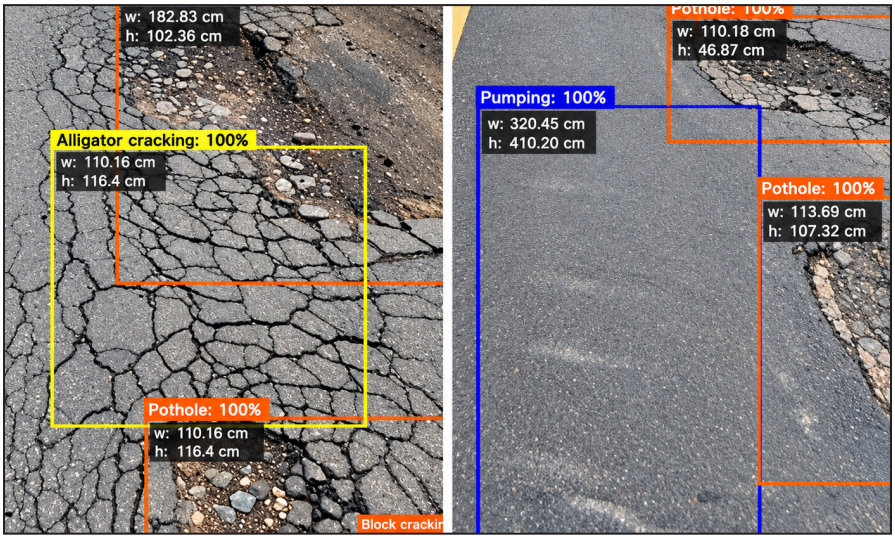
CTIPS Center for Transformative Infrastructure Preservation and Sustainability

USDOT Region 8 University Transportation Center

RESEARCH BRIEF

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An End-to-End Deep Learning System for Pavement Distress Detection, severity estimation, and Condition Reporting



the ISSUE

Transportation agencies need reliable information about roadway conditions to plan maintenance and repairs. Traditional pavement inspections are time-consuming, labor-intensive, and sometimes inconsistent. Existing automated tools often provide limited explanations of detected damage, creating a need for technology that both evaluates pavement conditions and clearly communicates the findings.

the RESEARCH

The researchers developed and evaluated PaveCap, an artificial intelligence system that examines roadway photographs to assess pavement conditions and describe visible damage.

Researchers used 7,158 pavement images collected from Jefferson City, Missouri; Peoria, Illinois; and Washington, Illinois. Pavement experts provided condition ratings and detailed descriptions of the damage visible in each image. The dataset included several common types of roadway damage such as cracks, potholes, and pavement patches.

The system was developed with two main capabilities. First, it identifies damaged pavement areas and estimates an overall condition score on a scale of 0 to 100. Second, it automatically generates written descriptions identifying the types and severity of damage present.

Researchers trained the system using approximately 80% of the images and evaluated its performance using the remaining 20%. They compared the system's condition estimates with expert-assigned ratings and assessed how closely its written descriptions matched those prepared by pavement experts.

Additional experiments examined how different image-processing approaches influenced performance. The results helped identify the system's strengths, limitations, and opportunities for improvement before potential use by transportation agencies.

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Project Title

An End-to-End Deep Learning System for Pavement Distress Detection, Severity Estimation, and Condition Reporting

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the FINDINGS

The research demonstrated that artificial intelligence can assess visible pavement damage and generate written descriptions that help explain roadway conditions.

The system successfully identified several common forms of pavement deterioration and estimated pavement condition scores. During evaluation, its predicted scores differed from expert-assigned ratings by an average of 16.21 points on a 100-point scale.

The system also generated descriptions identifying pavement damage and its severity. Its description-generating approach performed better than five alternative approaches evaluated in the study.

Results further showed that identifying the precise areas affected by pavement damage improved condition estimates. However, prediction errors occurred under challenging lighting conditions, when damage was difficult to distinguish, or when multiple types of deterioration appeared together.

Overall, the findings demonstrate the potential of combining automated pavement assessments with understandable written reports while highlighting the need for additional improvements before widespread implementation.

the IMPACT

This research could help transportation agencies assess roadway conditions more efficiently and communicate maintenance needs more clearly. By automatically identifying pavement damage, estimating condition ratings, and generating understandable descriptions, the technology could reduce repetitive inspection tasks and support more consistent assessments.

The system could also help agencies identify deteriorating roads earlier, prioritize maintenance investments, and communicate infrastructure conditions to decision-makers and the public.

Although operational costs and time savings have not yet been quantified, the technology offers a foundation for more efficient pavement management, better-informed maintenance planning, and improved stewardship of public transportation infrastructure.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1289

For more information or additional copies, visit the Web site at www.ctips.org, call (701) 231-7767 or write to Center for Transformative Infrastructure Preservation and Sustainability, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.

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