Monitoring of strain cycles on a railway bridge with a wireless sensor network

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Abstract

Cross girders of a riveted steel frame bridge were monitored with a wireless sensor network. Since strain sensing is very expensive in terms of power consumption a novel signal conditioning hardware was developed that enabled to significantly reduce the power consumption. An embedded data processing algorithm transformed the recorded raw data into a sequence of maxima and minima representing the strain cycles thus reducing data communication and enabling an additional energy saving. By using a software based event triggering algorithm the embedded data processing was performed only for data acquired during train transits. Strain cycles of more than 900 trains were recorded. The quality of the recorded data was very good and demonstrated that WSNs can be a competitive alternative to conventional tethered monitoring systems for recording operational data for fatigue assessment of steel railway bridges.

Keywords: Wireless sensor networks, strain monitoring, embedded data processing, low power signal conditioning hardware, strain cycles, field tests, railway bridge.

1 Introduction

Because of the increasing traffic volume on the European railway network many existing railway bridges are currently subjected to loads and speeds that exceed those for which they were designed. On metallic bridges a major concern is the remaining fatigue life. Past investigations demonstrated that monitoring allows to significantly reduce the uncertainties associated with the performance of old bridges subjected to dynamic loads [1, 2]. Typically, the monitoring program is focused on achieving strain data from critical structural components which are exposed to many high amplitude load cycles.

Among different concepts and technologies for monitoring civil structures, wireless sensor networks (WSNs) have the attractive properties of being highly automatable and cable-free thus enabling a rapid and cost-saving deployment. Reduced installation costs favour mainly short and medium term deployments which in practice represent the majority of monitoring applications. However, battery-operated WSNs are only competitive if they can provide good quality data and can be operated reliably and with minimal maintenance for a sufficiently long time.

Strain monitoring for fatigue life evaluation of railway bridges are characterized by several peculiarities. Since fatigue assessment is performed by considering only strain cycles induced by traffic loads the absolute strain usually do not need to be recorded. As a consequence, strain recording is only necessary when a train is crossing the bridge. The monitoring process is therefore event driven. Since on most of the bridges the average time interval between trains are much greater than the average recording period during train crossings the implementation