Seminar Title: Uncrewed aircraft system (UAS)-enabled dynamic displacement measurement techniques

Abstract:

Measuring the dynamic displacements of a structure provides a comprehensive understanding of the structure, especially when subjected to different types of dynamic loading (i.e., wind, traffic, impact loads, blast loads, etc.). Despite their usefulness, direct displacement measurements are typically not collected due to the cumbersome logistical issues of sensor placement and maintenance and the impracticality of instrumenting contact-based sensors across all significant structures. In this context, this talk introduces two new techniques to measure dynamic displacement of structures, using portable, noncontact measurement systems enabled by uncrewed aerial systems (UASs). In the first technique, an Intel RealSense sensing unit with one optical camera, two infrared (IR) cameras, and one IR projector is equipped on a UAS. The optical camera is used to measure dynamic displacement for in-plane motion (x-, and y-directions), while the IR cameras are adopted to measure dynamic displacement for in-depth direction (z-direction). This technique simultaneously extracts the 3C displacement of a 3D structure, which presents a unique advantage compared to the earlier UAS-based displacement measurement techniques that allow the measurements in only one or two directions using optical cameras or laser sensors.

However, the first technique has limitations for large scale applications due to decreased accuracy with increased distance between UAS and the structure, as well as the interference of sunlight with infrared targets. To overcome these limitations, a novel dual stereovision technique (i.e., the second technique) is developed using a UAS equipped with four optical cameras. One pair of cameras tracks the three-component (x, y, and z) motion of a region of interest (ROI) on a structure with respect to the UAS system, and the other pair of cameras measure the six degrees of freedom motion (6-DOF) (both rotational and translational motion) of the UAS system by tracking a stationary reference. The motion of the UAS is then compensated for, recovering the true dynamic displacement of the ROI. The proposed dual stereovision technique realizes simultaneous measurement of all three components of displacements of the structure and 6-DOF of UAS motion through a mathematically elegant process. The unique dual stereovision technique allows flexibility in choosing a global reference coordinate system, greatly enhancing the feasibility of applying the new technology in various field environments. This new technique has overcome the major challenge of significant UAS motions in full-scale applications. Furthermore, this technique relies on natural features and eliminates the requirement of artificial targets on the structure, permitting applications to difficult-to-access structures.

Bio: Yanlin Guo is an Associate Professor in the Department of Civil and Environmental Engineering and the Director of Center for Sustainable and Intelligent Transportation Systems at Colorado State University (CSU). Her research expertise lies in the areas of mitigation of wind and compound (e.g., concurrent hurricane wind and surge) hazards in built environment, real-time structural health monitoring (SHM), data-and-physics integrated simulation and modeling of extreme winds and wind effects on structures, remote sensing using computer vision, system identification, and structural dynamics. These research topics embrace the advances in natural hazard engineering, modeling, monitoring, dynamics and data science to help evaluate the conditions of buildings, transportation and energy infrastructure, provide quick decision-making support regarding emergency response, maintenance or retrofitting, etc., and ultimately improve the life-long performance and resilience of structures subjected to both in-service loadings and multiple hazards. Dr. Guo completed her undergraduate studies in Civil Engineering at the Southeast University in Nanjing, China in 2007 and obtained her Master of Philosophy degree in Civil Engineering from the Hong Kong Polytechnic University in 2010. Later she received her Ph.D. degree in Civil Engineering from the University of Notre Dame in 2015.