Time & Location: April 10, 2015 at 10:00 AM in Engineering 2 426 - Structural Health Monitoring Lab
Title: Analytical Study of Computer Vision-Based Pavement Crack Quantification using Machine Learning Techniques

Image-based techniques are a promising non-destructive approach for road pavement condition evaluation. The main objective of this study is to extract, quantify and evaluate important surface defects, such as cracks, using an automated computer vision-based system to provide a better understanding of the pavement deterioration process. To achieve this objective, an automated crack-recognition software was developed, employing a series of image processing algorithms of crack extraction, crack grouping, and crack detection. Bottom-hat morphological technique was used to remove the random background of pavement images and extract cracks, selectively based on their shapes, sizes, and intensities using a relatively small number of user-defined parameters. A technical challenge with crack extraction algorithms, including the Bottom-hat transform, is that extracted crack pixels are usually fragmented along crack paths. For de-fragmenting those crack pixels, a novel crack-grouping algorithm is proposed as an image segmentation method, so called MorphLink-C. Statistical validation of this method using flexible pavement images indicated that MorphLink-C not only improves crack-detection accuracy but also reduces crack detection time.

Crack characterization was performed by analysing imageial features of the extracted crack image components. A comprehensive statistical analysis was conducted using filter feature subset selection methods, including Fischer score, Gini index, information gain, ReliefF, mRmR, and FCBF to understand the statistical characteristics of cracks in different deterioration stages. Statistical significance of crack features was ranked based on their relevancy and redundancy. The statistical method used in this study can be employed to avoid subjective crack rating based on human visual inspection. Moreover, the statistical information can be used as fundamental data to justify rehabilitation policies in pavement maintenance.

Finally, the application of four classification algorithms, including Artificial Neural Network (ANN), Decision Tree (DT), k-Nearest Neighbours (kNN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) is investigated for the crack detection framework. The classifiers were evaluated in the following five criteria: 1) prediction performance, 2) computation time, 3) stability of results for highly imbalanced datasets in which, the number of crack objects are significantly smaller than the number of non-crack objects, 4) stability of the classifiers performance for pavements in different deterioration stages, and 5) interpretability of results and clarity of the procedure. Comparison results indicate the advantages of white-box classification methods for computer vision based pavement evaluation. Although black-box methods, such as ANN provide superior classification performance, white-box methods, such as ANFIS, provide useful information about the logic of classification and the effect of feature values on detection results. Such information can provide further insight for the image-based pavement crack detection application.

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Approved for distribution by Hae-Bum Yun, Committee Chair, on April 10, 2015.
The public is welcome to attend.