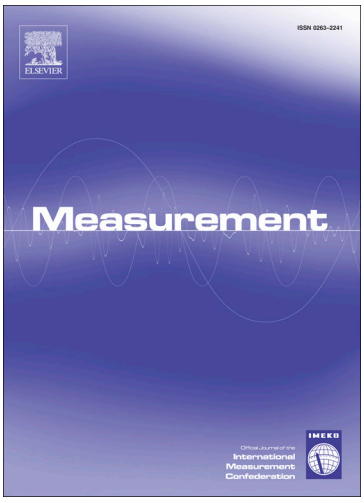

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A LOW COST DISTRIBUTED MEASUREMENT SYSTEMS BASED ON HALL EFFECT SENSORS FOR STRUCTURAL CRACK MONITORING IN MONUMENTAL ARCHITECTURE

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Abstract: In this paper the authors discuss a low-cost distributed monitoring system for structural crack monitoring in monumental architecture. The proposed solution is suitable for monitoring widely extended areas like the Siena's ancient city walls. The prototype sensing system, based on Hall sensor technology, has been developed and characterized to reach a displacement resolution in the order of tens of micrometers. The distributed measures are transmitted to a server using a wireless communication network based on a mesh topology. The server receives, collects, post-processes and stores the data in a database.

Keywords: Hall Effect Sensors, Monumental Monitoring, Wireless Sensor Network.

1. INTRODUCTION

The field of monumental architecture preservation is under continuous development thanks to the possibility to merge traditional approaches with emerging and more sophisticated monitoring techniques. From this point of view, a significant opportunity, in particular when wide area structures like palaces or ancient city walls are considered, is represented by the use of low cost wireless sensor networks together with different types of sensors [1-8].

When considering a wide distributed network of sensors, different aspects have to be taken into account for its design, e.g., the network architecture, the measurement accuracy, the environmental scenario, the energy budget, the physical dimensions of network nodes, the system durability and the extent of the area to be monitored.

In this paper the authors discuss these issues with reference to a low-cost measurement sensor network to be used for structural crack monitoring in a widely extended area like the Siena's ancient city walls.

Our goal is to have network nodes providing accurate information about the crack width whereas exploiting a low cost technology and requiring a reduced energy budget. To this aim, the network architecture is based on a mesh topology based on local multi-hop transmissions, being the power supply based on local energy harvesting. Moreover, the nodes can measure different physical quantities related to the spot being monitored such as the local temperature and the humidity (this latter is not measured in the release of the node described in this paper). This approach allows for the correlation analysis of acquired data, to compensate, e.g., their influence on the crack width measurement.

Nowadays structural crack monitoring in structures like palaces or ancient city walls is generally achieved by means of Linear Variable Displacement Transducer (LVDT) sensors or potentiometric devices, capable to provide high accuracy, but which are quite expensive [9-11]. In the system proposed in this paper, instead, the circuit for the crack width measurement exploits a displacement sensor based on a permanent magnet and an IC Hall-effect sensor mounted in a special holder, obtained by 3D printing in PLA. This low-cost solution is characterized by a large sensitivity, a low power consumption and a low-complexity conditioning electronics, and it is suitable for being embedded in devices that have to be remotely managed and accessed through a wireless network.

The paper is organized as follows: In section 2 we discuss the crack width sensing system composed by the sensor and the conditioning circuit. In this section we also present the sensor characterization. In Section 3 we present the network architecture, and the node architecture. Finally in section 4 a compensation strategy for the temperature influence and the experimental results based on an 8 months pilot measurement campaign are discussed.

2. DESIGN AND CHARACTERIZATION OF THE MEASUREMENT SYSTEM

As shown in Fig. 1, the measurement system includes analog front-end circuits for the displacement and the temperature sensors, a DAC unit, a microcontroller, a GSM transmission module and a power supply unit. In this Section we present a detailed discussion of the measurement system components, from the sensors to the transmitting module.