DEVELOPMENT OF A VIRTUAL REALITY TESTBED TO STUDY INCONSISTENCIES AMONG BRIDGE INSPECTORS

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ABSTRACT

The present condition of US infrastructure requires a data-driven, risk-based approach to asset management. In the case of bridges, inspectors in every state visit these structures, collect data, and based on the information they report, departments of transportation evaluate bridge conditions, predict deterioration, and make repair and retrofit decisions. However, current inspection practices are manual and subjective, which could result in inaccurate assessments, with a significant impact on the allocation of economic resources and work schedules oriented to the maintenance and operations bridges. Furthermore, the capacity of inspectors for defect or deficiency detection might be inconsistent due to several cognitive and physical factors, such as the inspectors' experience or eyesight.

This thesis describes the development of a Virtual Reality (VR) application supported by advanced computer graphics where the users are engaged in immersive, photo-realistic 3D environments. It provides a testbed to study the variability among bridge inspectors. The outcome will provide statistical information that will be used to enhance the current inspection practices.

With the use of VR technology, current limitations of inspection evaluation, such as multiple districts and different types of structures, logistics of people and equipment, and weather conditions, are addressed. Besides improving inspection training, time and cost savings are expected, along with safer conditions and innovative training tools. The final product is a state-of-the-art VR set-up with testing models of concrete and steel bridges under controlled conditions that are open to assessing other needs in the future. The system runs on a high-resolution tethered headset supported by a gaming laptop to ease portability across Indiana districts.

The VR-based application comprises two bridge modules: one for a steel truss bridge and one for a multi-girder concrete bridge. The 3D bridge models are synthetically recreated using reference images from two case studies. Through constant feedback and multiple

demonstration sessions with the Indiana Department of Transportation (INDOT) bridge inspectors, the bridge components, the defects and their severity, and the inspection tools to be modeled are defined. Nine types of defects are modeled, including efflorescence, cracking, corrosion, spalling, and delamination. Eight inspection tools are also recreated in the VR scene, such as chain drag, hammer, scratch brush, flashlight, and tape measure.

After completing the inspection in the VR scene, users are required to fill out an online survey, one for each bridge. Condition rating numbers and comments on the state of the deck, superstructure, and substructure are requested. Besides, factors such as years of experience and work location are asked to ascertain inconsistency patterns when compared with the rating numbers. The VR application also offers the possibility of taking screenshots that inspectors can later attach to their surveys to complement their reports. Statistical analysis, including pie charts and histograms, is automatically generated, giving a multi-faceted approach to consistency evaluation among inspectors.