Road cameras and machine learning can be combined to identify road surface conditions and inform Iowa DOT's winter maintenance decisions.

RESEARCH SOLUTIONS

Using highway cameras to monitor road surface conditions

Iowa DOT relies on a variety of automated data sources and high-tech systems to monitor pavement and weather conditions to help determine when winter maintenance treatments are needed on the state's roads. Conditions, however, can vary between monitored locations. New research indicates that combining still images from roadway cameras with machine learning algorithms can identify road conditions and support effective and efficient snow and ice clearing practices.

THE NEED

Winter maintenance supervisors increasingly rely on weather and road forecasting from maintenance decision support systems (MDSS) to determine when and how to clear snow and ice from roads. The systems incorporate multiple data sources, including from the road weather information network, snowplow sensors, and highway cameras to model conditions and ultimately recommend road treatments.

An incorrect identification of surface road conditions, however, can impact the MDSS forecast throughout the system and result in an ineffective road treatment recommendation. Camera imagery has not traditionally informed identification of road conditions. In fact, an MDSS road condition assessment may be inconsistent with the images taken by a highway camera: while one may indicate a clear roadway, the other could identify snow or ice on the road.

Computer algorithms and artificial intelligence can maximize the value of data by automatically analyzing and classifying it to potentially support MDSS purposes. Led by Iowa DOT, the Aurora transportation

(continued)

"The success researchers had in training machine learning algorithms to use still images for determining road conditions provide a great steppingstone for other applications. We'd like to explore using mobile imagery—such as snowplow cams—in the same way to gather road condition data from all over the state."

— **TINA GREENFIELD,**
Iowa DOT RWIS Coordinator/Winter Operations Team

pooled fund study sought to explore whether image recognition combined with other data can accurately identify road conditions during winter weather.

RESEARCH APPROACH

The research team collected roadway camera images representing a full winter season in North Dakota. Images from Alaska were added to ensure a range of winter conditions was represented and prepared the data set to train the machine learning process to identify road conditions.

The team manually labeled approximately 20,000 images to identify conditions that may impact the road's surface. Primary considerations involved in labeling included how the camera's view of the road affected image identification, what conditions are most important for identifying road surface condition, how to expedite image labeling, and how to improve labeling accuracy. Researchers explored how to interpret, for example, a light dusting of snow on the road, snow on shoulders but not traffic lanes, and how visibility conditions can affect the ability to identify snow on the road.

Finally, an evaluation of three machine learning algorithm tools explored the suitability of each approach, image labeling considerations, and the completeness of the data set to train the system to identify road surface conditions.

WHAT IOWA LEARNED

Researchers discovered that while the three machine learning tools performed very similarly, efficient image labeling is a primary factor in an algorithm's ability to accurately identify road conditions. Clear, unambiguous, and consistent labeling rules included consolidating multiple condition categories into "snow" or "no snow" and whether visibility in the image was high or low/moderate.

Images taken through a clean camera lens with a clear and close view of the road, that were free from glare and not marred by low visibility or other obstructions, provided the most accurate automatic identification of road surface conditions. Additionally, having a sufficient number of accurately labeled images to cover each winter weather condition of interest is important for successful machine learning.

Finally, the research team provided directions for incorporating automatic identification of road surface conditions using camera imagery into a maintenance decision support or other system.

PUTTING IT TO WORK

While images must meet several criteria to be effectively incorporated into a machine learning tool, using images from a variety of cameras to help determine road conditions could benefit other Iowa DOT functions in addition to determining road treatment approaches. Image recognition could support other real-time monitoring needs, public information websites, and performance measurements.

Like other states, Iowa's roadway cameras do not provide complete coverage of all roads. Future research efforts may explore the application of machine learning to dash-cameras, such as those used in snowplows and other video streams.

ABOUT THIS PROJECT

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