2015-44TS
Published October 2015

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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:
$110,400

Normal condition regain time is a data-determined alternative measure of when a road recovers from a winter storm.

Automatically Measuring Traffic Recovery Times After Snowstorms

Researchers developed software to implement an algorithm that uses traffic data to determine when road conditions have recovered after a winter storm. The data-determined normal condition regain time is potentially more accurate and could save time and costs over manual observation.

What Was the Need?

The performance of winter maintenance operations in Minnesota and most other states is generally measured by "time to bare pavement"—the length of time between the end of the storm and a road being clear of snow and ice. Currently maintenance personnel determine performance by a visual observation.

However, visual observation is an imperfect measure with the potential for error or lag time in reporting. MnDOT wants to leverage its existing traffic operations infrastructure to automate this process in order to improve accuracy and save time related to observation and reporting.

What Was Our Goal?

MnDOT's Metro District has operated and expanded upon a network of loop detectors on its freeways to measure traffic flow for decades. A previous phase of research developed algorithms to use traffic flow data from these detectors to automatically estimate when traffic flow patterns returned to normal after a snow event. This phase sought to expand the effort and test the algorithms in selected locations in the Metro District.

What Did We Do?

Researchers used weather data from MnDOT's Road Weather Information System to identify dry days from the 2012-2013 winter season. They extracted traffic flow data for these days from each detector station on two test routes: one including sections of Interstate 694 and I-35E in the northern Twin Cities, and the other including sections of I-94 and U.S. Highway 52 primarily in St. Paul. Next, they analyzed the data to evaluate patterns in the relationships between traffic speed and traffic density during free-flowing conditions, congested conditions and conditions that are transitioning from free flowing to congested. Researchers also analyzed traffic flow data after snow events, including during plowing operations and at reported bare-lane regain times.

Using this information, they developed a process to determine the normal condition regain time, an alternative measure of winter maintenance performance based on the observed relationship between traffic speed and traffic density.

Then they developed a prototype software to automatically analyze data and determine the NCRT after snow events, first on two test routes using data from the 2013-2014 winter season and then networkwide on two events from the 2014-2015 winter season.

What Did We Learn?

Traffic speeds on normal dry days vary significantly due to traffic levels, incidents and other random factors, so time-of-day-based average speed is not necessarily adequate to identify a "normal" condition. The relationships between traffic flow rate and density as well as traffic speed and density at a detector station under dry conditions show more consistent patterns. Up to a certain level of density—before the road is congested—flow rates will increase steadily and speeds will stay consistent at the speed limit. Once the road becomes congested, flow rates and speeds drop in predictable ways.

continued

"Other states have tried to improve how they identify bare-lane regain times, but using traffic data to determine it is cutting-edge. We're at the point where we have a higher confidence level in the data-driven approach than in human detection."

—Tom Peters,
Research and Training Engineer, MnDOT Maintenance Operations

"By comparing the speed and density patterns during a snow event to those during normal weather conditions, we can identify the recovery status of the traffic flow at a given location."

—Eil Kwon,
Director, Northland Advanced Transportation Systems Research Laboratory, University of Minnesota Duluth

Produced by CTC & Associates for:
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Traffic speeds tend to decrease but density increases during plowing operations as vehicles queue behind plows. The relationship between speed and density, however, is a good indicator of the extent of a road's recovery.

These relationships are much more varied while the road is recovering from a snow event, depending on road surface conditions, traffic demand and snowplow activity. During plowing operations, traffic density on a given route increases, but speed decreases because vehicles form a queue behind the plow limited by the plow's speed. After the plow leaves the road, both speed and density increase. However, by comparing the speed-density relationships during a recovery period to the relationship during normal weather conditions, it is possible to determine whether traffic flow has recovered to its normal state.

Researchers calculated several NCRT values based on percentage of recovery, from 50 percent to 100 percent. NCRT-80 and NCRT-90 (representing the times when traffic speeds are 80 percent or 90 percent, respectively, of the normal speed under the same density conditions) were both close to reported bare-lane regain times. While traffic data indicates that travel speeds at reported bare-lane regain times were about 80 percent of average speeds on normal days, NCRT-90 matches the manually reported bare-lane regain time slightly better for most events.

MnDOT anticipates that it will have a higher level of accuracy in the automatically calculated NCRTs than in manually observed bare-lane regain times.

What's Next?

A third phase of research led by the Metro District—Development of a Road Condition Recovery Time Estimation System for Winter Snow Events—is underway. This research will implement the system more widely on the Twin Cities freeway network and adapt it into one that can be used on a daily basis for analyzing winter maintenance operations. Researchers also recommend developing an online version that can be used to coordinate operations in real time. In the long term, MnDOT may investigate the possibility of expanding the system statewide.

This Technical Summary pertains to Report 2015-44, "Estimation of Winter Snow Operation Performance Measures with Traffic-Flow Data, Phase 2," published August 2015. The full report can be accessed at mndot.gov/research/TS/2015/201544.pdf.