Human Reliability Analysis and Prediction for Visual Inspection in Bridge Maintenance

Ruoxin Xiong, S.M.ASCE,[1] Pengkun Liu, S.M.ASCE,[2] and Pingbo Tang, Ph.D., P.E., M.ASCE[3,*]

[1]Dept. of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213; e-mail: ruoxinx@andrew.cmu.edu
[2]Dept. of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213; e-mail: pengkunl@andrew.cmu.edu
[3]Associate Professor, Dept. of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213; e-mail: ptang@andrew.cmu.edu

ABSTRACT

Visual inspection is the predominant practice used to determine the physical and functional conditions of bridges. Inspection processes typically require significant cognitive effort. Multiple bridge defects with various severity levels and locations could increase the cognitive demands of tasks. As a result, inspection records obtained from visual inspection often showed unpredictable errors. On the other hand, inspectors' abilities to correctly identify defects can vary drastically among individuals and lead to different error rates in inspection reports. Personalized task performance predictions for individual inspectors are critical for proactively guiding bridge inspectors to avoid unique issues related to individuals' nature. This study presents a Personalized Coach for Bridge Inspector (PCBI) training system that provides personalized predictions of an inspector's performance in given tasks based on their behavioral traces in similar tasks. The predicted personal inspection task performance can help maintain a quality control system for bridge inspection. The authors developed a computer-simulated environment for bridge inspection processes to track inspectors' cognitive behaviors and task performance. The authors analyzed and predicted inspectors' performance individually using the Personalized Multi-Linear Regression (PMLR) model based on recorded cognitive patterns. Evaluation of the proposed model with the mean square error (MSE) between the actual and predicted performance achieved an MSE of 0.077. Finally, the authors compared human performance with state-of-the-art automated bridge inspection systems and discussed the effect of work experience on eye movement patterns.