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TEXAS TRANSPORTATION INSTITUTE

In cooperation with
Texas Department of Transportation
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Summary Report

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Summary Report 1189-S
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ANALYZING PAVEMENT DISTRESS: NEW AUTOMATION OF DATA INTERPRETATION

PROBLEM STATEMENT

The Automatic Road Analyzer (ARAN) is a multi-purpose road survey vehicle used in the Texas Department of Transportation (TxDOT) Pavement Management Information System (PMIS). With a two-camera video system, the ARAN unit can drive at highway speeds collecting pavement video footage that is then brought back to a lab and visually evaluated for cracking distress. This automated location and recording of pavement distress reduces the labor costs of a manual rater team and allows the pavement manager to safely identify candidates for maintenance and rehabilitation.

However, manual analysis and classification of the videotape collected by ARAN is labor intensive, tedious, and often inconsistent. Now, with computer hardware prices coming down and processing power increasing, advanced video and image processing hardware opens the door to the possibility of a fully computerized interpretation system for analyzing pavement distress data from video tape.

OBJECTIVES

The Texas Transportation Institute conducted study 1189, *Automatic Photo Interpretation System for the ARAN,* in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) to develop a comprehensive image processing system for TxDOT's pavement distress data collection. Researchers first gathered hardware to do the video analysis. They then evaluated and proposed improvements necessary to collect the most accurate and clear video images. A second phase of the study developed an image analysis algorithm for the cracking classification software that, when combined with the hardware upgrades, automatically extracts and classifies distress data from video photos of asphalt-concrete pavement (ACP) and continuously reinforced concrete pavement (CRCP).

FINDINGS

Hardware Needs

Effective automatic evaluation of the pavement surface distress video requires high resolution, sharp, shadow-free images of the pavement surface, thus allowing the computer to process more efficient and accurate distress data.

In order to overcome current problems with variations in natural light, shadows (usually from trees, passing vehicles, bridges, and the survey vehicle itself), camera viewing angle, and inadequate resolution, all of which distort crack images and complicate the processing algorithms, TTI researchers designed (for research purposes) a new prototype videolog system with the following key components:

• an open-bottom enclosed trailer with a rubber skirt to block out the sunlight;

• a special lighting system inside the trailer to give enough illumination for a clear image at 1/4000th of a second shutter speed with the survey vehicle traveling at 50 mph;

• two high resolution shuttered cameras (SONY XC-77RR) with remote camera heads and high signal-to-noise ratios;

• an image processing workstation using a Sun IPX host system that is computer interfaced to a digital effect VCR (Panasonic AG 1830).

TTI Research Report 1189-1 describes evaluation and selection of the different hardware components.

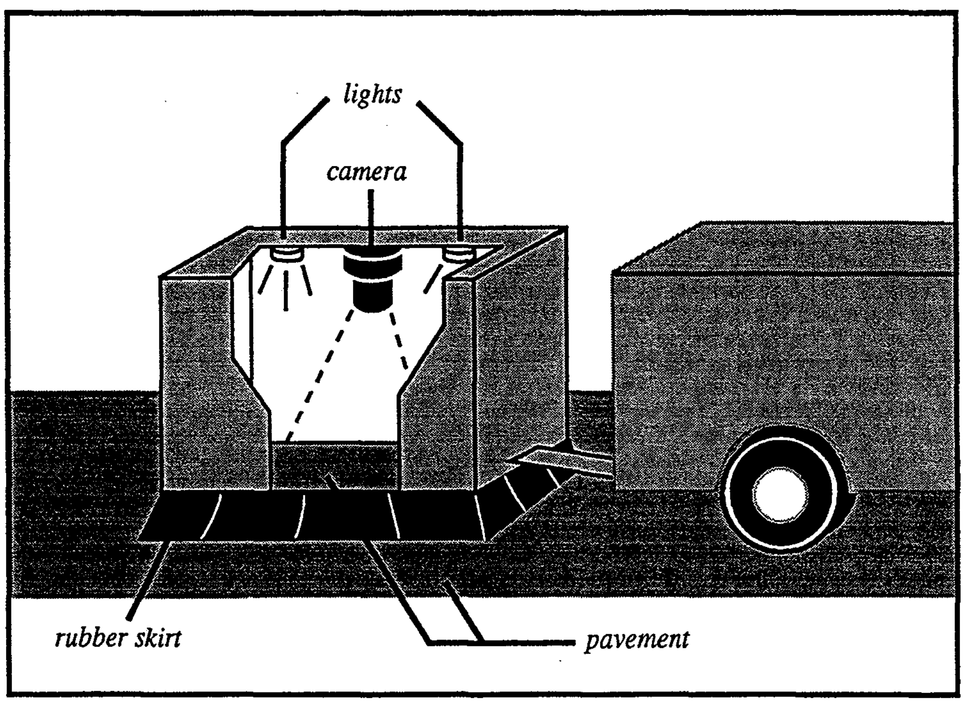
Software

The image algorithm developed for the system evaluates the four most frequently occurring distress types—longitudinal cracking, transverse cracking, alligator cracking for ACP, and block cracking for Continuously Reinforced Concrete Pavement (CRCP). TTI Research Report 1189-2F discusses technical details of the software development, as well as explains processes behind image analysis, image features, and the image classification rules.

Simply put, the image processor converts the video image to pixels, the basic unit of information in a digitized image, and then analyzes the graylevel (intensity) of square blocks sized at 48 pixels each. In an image, the cracks on pavement show as the dark pixels and are assigned a lower graylevel value(40-60), while the lighter pixels, usually pavement background, take on higher values (80-120). So a crack detection scheme locates pixels with lower graylevels by differentiating them from the background; it then creates a projection histogram and an edge map which are used to compute the extent and orientation of these pixels, thus determining the crack type and severity.

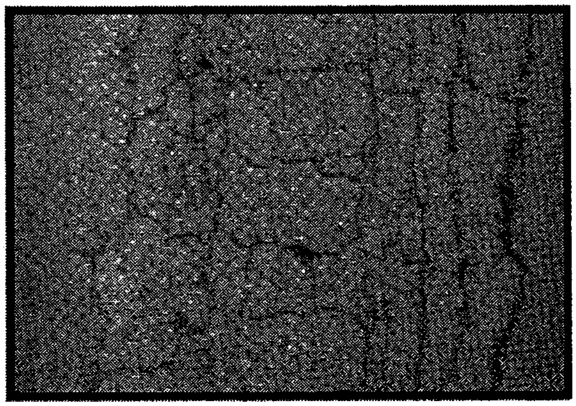
To evaluate the video data, processing methodology, and classification rules, the algorithm was tested on SH 6 near Navasota for ACP and on US59 for CRCP. For the ACP, 12 miles of one wheel path videolog (equaling 21,600 frames) was processed. The results were over 70% accurate, consistent and reliable, even in noisy images such as sealcoat surfaces or "stained" images such as oil spots. In fact, detecting transverse cracks in one section, the computer had a 90% accuracy rate, and the visual PMIS number matched the computer number at 3. For the CRCP footage, the initial 0.5 mile results show that the percent accuracy of spalled and transverse cracks is over 70%.

To avoid analyzing large amounts of video, a sampling

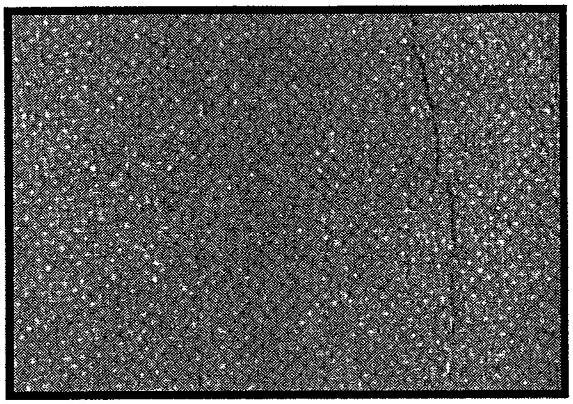


For collecting pavement distress video, the recommended system is a survey vehicle pulling an open-bottom trailer with lights and camera inside, and a rubber skirt along the bottom to prevent shadow distortions.

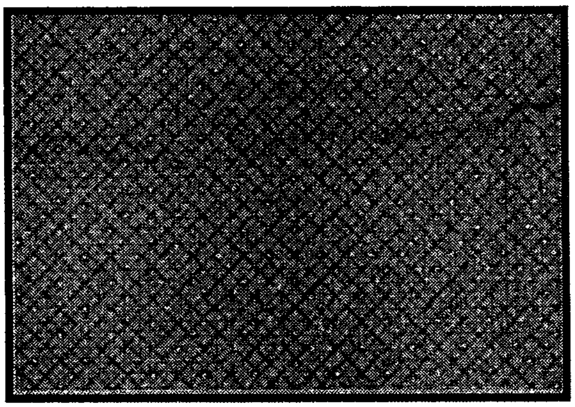
FOUR COMMON PAVEMENT CRACKS



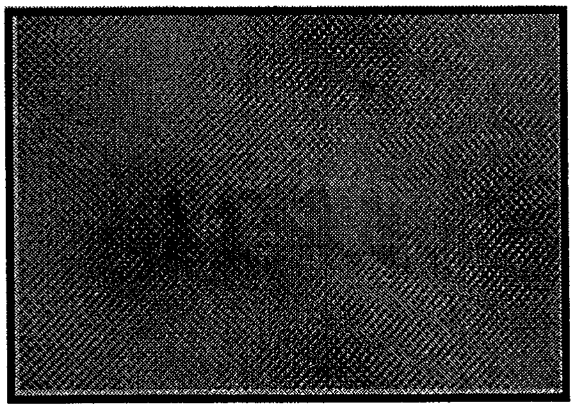
Alligator Cracking (ACP)



Longitudinal Cracking (ACP)



Transverse Cracking (ACP)



Block Cracking (CRCP)

The image algorithm developed for the videolog system evaluates the four most frequently occurring crack types—longitudinal, transverse, and alligator for ACP, and block cracking for CRCP.

scheme will be used. During data collection, the operator indicates pavement type, rates non-cracking distresses, and flags areas where cracking is present. This procedure can also be a post-processing operation if necessary. The information is then passed to the automated workstation. If the operator indicates that no cracking is present, then the pavement will only be sampled to confirm the findings. The operator will also be able to visually double check those sections that show great differences between field conditions and the automatic evaluation results.

CONCLUSIONS

Since the study's prototype open-bottom trailer contributed to quality video images in the camera/lighting study and the software evaluation, and the Sun IPX host image processing system was reliable, researchers recommend that TxDOT fully implement a prototype videolog of this sort and an integrated video system for pavement surface condition video data acquisition. A follow-up implementation study is focusing on evaluation of newer, more sophisticated strobe lighting and low-light camera technology for the customized trailer unit.

The follow-up study will also further develop the office video image processing system by exploring the following recommendations:

1) Use a high resolution digitizer and frame buffer to enable detection of early stage cracking.

2) Use a variable speed tracking VCR to overcome the video jitter that can cause decreased accuracy.

3) Evaluate recently manufactured hardware which could convert the office processing system from a workstation to a user-friendly, flexible PC platform.

Use of the system developed in this project should reduce costs, as well as increase the quality of work conditions and data in the Pavement Management Information System (PMIS).

Prepared by Kelly West, Science and Technology Writer, Texas Transportation Institute

The information in this summary is reported in detail in TTI Research Report 1189-1, "System Hardware for Acquisition and Automatic Processing of Pavement Distress Videolog," by P. Chan, A. Rao, and R. Lytton, November 1992; 1189-2F, "Development of Image Algorithms for Automated Pavement Distress Evaluation System," by P. Chan, A. Rao, L. Li, and R. Lytton, November 1992. The contents of the summary do not necessarily reflect the official views or policy of TxDOT or the FHWA.

FURTHER READING

Caroff, G., P. Joubert, F. Purdhomme, and G. Soussain. "Classification of Pavement Distresses by Image Processing (MACADAM SYSTEM)." *Proceedings*. First International Conference on Application of Advanced Technologies in Transportation Engineering. 1989. pp. 46-51.

Chan, K., S. Soetandio, and R. Lytton, "Distress Identification by an Automatic Thresholding Technique." *Proceedings*. First International Conference on Application of Advanced Technologies in Transportation Engineering. 1989. pp. 468-473.

Curphey, D., D. Fronek, and J. Wilson "Pavement Management System Using Video Image Processing." Report 17,045-762. National Science Foundation. July 1984.

Fukuhara, T., K. Terada, M. Nagao, A. Kasahara, and S. Ichihashi. "Automatic Pavement Distress Survey System." *Proceedings*. First International Conference on Application of Advanced Technologies in Transportation Engineering. 1989. pp. 33-38

Fundakowski, R., *Video Processing for Evaluating Pavement Surface*. Project 1-27. National Cooperative Highway Research Program. Washington, D.C.: Transportation Research Board, 1992.

Gonzales, R. and P. Wintz. *Digital Image Processing*. 2nd ed. Addison-Wesley, Inc. 1987.

Mendelsohn, D. "Automated Pavement Crack Detection." *Proceedings*. First International Conference of Pavement Management. 1987.

Smith, R., M. Darter, and S. Herrin. *Highway Pavement Distress Manual*. Report DOT-FH-11-9175/NCHRP. U.S. Department of Transportation, Federal Highway Administration. 1979.

Texas State Department of Highways and Public Transportation. *1991 Pavement Evaluation System Rater's Manual*. 1991.