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EVALUATION AND VALIDATION OF A HIGH-SPEED MULTI-FUNCTION SYSTEM FOR AUTOMATED PAVEMENT CONDITION SURVEY

PROBLEM STATEMENT

Manual surveys still represent the most widely used means for inspecting and evaluating pavements. Manual rating of pavements through windshield surveys to identify the types of surface cracking and other distresses leads to relatively slow evaluation. Furthermore, the survey crew must sometimes physically be in the travel lane to evaluate the pavement, exposing themselves to hazardous conditions. Conversely, high speed automatic pavement evaluation is an efficient and cost-effective alternative that assures the safety of the field survey personnel and the traveling public.

The Florida Department of Transportation (FDOT) has developed a state-of-the-art Multi-Purpose Survey Vehicle (MPSV) for high-speed collection of pavement-related data such as pavement images, cross-slopes, grades, curvatures, rutting and roughness information, and location referencing of the data. In order to allow the MPSV to be a viable tool, however, it must accurately gather and render the data. Consequently, before the MPSV can be implemented, it needs to be evaluated through controlled experiments to assess performance and validate the measurements each individual subsystem takes.

OBJECTIVES

This project was conducted in two phases. In the first phase, researchers were to evaluate the pavement imaging subsystem by investigating (1) the sources of noise that affect the quality of digital line-scan pavement distress images and (2) the effect of vehicle speed, ambient lighting conditions and the pavement lighting system on the accuracy and precision of digital line-scan images in representing the actual crack condition of a pavement. In the second phase of the study, researchers were to evaluate the Inertial Measurement Unit/DGPS subsystem by verifying that the roadway geometrical design features, such as cross-slopes, super elevations, radii of curvature, and grades, were within acceptable tolerances

FINDINGS AND CONCLUSIONS

The Signal-to-Noise Ratio (SNR) was identified as an appropriate and objective parameter to evaluate the quality of pavement images. A number of widely used noise filtering methods that can enhance the images captured by the pavement camera, thereby improving the accuracy of crack evaluation, were also identified. During the first phase of the study, a novel and efficient technique was developed to filter out noise (especially present in the pavement crack images). This technique employs intensity measurements obtained from a standard grayscale target.

The results of this study revealed that the speed of the survey vehicle does not significantly affect the quality of pavement images or the precision and accuracy of crack evaluation. Furthermore, the artificial lighting system was found to be redundant and even counter-productive in the evaluation of cracks under adequate ambient lighting conditions. The experimental results also indicated that the accuracy and precision of crack evaluation based on digital images from the existing MPSV imaging system is satisfactory only when evaluating high-severity cracks.

In the second phase of the research, researchers found that the cross-slope and super-elevation data were generally repeatable and accurate on both newly laid and relatively aged asphalt pavements. Furthermore, certain efforts and measures taken to improve the system yielded improved precision and accuracy results for grade and radii of curvature measurements; for example, an additional laser was installed on the rear bumper which, combined with operator attentiveness to tracking the same wheelpaths during multiple runs, will achieve improved repeatability and accuracy for grade measurement, particularly on curves.

BENEFITS

Innovations in vision sensing and inertial navigation technologies have been incorporated in the FDOT MPSV to enhance its functionality and thereby improve FDOT's pavement management system (PMS). This project has demonstrated that the FDOT MPSV is well-equipped to perform automated cross-slope and super-elevation measurements, as well as automated project-level safety evaluation of roadway curvature. Furthermore, the MPSV, at highway speeds, can collect pavement crack images with sufficient accuracy and precision. Hence the FDOT MPSV would be an efficient, cost-effective, and safe alternative for collection and evaluation of pavement distress data and identification of conditions that are detrimental to highway safety.

The frontier of imaging technology lies in the development of software that can be used to accurately classify and quantify pavement distress on a real-time basis. This means that when appropriate automated or interactive evaluation systems that can function in conjunction with the MPSV's imaging and inertial sub-systems are identified, the MPSV will be able to perform automated or interactive crack evaluation. This research will be useful in enhancing such automation efforts. Moreover, an automated crack evaluation system has the potential to be calibrated to detect excessive distress levels that do not conform to the age of pavements or the cumulative traffic imposed on them; this would enable the MPSV to be used effectively in setting up definitive pavement construction job acceptance standards with respect to cracking. Thus, the MPSV can be an invaluable tool not only in the formulation of pavement crack thresholds and acceptance standards with respect to the pavement age, but also in the speedy verification of those standards in new construction projects.

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