MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-565 (project 612) | September 2024

Studying the Use of Low-Cost Sensing Devices to Report Roadway Pavement Conditions

the ISSUE

Road surface irregularities, such as cracks, joints, and potholes, have a significant impact on ride quality, safety, travel time, traffic conditions, and driving costs. Current road inspection techniques include visual assessment by inspectors, the use of specialized vehicles equipped with laser devices and cameras to measure distress, and the involvement of citizens who report their observations. However, these techniques are inefficient, labor intensive, and costly. For instance, it is estimated that, on average, these inspection techniques cost $429 per mile. More advanced techniques, such as image processing and video analysis, have high data storage and processing needs and heavily rely on the quality of images and videos, which limits their applicability to daylight and favorable weather conditions.

the RESEARCH

The research investigates the use of low-cost sensing devices such as GPS accelerometers and smartphones to monitor roadway pavement conditions in real time. The methodology involves collecting data from sensors embedded in vehicles, which detect road anomalies like cracks and potholes. These data are processed using machine learning models, including decision trees, random forests, and artificial neural networks, to classify road surface anomalies. The models are evaluated based on accuracy, with the random forest model performing the best.

Additionally, the research includes developing a mixed-integer linear programming (MILP) optimization model to prioritize and plan road maintenance and repair (M&R) strategies under budget constraints. The model incorporates a non-linear deterioration rate based on road conditions to predict the optimal timing and selection of M&R activities. A case study of a road network in Denver, CO, is used to evaluate the models' performance and optimization framework.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

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Project Title

Understanding Paratransit: Examining Time Inefficiencies and the Efficacy of Alternative Modes for Persons with Disability

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the **FINDINGS**

The research demonstrated that low-cost sensing devices, such as GPS and smartphone accelerometers, can effectively detect road surface anomalies like cracks and potholes. Among the machine learning models tested, the random forest model achieved the highest accuracy (83.6%) in identifying road anomalies.

Additionally, the MILP model successfully optimized road M&R planning under budget constraints. The results showed that increasing the annual maintenance budget significantly improves road conditions over time, with a budget of $2 million annually transforming all road segments in the case study to “very good” condition after 10 years.

This approach allows transportation agencies to monitor road conditions more frequently and optimize M&R resource allocation, reducing operational costs and improving road network longevity.

the **IMPACT**

The research offers a low-cost, scalable solution for real-time monitoring of roadway conditions, reducing traditional inspection costs from $429 per mile to near zero by utilizing GPS and smartphone sensors in vehicles. By optimizing maintenance schedules through machine learning and MILP models, transportation agencies can improve road safety, extend infrastructure lifespan, and potentially reduce maintenance costs by 20% to 30%. This proactive, data-driven approach also minimizes traffic disruptions and enhances resource allocation efficiency.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1228

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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