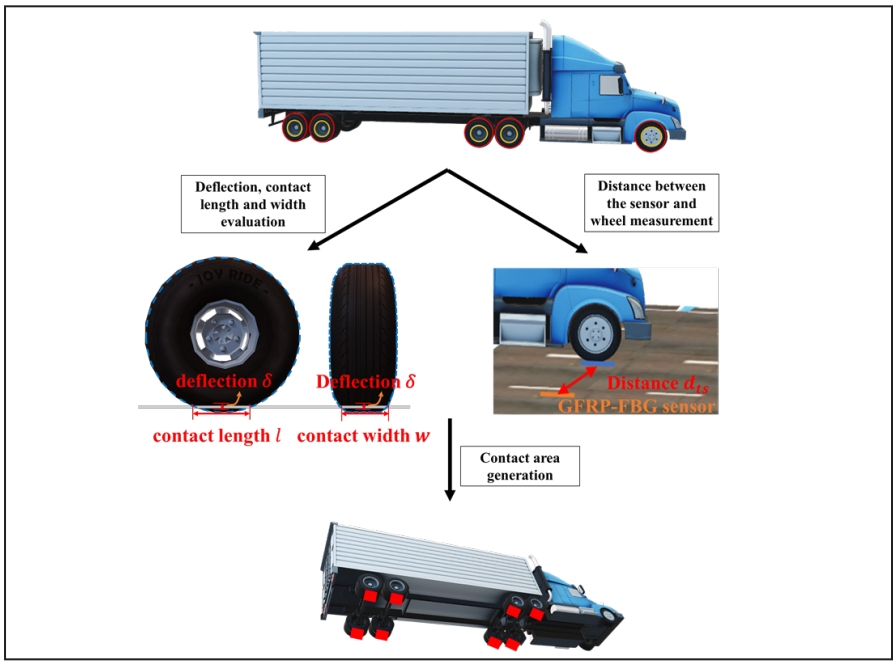
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-548 (project 601) | August 2024

Sensitivity and Accuracy Assessment of Vehicle Weigh-In-Motion System Measurement Errors Using In-Pavement Strain-Based Sensors



the ISSUE

Rapid increases in traffic volume and heavy vehicle loads are causing accelerated pavement deterioration. Accurate measurements and predictions of traffic loading impacts on pavement performance are needed to address the effects of overweight traffic and dynamic axle loads on pavement deterioration. Finally, vehicle weight monitoring systems need to be enhanced by integrating advanced technologies.

the RESEARCH

This research focuses on addressing key challenges in pavement performance prediction and vehicle weight monitoring by developing innovative methodologies and integrating advanced technologies. The study aimed to enhance the accuracy and reliability of pavement performance predictions under various traffic loading conditions and to improve vehicle weight monitoring systems, particularly in the context of overweight traffic impacts and dynamic axle loads.

The methodology involved the development of support vector regression (SVR) models to predict pavement performance by incorporating axle load spectra and dynamic loading effects. Machine learning techniques were applied to analyze the impact of overweight traffic on asphalt pavement life. The research also integrated dynamic axle load spectra into mechanistic-empirical models to better predict pavement performance. Temperature prediction models were developed using multiple regression and artificial neural networks to account for environmental factors across different pavement depths. The study also designed hybrid weigh in motion (WIM) systems that combine in-pavement sensors with computer vision technology to address the wander effect and improve vehicle weight measurement accuracy. Extensive data collection from various sources, including state departments of transportation and field experiments, supported the model development and validation processes.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

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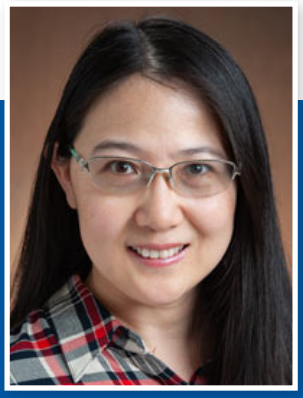

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Project Title

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the FINDINGS

We conclude that:

- SVR models, when integrated with axle load spectra, significantly improve the accuracy of pavement performance predictions.
- Overweight traffic is a major contributor to pavement deterioration, particularly causing issues like alligator cracking and rutting.
- Dynamic axle loads due to longitudinal pavement unevenness accelerate pavement fatigue and are effectively captured by advanced mechanistic-empirical models.
- Temperature prediction models incorporating environmental factors such as solar radiation and humidity provide more accurate insights into pavement temperature variations.
- Hybrid WIM systems that combine in-pavement sensors with computer vision technology effectively mitigate the wander effect, leading to highly accurate vehicle weight measurements.
- The integration of machine learning and advanced sensor technologies into WIM systems enhances the ability to predict and manage pavement performance, contributing to more resilient and efficient road infrastructure.

the IMPACT

The research introduces a cost-effective hybrid WIM system that increases vehicle weight monitoring accuracy by more than 90% at close sensor distances, addressing the vehicle wander effect. The random survival forest method revealed that overweight traffic can reduce pavement life by 16% to 43% for longitudinal cracking, 3% to 42% for alligator cracking, and up to 33% for rutting, guiding more effective infrastructure management strategies. The approach led to six journal publications and two conference presentations and has garnered 43 citations on Google Scholar and 493 reads on ResearchGate, highlighting its growing influence and potential to shape future developments in traffic management and infrastructure planning.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1206

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.

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