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# Use of Two-Stage Optimization to Estimate Deformations of Scaled Truss Bridge from Cameras

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## ABSTRACT

Structural integrity can be evaluated from dynamic deformations of structures, which can be acquired from optical sensors, e.g., video cameras. Kanade-Lucas-Tomasi algorithm is one of the commonly used methods for motion tracking. However, averaging throughout the extracted features would deviate measurement. Moreover, when the depth information is not available, converting pixels into physical lengths is challenging. Thus, the assigned homogeneous coordinates would then mismatch manually selected feature points, resulting in measurement errors during coordinate transformation. In this study, a two-stage optimization method for video-based measurements is proposed. The manually selected feature points are first optimized by minimizing the errors presented in the homogeneous coordinate. Then, the optimized points are exploited for the Kanade-Lucas-Tomasi algorithm to extract displacements through the inverse projection. Two additional criteria are employed to eliminate outliers from the Kanade-Lucas-Tomasi algorithm, resulting in more reliable displacement responses. The second-stage optimization subsequently fine-tunes the geometry of the selected coordinates. The optimization process also considers the number of interpolation points at different depths of an image to reduce the effect of out-of-plane motions. As a result, the proposed method is numerically investigated using a truss bridge as a physics-based graphic model. Displacements are successfully extracted with high accuracy from recorded videos under various capturing angles and structural conditions.

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