SWZDI
Smart Work Zone Deployment Initiative

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RESEARCH PROJECT TITLE
Usefulness and Reliability of Probe Data When Alerting Work Zone Message Signs

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The Smart Work Zone Deployment Initiative (SWZDI) is a transportation pooled fund that supports research investigations into better ways to improve the safety and efficiency of traffic operations and highway work in work zones. The primary objective is to promote and support research and outreach activities that focus on innovative policies, processes, tools, and products that enhance the implementation, safety, and mobility impacts of work zones. The fund is administered by Iowa State University's Institute for Transportation, and the lead agency is the Iowa Department of Transportation.

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Usefulness and Reliability of Probe Data When Alerting Work Zone Message Signs

tech transfer summary

Data sets such as segment speed data and connected vehicle data have the potential to provide work zone information without the need to deploy and manage sensor infrastructure.

Objectives and/or Goal

This study investigated the viability of using crowdsourced data sets, specifically segment speed data (SSD) and connected vehicle data (CVD), for providing real-time traffic information to the public via work zone queue warning systems (QWS).

Background

Transportation agencies use QWS to inform drivers of the presence of slow or stopped traffic in work zones, which helps reduce the number and severity of rear-end crashes. When speeds fall below a certain threshold, a warning is presented to approaching drivers using a changeable message sign (CMS) or other media.

QWS for work zones have mostly relied on the use of temporary speed sensors (most often radar sensors) to directly measure traffic speeds in the field. While these sensors can provide reliable measurements of actual traffic speeds, their deployment and management incurs costs, and challenges arise when work zone boundaries change.

Recent advances in data collection have made it possible to obtain real-time traffic data from crowdsourced data sets without field infrastructure. Promising data sets include SSD, which provide the average speed for a given time interval and road segment, and CVD, which include entire vehicle trajectories consisting of waypoints with a time resolution on the order of seconds. Agencies have explored the use of these data sets, especially SSD, for a variety of applications.

Neal Hawkins, Institute for Transportation at Iowa State University
Queue warning display on portable CMS

Problem Statement

The ability of SSD and CVD to fill the role of physical radar sensor data in providing work zone information to the public warrants exploration. To determine whether SSD and CVD can supply sufficient data for QWS, it is necessary to determine whether these data sets are complete (i.e., covering all times of day and days of the week), are accurate, and have low latency.

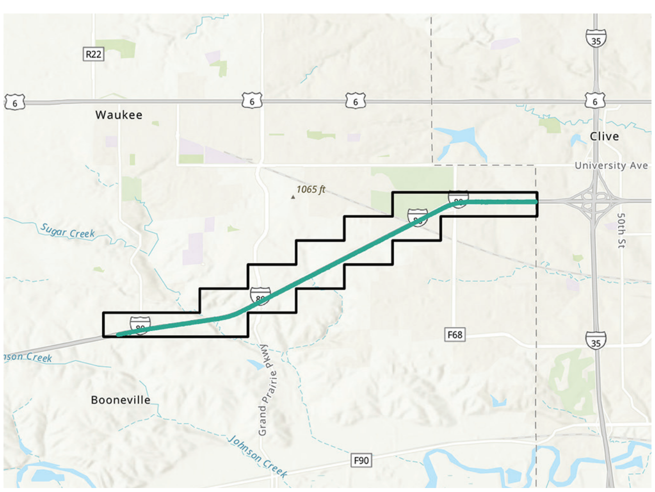
Research Description

Data were obtained from six work zones in Iowa for June 2022. Field sensor data from the work zones were considered to be the ground truth record of congestion, and sensor data exhibiting errors were excluded. The SSD included average speeds obtained from INRIX, while the CVD were sourced from Wejo.

Four tests were carried out to examine the completeness, accuracy, and latency of the SSD and CVD. To evaluate completeness, the first test compared the available SSD and CVD for the six work zones to assess the number of 1-minute intervals during the study period for which data were available.

To assess accuracy, the second test examined whether the SSD and CVD captured congestion reported by the sensors and whether congestion reported by the SSD and CVD was also detected by the sensors. Failure to detect congestion resulted in a missed call, while the detection of unverified congestion resulted in a false call. To cover the many aggregation options for the SSD and CVD, 36 performance measures for the CVD and 2 for the SSD were tested.

To examine latency, the third test used the best-performing SSD and CVD metrics from the second test to compare occurrences of congestion in the sensor data against occurrences in the SSD and CVD for the same location during the same period. Latency in the detection of congestion onset and congestion recovery by the SSD and CVD was tested.



Example CVD from a work zone

The fourth test simulated when a QWS would display a warning based on the sensor data, the best-performing SSD and CVD metrics from the second test, and a fusion option combining both the SSD and CVD. The amount of agreement with the sensor data was calculated by counting the minutes when the CVD, SSD, or fusion data would also trigger a warning.

Key Findings

- The SSD were complete, with real-time information available for the vast majority of minutes during the testing period. For the CVD, a considerable amount of data were missing during overnight hours.
- A tradeoff was found between missed calls and false calls among the SSD and CVD performance measures. The best option for minimizing missed calls generated about 45% false calls, while the best option for minimizing false calls generated about 45% missed calls.
- Because missed calls are more detrimental than false calls, the selected CVD performance measure minimized the number of missed calls while having a lower number of false calls than other options. This performance measure, which used the minimum value of all speeds reported for the past 3 minutes, also helped mitigate the effects of missing data.
- The SSD performance measures had much higher numbers of missed calls and false calls than the CVD performance measures.
- For congestion onset, the CVD had much lower latency than the SSD, with the average value showing that the CVD reported congestion slightly before the sensor data. The SSD had an average latency of about 5 minutes but in many cases did not identify congestion reported by the sensors.
- For congestion recovery, the SSD had slightly less latency than the CVD and exhibited more predictable behavior. The CVD recovery latencies showed much more variation.
- The QWS simulation showed that for most work zones, the SSD had low amounts of agreement with the sensor data, less than 50% in most cases. The CVD and fusion options had much higher values, usually above 50%. The fusion option performed marginally better than the CVD.

Conclusions and Recommendations

- The most promising CVD results showed that certain performance measures achieved very low numbers of missed calls (2% to 3%), despite low overnight data completeness. However, these options had high numbers of false calls, with the lowest being about 45%.
- Aggregating the CVD using a 3-minute rolling window significantly reduced false calls, suggesting that the CVD could be used to support QWS.
- Missed calls and false calls might be reduced by refining geographic data definitions, performing more data cleaning, exploring additional performance measures, and implementing other refinements.
- Data coverage was a challenge for the CVD, particularly during overnight hours. As more connected vehicles join the vehicle fleet, increasing data coverage is likely to mitigate these issues.
- The SSD had excellent data coverage at all hours but did not perform as well as the CVD in QWS applications, likely due to the reliance on average speed over relatively long segments, making the data less sensitive to localized slowdowns.
- Cooperation with data vendors to use other existing or new products, such as smaller segments, or to add other statistical measures besides average speed might improve SSD performance.
- The results of this study suggest that further investigation of the combination of CVD and SSD for QWS applications would be worthwhile.

Implementation Readiness and Benefits

Crowdsourced data such as SSD and CVD have the potential to provide real-time traffic information for QWS applications in work zones without the need to deploy and manage temporary speed sensor infrastructure.

Given the performance of the CVD in detecting stopped or slowed traffic, this data set could be used to support QWS. However, further refinement is recommended to reduce the numbers of false calls and missed calls. The SSD performed less well, but performance might be improved through the use of other data products or statistical measures besides average speed.