Road Work Ahead: Using Deep Neural Networks to Estimate the Impacts of Work Zones

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Roadside construction – be it a detour, a closed lane, or a slow weave past workers and equipment – work zones impact traffic flow and travel times on a system-wide level. The ability to predict exactly what those impacts will be, and plan for them, would be a major help to both transportation agencies and road users. Funded by the National Institute for Transportation and Communities, the latest Small Starts project led by Abbas Rashidi of the University of Utah introduces a robust, deep neural network model for analyzing the automobile traffic impacts of construction zones.

The top three causes of non-recurring traffic delays are crashes, work zones, and adverse weather conditions, with work zones accounting for 10% of all non-recurring delays. Precise work zone impact prediction could significantly alleviate fuel consumption and air pollution.

"Machine learning and deep learning are powerful tools to build different types of data and predict future situations. Using AI for analyzing data is the future of transportation engineering in general," Rashidi said.

The Utah Department of Transportation (UDOT) collects various types of data related to work zone operations. Working with these data, Rashidi and graduate research assistant Ali Hassandokht Mashhadi explored ways to evaluate the impacts of different variables on traffic and mobility conditions for the entire roadway system. This analysis could help UDOT:

- **better understand and plan for more efficient work zone operations,**
- **select the most effective traffic management systems for work zones, and**
- **assess the hidden costs of construction operations at work zones.**

WHAT FACTORS IMPACT AUTO TRAFFIC?

The traffic impacts of work zones can vary depending upon other existing conditions and how they intersect with work zone factors:

- **Work Zone Factors:** the layout and location of the work zone, length of the road closure, traffic speed at the work zone, and daily active hours.
- **Traffic Factors**: the percentage of heavy vehicles, highway speed limit, capacity, mobility, flow, density, congestion and occupancy.
- **Road Factors:** the number of total lanes, number of open lanes, pavement grade and condition.
- **Temporal Factors**: the year, season, month, day of the week, time of day, and darkness/light.
- **Spatial Factors**: road lane width and the presence and number of highway ramps nearby

UDOT collects massive amounts of raw data - including the above - on work zones, which made this project possible. The deep neural network (DNN) model developed by the researchers is capable of evaluating the impacts of multiple factors, and the interplay between them. DNNs can capture the relationships between input variables and output, in contrast to traditional machine learning algorithms.

HOW DOES THE MODEL PERFORM?

The DNN was trained and evaluated on around 400,000 data points collected from about 80 projects on Utah roadways. Researchers evaluated the model's performance using three different measures, including R2 score, Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). The accuracy of all types of work zone results, including short and long term, day and night time, and interstate and arterial work zones, were acceptable, with under 2% error in the predicted traffic volume. This is the first study that has attempted to investigate the effects of work zone features on hourly traffic volume.

The main benefit of the proposed model is that it does not require users to set various adjustment factors based on practical experience. Previously developed models usually need a couple of adjustment factors in the mathematical model to estimate the work zone capacity. However, the model developed by Rashidi and Mashhadi is capable of estimating hourly traffic volumes without any need for adding factors manually. It is also worth noting that, by using work zone features, road features and temporal features as the input variables, the model can estimate work zone traffic even in areas without any traffic sensors.

IMPLEMENTING THE METHOD

Funded by a NITC Small Starts grant, this pilot project has shown promising results. To get this model into the hands of professionals who can use it, the research team has already published one paper in Transportation Research Record: Review of Methods for Estimating Construction Work Zone Capacity, and are in the process of publishing another journal paper. Next steps include sharing the outcomes of the research with UDOT to get their feedback and ascertain how the model could be useful for them. Rashidi also hopes to expand the model's capabilities with future research.

"This study was focused on Utah data, so it would be great if we can conduct similar studies and compare the results with other states; see how the behavior patterns are similar," Rashidi said.

ABOUT THE AUTHORS

The research team consisted of Abbas Rashidi and Ali Hassandokht Mashhadi of the University of Utah.

ABOUT THE FUNDERS

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THE REPORT and RESOURCES

For more details about the study, download the full report Evaluating Mobility Impacts Of Construction Workzones On Utah Transportation System Using Machine Learning Techniques at nitc.trec.pdx.edu/research/project/1362

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