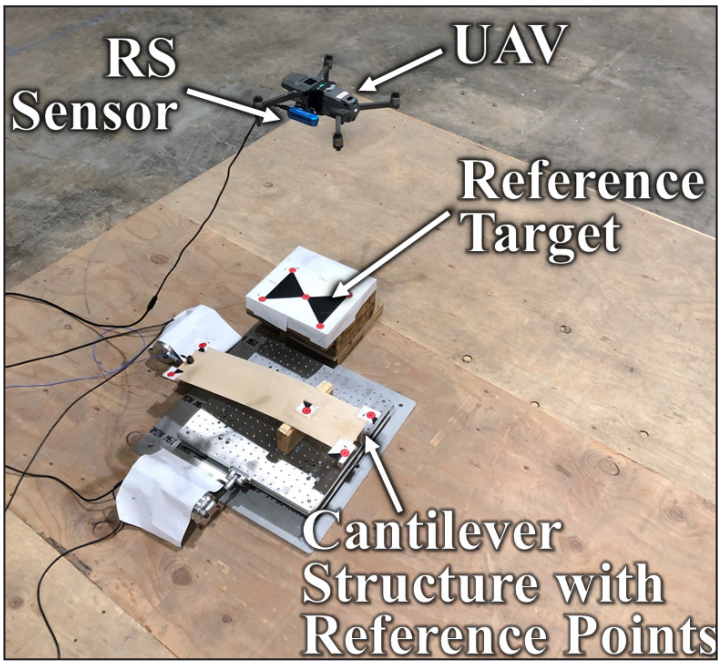
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-552 (project 643) | September 2024

Development of a New Airborne Portable Sensing System to Investigate Bridge Response



the ISSUE

Understanding structural dynamics is critical for evaluating long-term structural performance and decision-making regarding maintenance and operation of the structure. Quantifying the displacement of structural vibration is an important means to evaluate the dynamic performance of structures under various dynamic loading, such as winds, traffic, and impact loading. Instrumentation of structures such as bridges is complex, requiring careful placement of sensors and management of wires or wireless systems. Such systems are difficult to relocate after installation. Non-contact remote sensing systems using cameras or laser Doppler have been deployed, but safe placement for such a system may be difficult.

the RESEARCH

The research works on developing an uncrewed aerial vehicle (UAV)-based remote sensing system to measure three-component (3C) dynamic displacements of structures. It integrates optical and infrared (IR) sensors on a UAV platform to capture both two-component (2C) planar movement using optical sensors and one-component (1C) depth movement using IR sensors. The methodology employs a double-faceted computer vision technique, combining direct linear transformation (DLT) and active stereo vision, to simultaneously extract 3C displacement data from videos.

The UAV-based system addresses limitations of traditional sensor-based structural health monitoring methods, such as the need for fixed sensor placement and extensive logistical setup. The UAV, equipped with Intel RealSense sensors, hovers near structures and records displacements, compensating for its own motion using stationary reference targets. The accuracy of the proposed technique was validated through laboratory experiments, with results showing less than 2-mm root-mean-square error (RMSE) in dynamic displacement measurements. This portable and cost-effective sensing method is ideal for short-term monitoring or modal testing of civil structures, offering flexibility and ease of deployment in various environments.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

Colorado State University
North Dakota State University
South Dakota State University
University of Colorado Denver
University of Denver
University of Utah
Utah State University
University of Wyoming

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Project Title

Development of a New Airborne Portable Sensing System to Investigate Bridge Response

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the **FINDINGS**

By integrating optical and IR sensors, the system accurately captures planar and depth movements, addressing limitations of traditional methods. The research findings show that the system achieved an RMSE of less than 2 mm in displacement measurements, with frequency and damping estimation errors below 5%.

the **IMPACT**

This research lays a foundation for cost-saving measures that are more efficient and reliable for sensing systems. The study advances the UAV-based portable sensing techniques for dynamic displacement measurement by enabling simultaneous measurements of three components, as opposed to only two or one in existing UAV-based remote-sensing studies. This portable, non-contact approach is highly accurate for structural health monitoring and is more practical for short-term dynamic testing than conventional sensor-based methods. The results highlight the system's scalability and potential for field application in monitoring civil structures such as bridges.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1191

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.

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