Development of industrial monitoring systems with sensor integration, data fusion and information management

PhD thesis – summary

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Maintenance of civil structures is a very serious matter in modern day transportation network. Old civil structures in poor condition can be dangerous and may cause trouble instead of bringing profits. Therefore, SHM with reliable NDT techniques comes to attention. According to results found in literature, the application of SHM systems is very broad and is necessary for proper operation of civil structures nowadays. One of the main challenges of SHM remains the transfer of sensing and damage detection technologies from the laboratory environment to routine field applications. This doctoral dissertation discusses the development of a methodology to assess the technical condition and monitoring of real RC structures based on embedded sensors.

The main goal of the research was to develop the effective signal processing and data fusion methods for different or the same measurement systems that increase efficiency and reliability of damage detection qualitatively, provide new information about the state of the monitored RC structures and contribute to improving the assessment of the current condition of the examined structures. The objective was achieved with the use of advanced signal processing and physics-based analysis.

In order to achieve the determined objectives, different types of structures were considered and experiments were carried out. For this purpose, a benchmark RC structure with initiating cracks till failure, artificially damaged reference real structure, and a real bridge in service were discussed. First, the data acquisition system was specially developed for these applications, and acquired signals were analysed which allowed for the selection of parameters for post-processing. Several signal processing methods were investigated to extract features from the raw signals and validated in the context of early damage detection. Afterwards, information fusion algorithms were used to assess different sensors in order to enhance the overall level of information. Then feature-based fusion, that ultimately increased detectability, was applied to combine information. Since information obtained from sensors is often located in different places which contain different categories of information, signal-based fusion technique was used to integrate different types of information, and fused signals were obtained using multiple sensors to produce more comprehensive information on the condition of the tested structures. The results were verified using digital image correlation and the Receiver Operating Characteristic. The developed methodology was tested on two real structures, which confirmed the validity of the formulated hypothesis.

Keywords: Reinforced concrete; Damage detection; Ultrasonic NDT; Diffuse ultrasonic wave; Data fusion; Signal processing.