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Vibration-based Monitoring for Structural Assessment

Abstract

Over the course of its service life, structures are subjected to ageing processes and different types and magnitudes of loading. Both phenomena can significantly affect the structural behavior. In the context of Structural Health Monitoring (SHM) vibration-based methods can be used to determine the structural state of a structure; thereby, changes of the structural condition are identified from changes in the dynamic properties. Measured responses can be further used to calibrate numerical models (model updating) for various simulation tasks. The structural state can be identified from measurements by applying methods of system identification.

Traditionally piezoelectric accelerometers are used to measure local accelerations of the structure. MEMS-based sensors are growing in popularity because they are small, cheap and easy to include in embedded systems, wireless sensor networks or smartphones. Since these MEMS accelerometers are mostly less accurate than piezoelectric sensors, it becomes therefore necessary to account for the reduced accuracy in order to determine limitations for applications in SHM.

The research in the field of vibration-based monitoring does not focus on developing new methods of system identification, damage detection, signal processing, etc., but on the determination of the influence of different sensing and data acquisition characteristics as well as their processing using the existing methods. Different qualities of sensors are therefore considered in aspects of simulation of measurement, design of monitoring systems and damage detection amongst others.

In addition, a software framework based on the Raspberry Pi platform was developed that allows for synchronized measurements within a wireless sensor network. Further, also an Android Application was implemented to enable measurements employing the integrated MEMS sensors. Both, mobile devices as well as the wireless sensor network are utilized to collect measurement data in laboratory experiments and on existing structures.

Besides the vibration-based methods also a quasi-static approach using measured inclinations was applied in a few monitoring campaigns.

Related software

RasPyre Software Framework, Mosaic Smartphone App

Different sensors and mobile devices used to measure structural acceleration during a short-term monitoring campaign

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Related publications

1. Morgenthal, G., Rau, S., Taraben, J., Abbas, T., Determination of stay cable forces using highly mobile vibration measurement devices, ASCE Journal of Bridge Engineering, 23(2) (2018), pp. 04017136
2. Morgenthal, G., Eick, J. F., Rau, S, Taraben, J., Wireless Sensor Networks Composed of Standard Microcomputers and Smartphones for Applications in SHM, Sensors, Special Issue Selected Papers from 7th Asia-Pacific Workshop on Structural Health Monitoring 2018, 19(9), 2070, DOI: 10.3390/s19092070
3. Rau, S., Morgenthal, G., An assessment framework for sensor-based detection of critical structural conditions with consideration of load uncertainty, Structures, 12 (2017), pp. 168–178