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Research Summary Report 7-3997
Project 7-3997: Automatic Crack Monitoring System
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PROJECT SUMMARY REPORT

Automatic Crack Monitoring System: Summary Report.

A Highway Crack Monitoring System (HCMS) is designed and implemented for Texas multi-purpose load simulation (TxMLS) test site. The HCMS is a black-and-white CCD camera-based image-processing device that processes the image of the cracked pavements, extracts crack information and characterizes the cracks in terms of crack length and width. In this project, both hardware and software are developed. The hardware system is fully automatic with computer controlled x-y motor motion devices and Hall-effect sensors. Many lab tests were conducted. Processed results show that an accuracy of more than 90% is achieved for crack width and length classification. The crack-processing algorithm developed in this project uses the method of feature extraction and object characterization. A user-friendly, Windows-based user interface is developed, which allows user to control the camera motion, calibrate the system, acquire crack images, process images, and store data. The accuracy of the object characterization largely depends on the reliability of the features extracted from the original image data.

What We Did …

The HCMS consists of three major parts; the computer, the image acquisition device, and the motion system. The block diagram of the HCMS system is shown in Figure 1.

The main purpose of the HCMS system is to obtain the information about the crack and its coverage of the road image. Based on the width of the crack, it is classified into five categories.

The system performance is as follows:

(1) Hardware and Crack Imaging System

Imaging system is consist of a high resolution CCD camera, automatic focusing lenses, and image control and acquisition device inserted in a PC. The PC is the center of system control and image processing. Because of the huge amount of image processing and storage, the computer is equipped with high speed, large physical memory, massive storage space, and fast video processing power.

(2) Based on Microsoft Foundation Class Programming

The HCMS application software is programmed with Microsoft Foundation Class (MFC) on the 32-bit Windows NT operation system. Figure 2 shows the layout of this application program. It

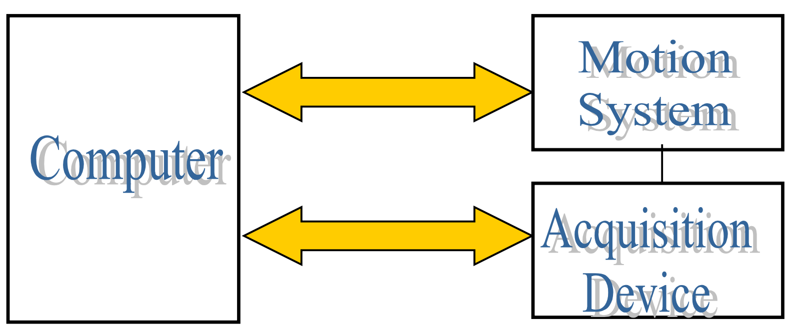


Figure 1. The block diagram of the HCMS

integrates the functionality of the image acquisition, image processing and motion-system control in one system. The double-view style enables the user to view both the original image and processing result at the same time.

(3) Image processing is based on Matlab 5.3

All the image-processing code is written with the MATLAB Image Processing toolbox. It processes the 256 gray-level intensity images acquired by the CCD camera. A binary crack image, an overlapped image, and a color-grid image are created as the outputs. Since we use the version 5.3 of MATLAB, which is not accompanied with a C++ compiler, a special piece of MATLAB interface code is designed to implement the MATLAB source code in the C++ program.

(4) Monochromatic CCD

The monochromatic CCD camera is used as the image acquisition device in the HCMS system. It can acquire images at 256 gray-scale, with resolution of 640-by-480 pixel format. The camera is placed on the frame of a motion system (Figure 3), about one meter above the ground, which makes the image area of 1.2-by-1.2 meters with the 6-mm lens. The acquired image is stored in the Windows bitmap format.

(5) 2-D Motion Control

The motion system of the HCMS is shown in Figure 3. These two vertical rails are fixed on both sides of the Texas Multipurpose Loading System (TxMLS). The motion system is capable of 2-dimensional movements to let the camera work continuously in either direction, so that full image coverage of the road is achieved. The control signal of the motion system is sent and received through the RS232 serial port of the computer. There are some magnetic markers set along the vertical and horizontal rail. The sensors are placed on both the removable frame and the roller hanger, so that they can move together with the motion system.

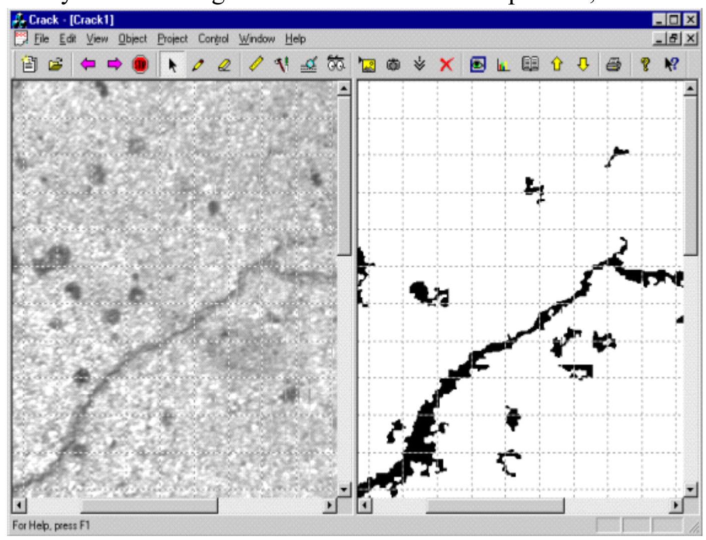


Figure 2 System program layout

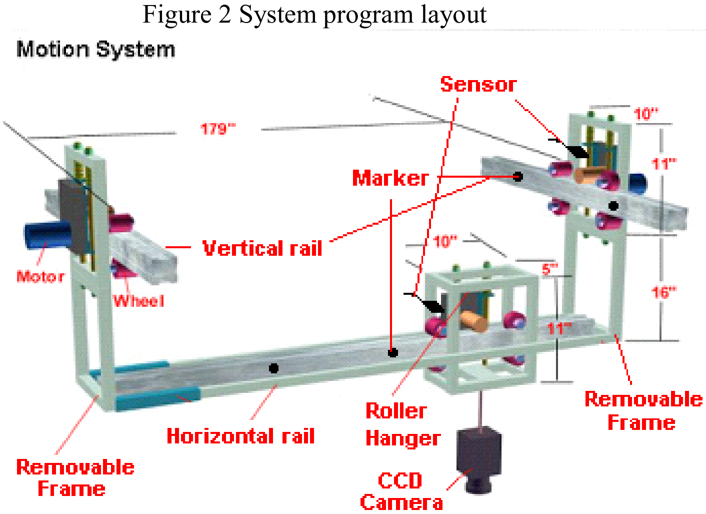


Figure 3 The motion system

What We Found…

The Highway Crack Monitoring System provides a complete platform for automatic highway crack detection and analysis.

The crack image-processing algorithm is proven to be highly accurate and efficient. The recurring thresholding method demonstrates very high sensitivity on the crack object detection. The gray-level threshold is adaptively determined from an estimation-verification process, which is based on the local image content. The band thresholding is implemented to compensate for the boundary effect. The bandwidth is adjustable to achieve the best processing precision.

Multiple noise removal methods are implemented during the image processing. The connected-component-object identification is implemented to remove the background noise and small fake objects. A large fake object is distinguished by setting certain thresholds according to the properties of the crack object.

Figure 4 demonstrates the performance of image processing in the real environment. Figure 4 (A) shows the source image acquired on the real highway pavement. The binary output, overlapped output and grid output images are shown in (B), (C) and (D) respectively.

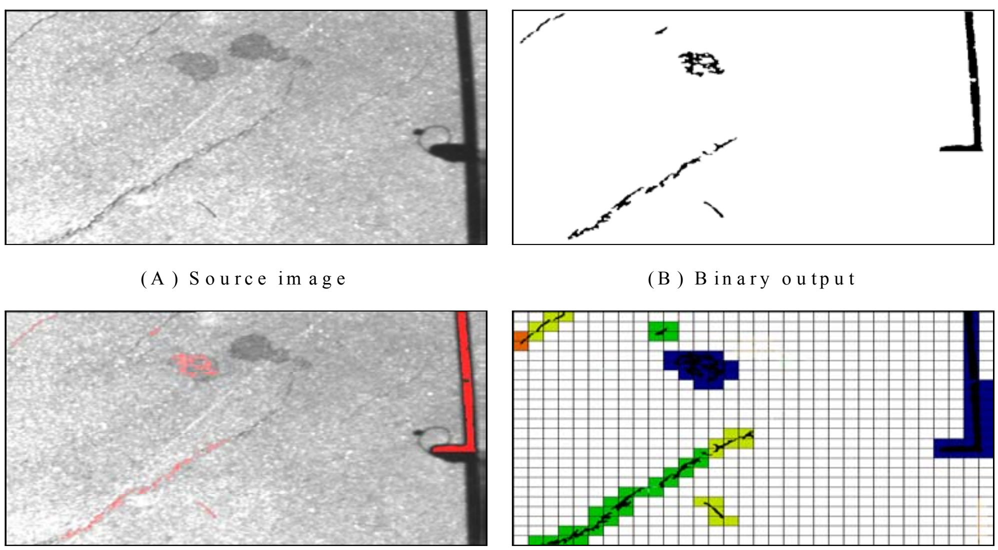
With the grid output image in Figure 4 (D), the information about the crack distribution is obtained. In the result, most of the crack objects are successfully detected with different light conditions. Some of the noise objects, such as the paint and shadow, are removed. The calculation results match the real objects. Table 1 shows the statistical result of the crack coverage.

The HCMS hardware system demonstrates great reliability and efficiency. The CCD camera is under precise control. The motion system works with great flexibility. It has multiple working modes to provide great freedom.

The Researchers Recommend…

Much work remains to improve the performance of the system.

- The recurring segmentation algorithm is needed to improve;
- Now the algorithm is restricted to detect the crack objects that have the similar gray level within the same local image, which results in a single peak appearing in the histogram;
- Although with distinct block processing, the local image is restricted to a small part of the whole image, there might be cracks existing in the same image with a different gray level. Multiple layer segmentation can be the solution for it;
- When TxMLS is in operational condition, we can install this system on to the TxMLS and do more field tests and improve the performance according to the results in the field.



(A) Source image

(B) Binary output

(C) Overlapped output

(D) Grid output

Figure 4 Source image and output result after image processing

Table 1 Crack coverage of example II

	Class I (0~3mm)	Class II (3~5mm)	Class III (5~7mm)	Class IV (7~10mm)	Class V (>10mm)
Road coverage (%)	0	0.2	2	3.6	5.4
Total length (mm)	0	89	304	545	832

For More Details...

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To obtain copies of the report, contact CTR Library, Center for Transportation Research, (512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT IMPLEMENTATION STATUS
This project is being implemented to the TxMLS site

For more information, please contact Dr. German Claros, P. E., Research and Technology Implementation Office, (512) 467-3381 or email: gclaros@dot.state.tx.us.

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