A Range of Data Mining Techniques to Correlate Multiple Sensor Types

Shengfa Miao[1,2], Arno Knobbe[1], Joaquin Vanschoren[1], Ugo Vespier[1], and Xiaoyun Chen[2]

[1] LIACS, Leiden University, the Netherlands
[2] IDM, Lanzhou University, China

With the development of sensing techniques, monitoring the health of infrastructural assets, such as buildings and bridges, becomes feasible. More and more sensors of various types are used to collect real-time information from such structures. How to analyse and deduce relevant knowledge from this abundant information is attracting much attention from data mining researchers. In this abstract, we will present the InfraWatch project. The target of this project is to monitor the health of a particular infrastructural asset, the Hollandse Brug, one of the Netherlands' major highway bridges. This bridge employs 145 sensors at several locations to measure the temperature, the vertical movement (vibration) and the horizontal stress (strain). Moreover, it is equipped with a weather station and a video-camera.

Our current work is focused on modelling the dependencies among these multiple types of sensors. In our case, dependency refers to the statistical relationship between two sensor signals. We placed extra emphasis on the dependencies between sensor signals of different types, such as strain vs temperature, and strain vs vibration. We looked into the sensor network from two different domains: the time and frequency domain.

In the time domain, correlation analysis has been extensively used, based on which we detected some interesting sensor pairs, and discovered a strong dependency between the strain and temperature sensors. A large concrete bridge has a considerable capacity to store heat, and as a result the effect of the outside temperature on the stiffness of the bridge is integrated over time, so there will be an inherent delay. To model this delayed influence on the bridge, an exponential filter was applied, after which linear regression was able to explain the gradual changes in the strain signal by changes in the outside temperature. Additionally, envelope analysis turns out to be useful to associate vibration and strain signals in how they capture traffic events.

In frequency domain, spectrum analysis is widely used to detect the damage and degradation in the field of civil engineering. We analysed the dependencies between vibration and temperature signals through the natural frequency of the bridge. A band pass filter helps us to get rid of the influence of low frequency factors, like gradual temperature changes, as well as high frequency factors, like noise. As such, we can focus on the frequency rang we are interested in. Through filtering the strain signal, we discovered a strong dependency between strain and the envelope of the vibration signal.