident predictions to actual outcomes indicate that the prediction accuracy is improving over time, as the model is updated with more recent historic data.

Currently, the SEMTOC project team is working on extending the prediction from the general metro region to specific areas or corridors of the state highway network, which will end up with a heat map for future traffic conditions in the region.

To sum up, the prediction tool at SEMTOC can

1) provides short-term forecast of incident and flooding conditions in the region
2) improve the operator staffing at SEMTOC and other TOCs, and staff and resource planning for state police, local police departments, fire departments, and towing companies.
3) facilitate decision making for TSMO
4) support quicker and more proactive responses of emergency agencies to incidents, and potential mitigation or avoidance of incident impacts or secondary incidents.

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