Cyber-Physical Framework For Efficient Evaluation Of Vision-Based Displacement Tracking Systems

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Monitoring of deflection levels in critical infrastructure is crucial to identify potential signs of deterioration or damage. Over the past decade, there has been an increase in the use of vision-based technologies for displacement estimation in structural health monitoring (SHM). The performance and error metrics of newly developed systems and proposed methods need to be evaluated in a laboratory environment before field deployment. Typically, this involves using targets mounted on a shake-table with the ground truth motion measured using sensors such as LVDT's and laser displacement sensors. Moreover, the task becomes more challenging for the experimental evaluation of sensitive parameters such as synchronization error between multiple cameras. The limitations on the accuracy of ground truth, repeatability of an experiment, and hardware often hinder the task of evaluation. We propose a framework for cost-effective and efficient evaluation of vision-based displacement tracking systems for SHM. The framework leverages the synthetic environment capabilities of an open-source platform, Blender, to develop virtual targets and simulate user-defined motion paths. The rendered simulation can be cast on a single/multiple display device, even a mobile display such as an iPad. The physical vision-based displacement monitoring setup is focused onto these mobile devices for the evaluation of performance metrics. The input ground-truth motion path is definitively known and is obtained based on the virtual-camera parameters and the display device's resolution. Moreover, the framework allows simulation of different environmental conditions in a repeatable fashion, such as lighting changes and snow/rain, without additional equipment in a laboratory setup. We demonstrate the use of this framework for the experimental evaluation of synchronization error between multiple wireless vision-based sensors designed for displacement monitoring of civil infrastructure.