A Remote Intelligent Structural Health Monitoring System

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1. Introduction

Monitoring the health condition of structures, for example, a long-span bridge or a high-rise building, is receiving more and more attention in the civil engineering community. In the structural health monitoring (SHM) system, hundreds of sensors may be employed. Current cable-based monitoring systems bear high installation costs and are vulnerable to adverse environments. These weak points hinder the wider application of SHM in practice. A Remote Intelligent Monitoring System (RIMS) is being developed in the Bridge and Structure Laboratory, University of Tokyo, for SHM purpose.

2. System Description

The RIMS mainly consists of five components, i.e., power supply, sensing interface, micro-controller, wireless communication and base station. The sensing interface is responsible for the measurement data from sensors. Currently one kind of micro-electro mechanical system (MEMS) based accelerometer is used, in which the sensing transducers are integrated with digital circuitry to yield high accuracy with small volume. The measured data is collected and transferred through the wireless modem to a wireless network. These tasks are controlled by the micro-controller. A centralized base station locates in the structure of being monitored to receive and process the ambient vibration data from the sensors. The NExT technique [1] is applied to deal with the received data, to identify the structural dynamic properties such as natural frequencies, damping ratios and mode shapes. Statistical inference algorithms [2, 3] will be embedded to explain the data and predict abnormality, if any. The framework of the system is simply illustrated in Figure 1.

Figure 2 demonstrates the structure of the wireless sensor unit. The main parameters of the current system are listed in Table 1.

3. Preliminary Test

The current RIMS has been installed on a streetlight pole in Rainbow Bridge in Tokyo Bay, as shown in Figure 1, to measure the vibrations due to traffic excitations. A typical time history record is shown in Figure 3 and the square root of auto spectral density (ASD) of one set of data shown in Figure 4. The first two natural frequencies are estimated as 2.93 Hz and 8.40 Hz, respectively. Since this is a preliminary test to check the applicability of the system, more sensor units will be installed to form an array or network to understand the whole picture of the vibration characteristics of the structure. These vibration data can be used as baseline data of the intact state for comparison in the later monitoring stage.

4. Summary and Discussions

This paper simply describes the RIMS under developing. Preliminary application shows that it can be used for health monitoring. Potential usage includes model calibration and damage identification. Moreover, it can provide a fast examination of the structural health condition after catastrophic events such as earthquakes. Some matters such as power supply, transmission distance, price and so forth are being considered to improve its whole performance for practical usage. The new generation of the system will be installed in a real RC building.

Reference

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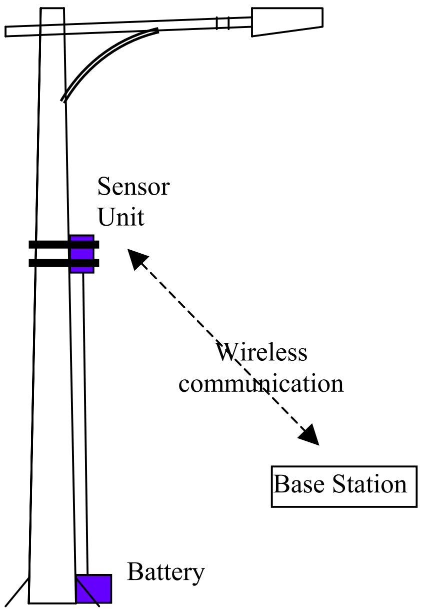

Figure 1. Framework of the RIMS

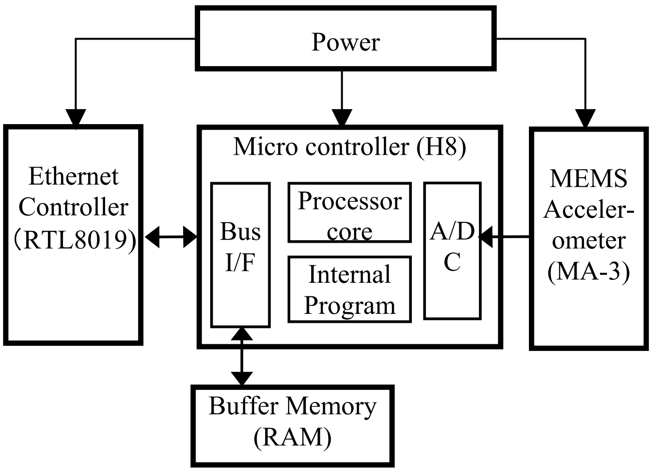

Figure 2. Structure of the Sensor Unit

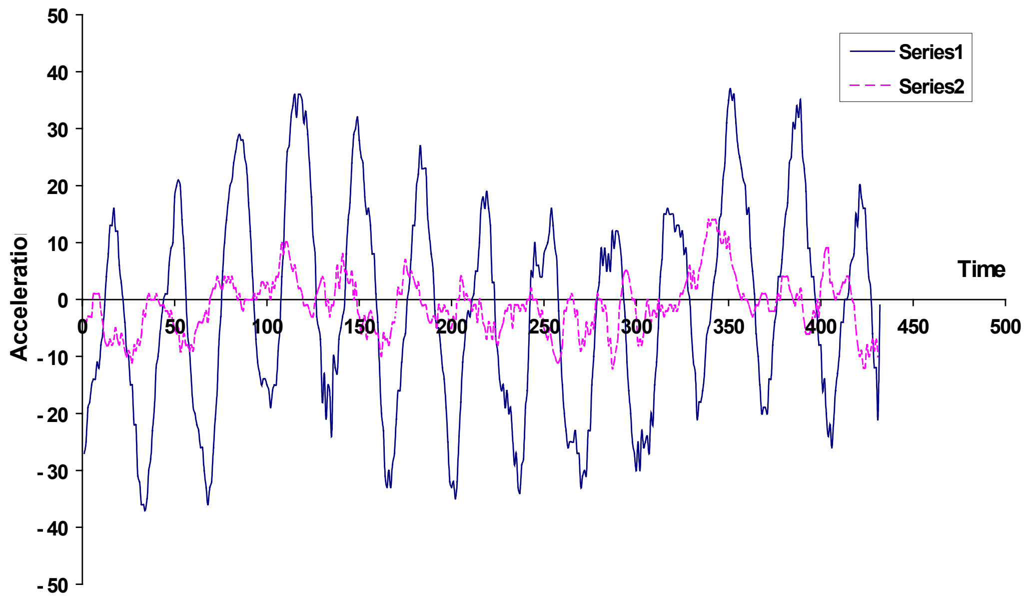

Figure 3. Time History of Acceleration

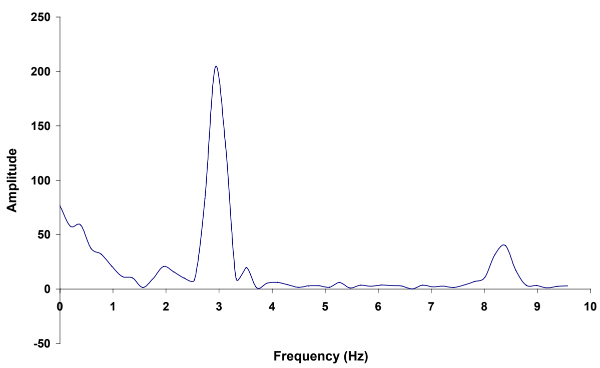

Figure 4. Square Root of Auto Spectral Density

Table 1. Specification of the System

CPU	16-bits, 20 MHz speed
Memory	2 Mbytes
Accelerometer	MA-3-4, range: +/-4g
Data sampling	100 Hz
RF transceiver	2.4 GHz
Range	100 m
Size	20×8×6 cm^3
Total price	50K JP Yuen