Machine-Vision-Based Roadway Health Monitoring and Assessment: Development of a Shape-Based Pavement-Crack-Detection Approach

tech transfer summary

Developing automated, low-cost image-based pavement-crack-detection algorithms can help highway agencies implement cost-effective and continuous roadway health monitoring and management.

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MTC RESEARCH PROJECT TITLE
Machine-Vision-Based Roadway Health Monitoring and Assessment: Development of a Shape-Based Pavement-Crack-Detection Approach

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The Midwest Transportation Center (MTC) is a regional University Transportation Center (UTC). Iowa State University, through its Institute for Transportation (InTrans), is the MTC lead institution.

MTC's research focus area is State of Good Repair, a key program under the 2012 federal transportation bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). MTC research focuses on data-driven performance measures of transportation infrastructure, traffic safety, and project construction.

Background

State highway agencies routinely employ highway-speed data-collection vehicles equipped with downward-looking digital cameras to collect network-level pavement images. These images are then processed using proprietary semi-automated or fully automated algorithms to identify pavement-cracking information, which can be used in pavement management systems that allow agencies to make pavement preservation and rehabilitation decisions.

Problem Statement

Advancements are still being made in the development of accurate and reliable image-based pavement-crack-detection and classification algorithms. There is a need for the development of automated, low-cost crack detection algorithms that can be implemented by highway agencies for cost-effective and continuous roadway health monitoring and management.

Objective

The objective of this proof-of-concept research was to develop a shape-based pavement-crack-detection approach to reliably detect and classify cracks from two-dimensional (2D) concrete and asphalt pavement images.

Research Description and Crack Detection Approach

Concrete and asphalt pavement JPEG images acquired through 2D-area-scanning digital imaging were used for the analysis. The images were 3,072 by 2,048 pixels.

The developed pavement-crack-detection approach was designed to take advantage of the spatial distribution of crack pixels and work on pavement image blocks measuring 75 by 75 pixels. The crack detection algorithm comprises four stages:

- Local filtering
- Maximum component extraction
- Polynomial fitting of possible crack pixels
- Shape metric computation and filtering

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A pavement joint-detection approach was also developed to remove joints before crack detection. After completing the crack-detection process, the width of each crack segment was computed to classify the cracks.

To verify the developed crack detection approach, a series of tests was conducted on real concrete and asphalt pavement images without cracks and with cracks of different severities (low, medium, and high) and types (continuous and noncontinuous).

Key Findings

- The shape-based pavement-crack-detection algorithm was able to detect cracks at different severities in both asphalt and concrete pavement images, although some partial misses were observed.
- The algorithm was able to compute crack widths from the images for crack classification and reporting purposes.

Implementation Readiness

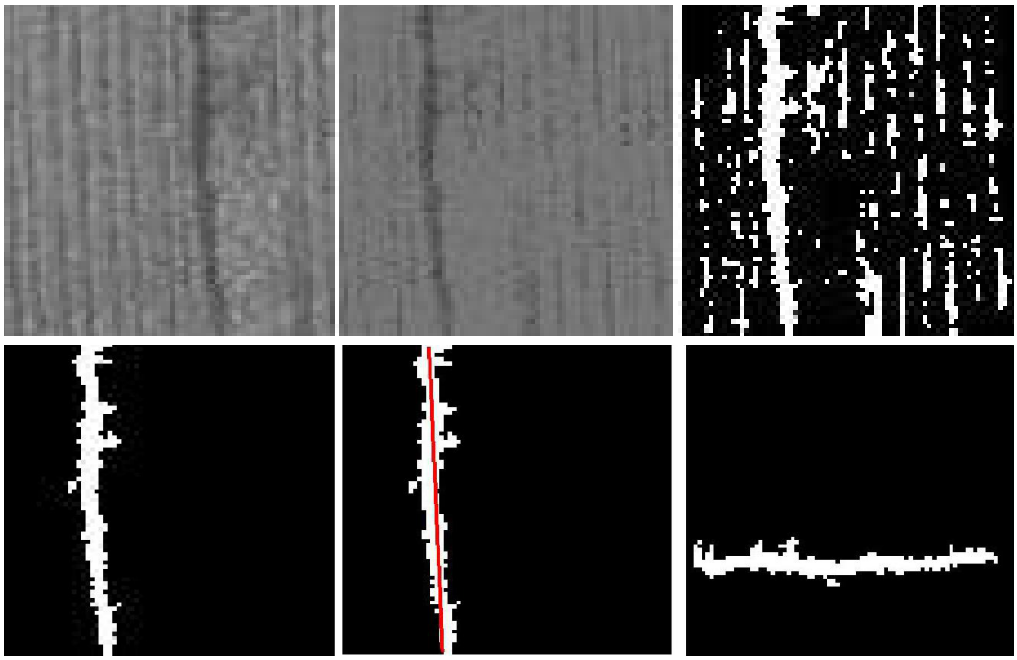
The crack-detection algorithm was able to detect cracks at different severities in both asphalt and concrete pavement images and was able to compute crack widths.

Additional research is needed to improve the robustness and accuracy of the developed approach in the presence of anomalies and other surface irregularities.

Implementation Benefits

Pavement cracking information identified through automated algorithms can be used in pavement management systems to help agencies make optimal pavement preservation and rehabilitation decisions.

Detecting a continuous pavement crack (from left to right): raw crack block, local filtering applied, minor removal, and maximum extraction



Computing average crack width in a 75- by 75-pixel block: crack block (top left), top hat filter applied (top center), segmentation (top right), minor removal (bottom left), computing orientation (bottom center), and rotation (bottom right)