Self-Sustainable Structural Health Monitoring sensor systems for large civil structures

Civil structures are currently maintained using preventive maintenance

The goal of this technique is to keep the state of the structures to the standards defined by infrastructure operators. Within the framework of preventive maintenance, inspections and repairs have to be executed on a pre-scheduled systematic base. Therefore, a significant amount of performed repairs is quite often redundant from both an economical and a safety point of view. Moreover, if the maintenance and repairs are only based on the results of visual inspections, a possibly non-obvious fatal failure might not be detected at all.

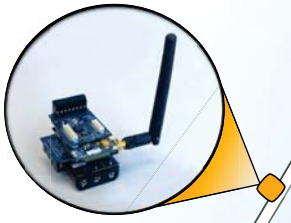
Maintaining large structures is expensive

For this reason the infrastructure operator is bound to hold the upkeep costs and inspections on the lowest possible level. One way for reducing the inspection and maintenance costs is to install a Structural Health Monitoring (SHM) system which regularly assesses the state of the structure in an automated manner. Currently available cabled-based SHM systems are expensive and can significantly affect regular operation of the structure throughout installation.

Wireless Sensor Networks offer a promising solution

SHM solutions based on a WSN enable usage of a more optimal maintenance planning schema, i.e., predictive maintenance. This approach enables maintenance decision making at an optimally planned schedule. Also, by combining it with non-destructive testing techniques such as vibration monitoring, inspectors gain insight into how the monitored structure presently functions. By exploiting this knowledge predictive maintenance can additionally estimate the future state of the structure.

The Wireless Sensor used in the project



The Wireless Sensor used in this project. It is equipped with a three axial accelerometer able to measure up to 256 samples per second. Assuming that it performs a measurement 6 times a day, it consumes only 440 J per day.

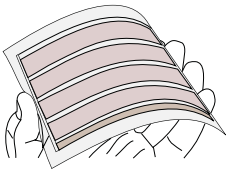
Data Compression

The data transmission volume for SHM systems is large. A system built on a WSN solution with highly energy-inefficient data transmission will results in battery drainage within a prescribed amount of time.

In this project, data compression aims at increasing the efficiency of data transmission by applying Model Based Compression. Within this framework, the laws governing the behavior of the structure are exploited. This knowledge allows signal reconstruction from a partially transmitted data.

Dye-Sensitized Solar Cells

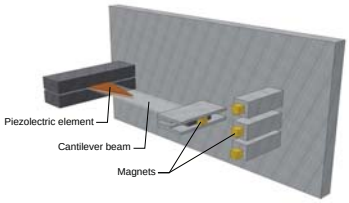
Photovoltaic energy harvesting is investigated in this project as one of the means for creating self-sustainable sensors. A 20 x 20 cm sheet of this thin-film solar cell can provide enough energy to power up a sensor throughout the course of the day.



The cell is combined with a proper electronic and energy storage circuit which helps realize the development of a sensor prototype. Another attractive advantage of thin-film solar cells is their flexibility as the cells can be shaped in various ways or simply glued to the structure.

Ambient Vibrations Energy Harvesting

Vibrations are commonly present on civil structures. Their levels might be as low as 0.01 m/s^2 up to 0.2 m/s^2 during passing of the heavy vehicles.



The idea behind ambient vibration energy harvesting is to transfer this unused energy into electrical energy by means of piezoelectric elements. To tune the device to the specific vibration patterns present on a given bridge, non-linear behavior of magnetic components will be explored.

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