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A Review of Robot-Based Automated Vibration Measurement for Civil Engineering Structures

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Abstract

Recent advancements in robotics and machine vision enable automated vibration measurement for civil engineering structures. A variety of robotic platforms, including drones and land robots outfitted with advanced navigation and data acquisition systems, have been developed. Specifically, various cameras have been deployed on robotic platforms to capture videos of structures, and machine vision approaches to extract structural vibration from captured videos have been developed. This forward-looking review discusses robot-based hardware, machine vision approaches, and the capabilities of automated structural vibration measurement. The emphasis is on clarifying the capabilities, technical limitations, promising solutions, and practical performance of robot-based approaches in field measurements with low vibration amplitudes and long-term monitoring needs. The challenges and opportunities are discussed, and recommendations are made to help.

Keywords: Robot; Civil engineering; Machine

Introduction

Indeed, neuroscientists can help architects understand scientifically what has previously been intuitive, thanks to new neuroscience discoveries that are bridging the gap between the physical built environment and human perception and behaviour. According to Pavia, it has been proven that the surrounding built environment can have a direct impact on how the unconscious mind works, and that a. [1, 2, 3].

Methods

UAVs, unmanned ground vehicles (UGVs), and cooperative systems are the three types of robotic platforms examined. In current research on automated vibration measurement, UAVs are the most commonly used robots. Other promising robot types are also introduced.

Resonance measurement is a crucial approach for health monitoring of structures (SHM) by assessing structural parameters such as the stiffness and damping features, which represents a classic SHM paradigm. The degradation of structures was reflected by the evolution of structural parameters. Cracks and buckling, for example, frequently cause significant reductions in structural stiffness, which can be measured using structural vibrations. Such methods have been used to assess the conditions of China's Yonge Bridge and Korea's Jindo Bridge [4, 5].

Strain gauges, linear variable differential transformers, potentiometers, laser Doppler barometers (LDVs), and global positioning systems (GPS) have all been used to measure structural vibration. In field applications, sensors provide useful data but have limitations. For starters, sensor deployment is typically expensive, time-consuming, and labour-intensive. Physical access to the target structure is frequently required, which is difficult in many scenarios, such as the monitoring of cable-stayed and suspension bridge cables and pylons. Furthermore, the majority of sensors are point-wise, measuring vibration at the location where the sensor is deployed. These limitations motivate the development of alternative approaches to measuring structural vibration [6, 7].

Recent advances in robotics and machine vision provide numerous opportunities. Unmanned aerial vehicles (UAVs) outfitted with vision-based sensors have emerged as a novel vibration measurement technology. Photos and videos from vision-based sensors provide rich structural information for remote condition assessment and enable multipoint measurement. When compared to traditional technologies, the deployment of UAVs is frequently less expensive and faster. Despite the benefits of vision-based approaches, their measurement performance is affected by a variety of factors, including the field condition, camera pixel resolution, camera viewpoints, and atmospheric distortions. Because of the enormous potential of robots, the research community is leaning toward combining machine vision approaches with robots for autonomous vibration measurement. [8].

Conclusion

This paper examines robot-based automated vibration measurement for civil engineering structures. The main topics covered include robotic platforms and sensors, measurement approaches, applications and performance, and challenges and opportunities. A method for automated vibration monitoring using robotic platforms is proposed, and representative algorithms are examined. [9, 10].

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Potential Conflicts of Interest

No conflict or competing interests in the publication of this paper.

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