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Project Summary Report 7-4975-S
Project 7-4975: Automated Pavement Cracking Rating System
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PROJECT SUMMARY REPORT

Automated Pavement Cracking Rating System: A Summary

Introduction

Pavement cracking is one of the most important distress types. To characterize pavement cracks quantitatively, three parameters of cracking are often used: type, extent, and severity. For flexible pavements, cracks are often classified into three types: network (alligator or map), longitudinal, and transverse. For rigid pavements, cracking is often evaluated in the ASSHTO protocol, i.e., by the crack density in five separate passes of the pavement. Traditionally, pavement cracks are rated with the standardized visual inspection method, which is subjective, tedious, and unsafe to the human graders. To improve the objectivity and efficiency of the pavement distress rating, various automated systems have been developed worldwide since the 1970s. But, most of the systems developed still have shortcomings, such as offline processing, partial coverage, and low speed alternatives, which hinder their widespread applications.

The overall goal of this project is to design a system that can acquire and analyze pavement images at real-time and highway speed, and to create effective image-processing algorithms that can reliably detect pavement cracks on both flexible and rigid pavements.

What We Did ...

Choosing and Installing the Hardware

The automated pavement cracking rating system, equipped with a line-scan camera, a high-speed frame grabber, and a 3.2GHz Pentium computer (Figure 1), is installed in a designated vehicle. It can take up to 44,000 lines or 88 meters pavement surface images per second while covering a full pavement lane (3.66 meters). The system is able to conduct the survey at a vehicle speed from 5 to 112 km/h and report the data through the Texas Department of Transportation's (TxDOT) VNet to the pavement information management database at user selectable distance interval in the PMIS or ASSHTO format. No human interference is required during the survey operation. The system does not need additional DSP hardware or processors, making the system cost efficient. The system mainly consists of a Dalsa linescan camera, a Coreco image frame grabber, a distance measurement instrument (DMI), a Pentium computer, and customized image analysis software (Figure 1).

Developing Image-Analysis Algorithms

A multiresolution segmentation algorithm for crack detection was developed to meet the requirement of highway speed inspections. The algorithm takes less than 20 milliseconds to process one pavement

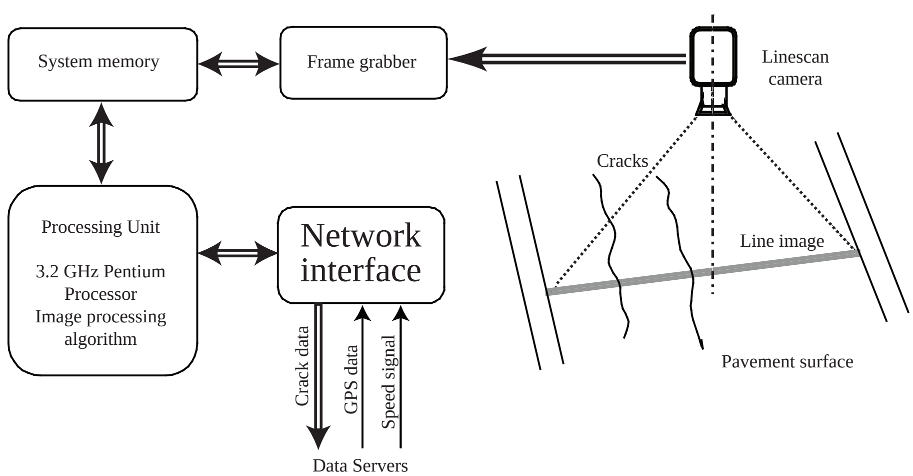

Figure 1: Pavement image acquisition and processing system

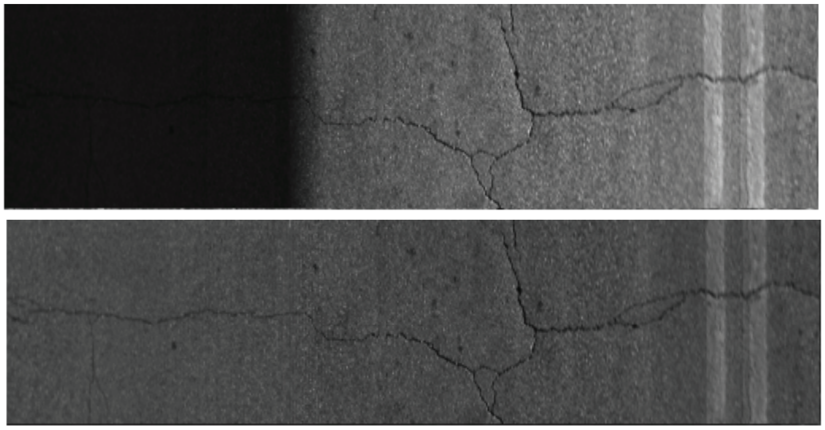

Figure 2: Image Equalizing, shadowed image (top) and equalized image (bottom)

image of 2048 x 512 pixels, running on a 3.2 GHz Pentium IV processor, and can reliably detect and classify a variety of cracking distresses. The main steps constituting the algorithm are:

- Image Equalizing: Transforms unevenly illuminated pavement images into images with more uniform brightness and contrast (Figure 2). The brightness and contrast parameters are used for adjusting the exposure time of the camera.
- Locating Crack Seeds: Analyzes individual cells of 8 × 8 pixels to determine whether they are crack cells. A crack cell is marked as a seed for further analysis (Figure 3).
- Seed Filtering: Checks the contrast and distribution of all seeds for validity (Figure 4).
- Seed Connection: Connects seeds by their directions and distributions. A look-up table is used to check the relationship between a seed cell and its neighbors (Figure 5). The patterns in the table indicate if a seed can be part of a given type of crack distress (Figure 6).
- Crack Connection: Connects crack segments that are in short distances and similar directions. Remove unconnected segments that are under the preset threshold (Figure 7).
- Crack Classification: Classifies the found cracks using the PIMS and AASHTO protocols.
- Data Reporting: The data can be reported at an interval from 0.05 to 2.0 miles. All data formats support multiple clients through its data network port. The system operation can be controlled or adjusted by TxDOT VNet through its command network port.

Conducting Project-Level Field Tests

The field tests were conducted during the period of 3/15/2003 to 5/20/2003 on five selected pavements in Travis and Williamson Counties. SL360 has a combination of sealed and unsealed, longitudinal, transverse, and alligator cracks. FM95, FM972, and FM3944 have narrower lanes. Mopac between RM 2222 and US183 is a relatively new pavement. The pavements were scanned by the system at different vehicle speeds, different lighting conditions, and different dates. The images of a 0.5 mile distance were also recorded for each pavement, and were used for the visual evaluations on the computer screen to do the comparison with automatic crack detections by the system.

What We Found...

It was found from the on-screen checking that 85 percent of sealed cracks, 75 percent of wide unsealed cracks (>3 mm in width), and 65 percent of narrow unsealed cracks (<=3 mm in width) in the images grabbed at 60 mph can be correctly detected by the system.

The correlations (R2) of the multiple scans for the PMIS data are 0.801 for longitudinal cracks, 0.811 for transverse cracks and 0.598 for alligator cracks.

The correlations (R2) of the multiple scans for the ASSHTO data are 0.803 for the left wheel path (LWP), 0.724 for the right wheel path (RWP), 0.706 for the between wheel path (BWP), 0.636 for the out left wheel path (OLWP), and 0.675 for the out right wheel path

Crack cell Non-crack cell

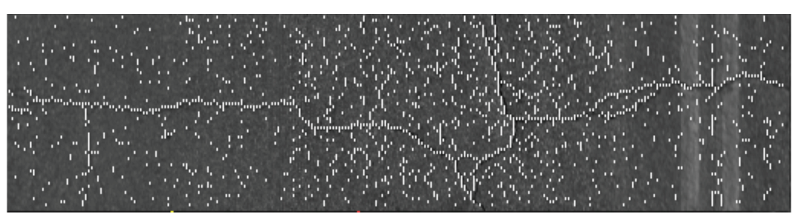

Figure 3: Crack seeds

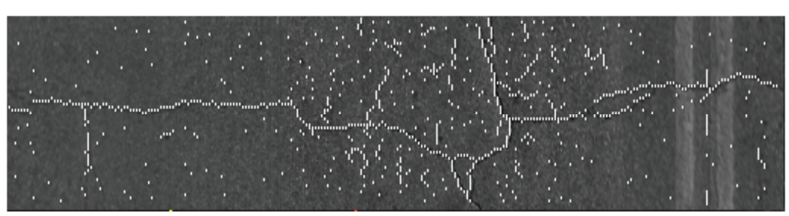

Figure 4: Crack seeds after the filtering

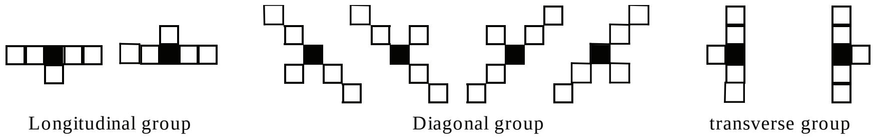

Figure 5: Look-up Table

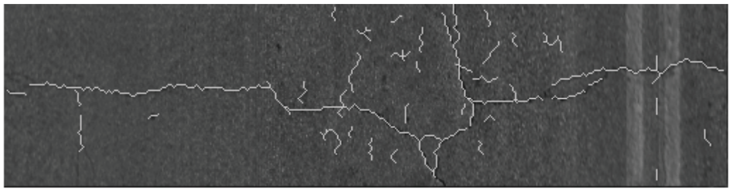

Figure 6: Seed connection

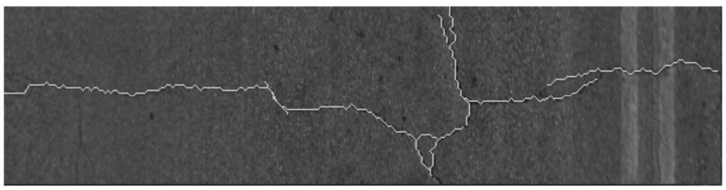

Figure 7: Crack map

(ORWP). Because of the influence of roadside objects, the R2s are lower in OLWP and ORWP.

The high repeatability of the crack data is reflected by the correlations between different scans. Here we use SL360 for more detailed analysis. The repeatability can also be observed from the crack distributions from multiple scans.

Pavement SL360 was scanned five times in different days. The coefficients of variance (CV) for longitudinal cracking (feet/station) was 17.65 percent and the CV for transverse cracking (counts/station) was 1.68 percent. CV is a measure of the repeatability of the data. Figure 8 shows the longitudinal cracks of three of the five scans.

The Researchers Recommend…

We recommend an implementation project to include the following tasks to further enhance the performance of the system.

- Modify the camera mounting device and the crack detection software to make the system more able to deal with images that include the shadows of the vehicle. The system now can effectively eliminate larger shadows cast from the vehicle body or the side objects, but is still not able to differentiate thin and long shadows, such as the shadow of the camera mounting post, from sealed cracks because of their similarity in shape and intensity. The post shadow can constantly appear in the images on a sunny day and can severely distort longitudinal crack data. We will experiment with transparent materials for the post and make it two to three times wider than the typical width of the sealed cracks to make the post shadow lighter and wider in the image. The software will be modified (expected to be minor changes) to identify the post shadow in the image.
- Modify the configuration table of alligator cracks by conducting more training with visually classified images.
- Finalize the merging of the crack measurement system with the other TxDOT survey systems through the VNet. The network interface between the central computer and the crack rating computer needs to be established in the survey vehicle and tested in real operations.
- Incorporate into the software the lane width information from the transverse scanning laser through the VNet so that side objects can be more effectively eliminated.
- Add functions of saving a pavement image at the end of a given distance interval to the hard disk in 2x, 4x, or 8x compression ratio.
- Fine-tune the algorithms for measuring cracks on concrete pavements.
- Continue the development for integration of hardware to better support the VNet standard.

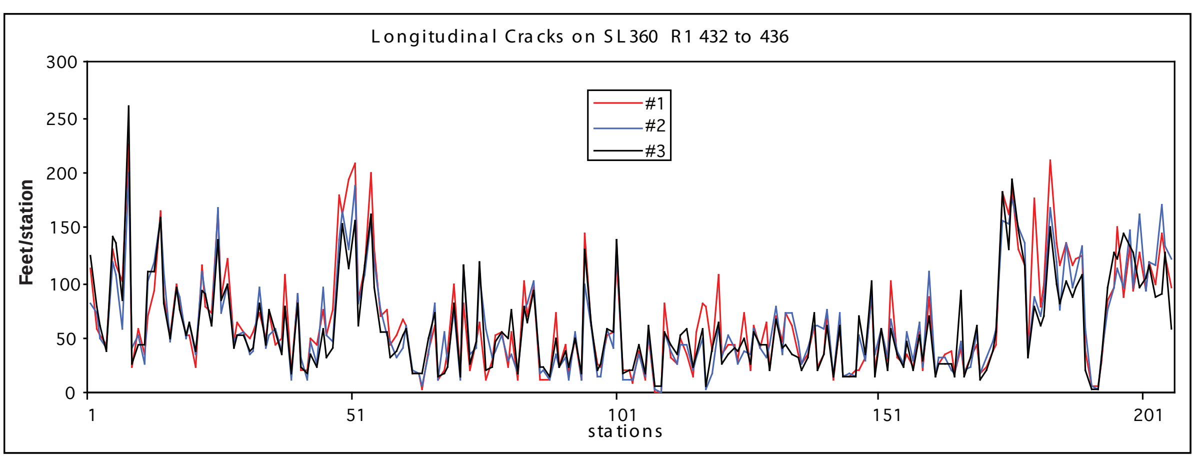

Figure 8: Multiple scans

For More Details...

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The research is documented in the following report:

7-4975-1 *Implementation of an Automated Pavement Surface Rating System for Asphaltic Pavements*
October 2003

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status
May 2005

The recommendations of this project are being implemented in TxDOT through project 5-4975, "Implementation of Automated Pavement Distress Rating System." This implementation project includes the purchase of 16-line scan cameras and additional hardware and software to equip all the TxDOT profiler units. It is expected that in the future this system will replace the manual condition surveys.

For more information, contact: Dr. German Claros, P.E., Research and Technology Implementation Office, (512) 465-7403, gclaros@dot.state.tx.us

Your Involvement Is Welcome!

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