Modeling Highway Speed Decreases during Winter Weather Events in Iowa

Winter weather events have an immediate and adverse impact on traffic flow on primary highways. Substantial resources, both financial and human, are employed to mitigate these impacts. For example, the Iowa Department of Transportation spends about $40 million per year on winter maintenance, including some proactive and some reactive activities. Assessing the performance of such maintenance activities is challenging as these measures contain inherent variability, i.e. performance will depend on severity of a winter weather event and other factors such as road conditions. Thus, any deficiencies of those procedures must be judged relative to that variability.

Automated systems that record information on traffic speed and road conditions at particular points on a road system offer a way to improve the information available for building empirical models that relate weather variables to changes in traffic flow at a local level. For this application, we used data from two sources in the Newton/Colfax area in Iowa: road weather information system (RWIS) data and automated weather observing system (AWOS) data. We further used maintenance crew reports to identify winter weather events throughout the year as reliable information on precipitation, such as snow intensity and type, was not available.

Based on the understanding that atmospheric variables, along with variables reflecting physical pavement condition, may contain a large number of complex interactions, such that the effect of one variable on traffic speed depends on values assumed by a suite of other variables, we developed an empirical adaptive stochastic model. Our approach makes use of a Bayesian model formulation in which the effect of weather variables are allowed to adapt over subsequent time segments of four hours. Data from previous four hour time segments provide a prior quantification of the effect that variables such as lane condition, temperature, and wind will have on changes in traffic speed over the next four hours. Additional data in the next time segment are then used to adjust these quantifications to better reflect observed traffic speeds during that period. This would allow, for example, the effect of wind speed to change somewhat (but not radically) over the course of a longer storm event, as low or high wind speeds will have a different effect on traffic speeds. In this manner, we can circumvent the difficulty of explicitly determining a plethora of interactions, which is not feasible, by approaching the problem from the viewpoint of a dynamic process in which the effects of key factors are allowed to undergo small shifts over time. The model also incorporates autoregressive error structure to reflect temporal dependencies in observations that occur at reasonably high frequency, such as every few minutes.

The response variables used in our modeling approach are in the form of a *change from baseline*, to account for the fact that *normal* traffic speeds typically depend on location, portion of the week, and time of day. Baseline speeds were determined from extensive data records during non-event periods of time for Newton/Colfax, Iowa. Variables selected in the model were absolute deviation in temperature from freezing point, wind speed (in miles per hour), visibility (in miles), and three categories of lane condition: wet, ice, or dry. Using this baseline measure, we modeled the deviations in traffic speed from baseline speeds for two winter weather events. The first event took place in February 26-28th, 2013, and was categorized as producing wet and blowing snow, and the second event took place in February 23-24th, 2012, and was categorized by rain, followed by a transition to wet, then blowing snow. For both events our model fit the data well and we were able to adjust for variable effects of the covariates. For example, in the first event, the coefficient of temperature varied from about -6, indicating a negative effect on traffic speed, in the first few time blocks to around zero towards the end of the event when there was blowing snow. Other coefficient estimates similarly varied as needed. We further employed short-term forecasting of what changes in traffic speed are anticipated over the next time period.