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Analysis of sensor signals for monitoring of heritage buildings

Kym Watson (1), Siegbert Kunz (1), Hylke van der Schaaf (1), and Filippo Ubertini (2)

(1) Fraunhofer IOSB, Karlsruhe, Germany (kym.watson@iosb.fraunhofer.de), (2) University of Perugia, Perugia, Italy (filippo.ubertini@unipg.it)

This presentation describes work carried out by the Fraunhofer Institute IOSB and the University of Perugia in the European H2020 project “HEritage Resilience Against CLimate Events on Site” (HERACLES) as part of the test bed in Gubbio (Italy) to protect its historic buildings (cf. http://www.heracles-project.eu/). Sensors positioned in the heritage buildings of Gubbio measure parameters such as acceleration, room temperature and crack amplitudes and deliver sampling data streams. The data is stored on a server implementation of the OGC standard SensorThings API (see also https://github.com/FraunhoferIOSB/SensorThingsServer). Special techniques have been developed to select, aggregate and visualize sensor data streams in a performant way in a web application.

Data analysis is conducted with a software framework to integrate R scripts for data processing into the HERACLES software platform. Algorithms have been developed to detect and remove man-made perturbations in the accelerator data streams arising from the periodic chiming of nearby clock bells. The algorithms are based on a Hanning filter. The acceleration sensors with a data rate of 100Hz are highly sensitive and are capable of measuring micro-tremors with accelerations much smaller than those induced by e.g. the clock bell, and with up to 0.5 g as the maximum. The R programing language enables efficient programming of software scripts for high performance data processing and offers a wide range of additional packages provided by a growing developer community, in particular for geo-statistics.

In particular, R code has been developed to make the acceleration data audible with different resampling rates e.g. 800Hz or 1600Hz, which transposes the frequency and stores them in .wav files. The audio files allow one to listen to multiple mechanical impulse acceleration signals due to the periodic clock bell sequences and ambient vibrations induced by traffic or wind.

The cleaned signals are further processed to extract the natural frequencies of building vibrations as part of structural health monitoring of the Consoli Palace.

In particular, possible anomalies in time series of natural frequencies of the structure caused by some structural damage are revealed through multivariate statistical analysis and control charts.
The presentation will describe the data analysis and signal correlation methods as well as giving an overview of the software framework set up for the flexible integration of analysis algorithms.

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