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Integrated Process of Images and Acceleration Measurements for Damage Detection

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Abstract

The use of mobile robots and UAV to catch unthinkable images together with on-site global automated acceleration measurements easy achievable by wireless sensors, able of remote data transfer, have strongly enhanced the capability of defect and damage evaluation in bridges. A sequential procedure is, here, proposed for damage monitoring and bridge condition assessment based on both: digital image processing for survey and defect evaluation and structural identification based on acceleration measurements. A steel bridge has been simultaneously inspected by UAV to acquire images using visible light, or infrared radiation, and monitored through a wireless sensor network (WSN) measuring structural vibrations. First, image processing has been used to construct a geometrical model and to quantify corrosion extension. Then, the consistent structural model has been updated based on the modal quantities identified using the acceleration measurements acquired by the deployed WSN.

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1. Introduction

Suitable procedures for inspection, maintenance and reconstruction of infrastructure are crucial for a sustainable management in developed countries. Even though the matter has strongly exploited in the scientific community, the raising of innovative technologies in mechatronics, robotics and ICT opens up new perspectives in facing the

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classical problems in the management of infrastructures. The basis to build models useful for decision-making process to assure safe operating infrastructures, is currently under discussion [1] and the adoptable procedures are partially sensible to the available technologies. In this respect, two emerging research fields might significantly impact in the inspection and monitoring of infrastructures: automated machine vision-based inspection integrated in building information modelling (BIM) [2,3] and distributed wireless sensor networks (WSN) [4,5]. In the first area the use of mobile robots and UAV have strongly increased the acquisition of images to sense the spatial characteristics of the environment, permitting the creation of "cloud" of 3D points. Intelligent proximity algorithms are used to convert these points into surfaces that corresponds to the real ones. Consequently, the generation and the management of a three-dimensional (3D) digital representation of physical and functional features of an infrastructure permits to involve the up-to-date concept of BIM. The emerging concept in this area is the use of BIM during the entire life-cycle, starting from creating a virtual 3D model during the design stage – an *as-designed model* – converting it, after construction, to – an *as-built model* – and finally using it for inspection and maintenance management through the development of – an *as-damaged model* [2]. Such scenario determines the condition for the integration of novel structural health monitoring systems using WSN in a BIM environment to permit visualization and management of sensor data, data interpretation and analysis and interaction with classical finite element model for structural behaviour simulation. Moreover, this novel available technology might modify the approach to the development of future Bridge Management System in which a key issue is the organization of data describing the condition of bridges with respect to the evaluation of extension, intensity and evolution of damages [6]. In this respect, in the present paper, a sequential procedure is proposed for bridge condition assessment and monitoring. In Fig. 1 the main steps of the procedures are highlighted. At the first step the acquisition of images in automated manner (UAV, drones, robots, etc) or eventually a laser scanner of the observed bridge permits to construct 3D point clouds from which a geometrical model of surfaces can be created. Such geometrical reconstruction constitutes a basis for the development of a BIM model of the bridge and the associated Finite Element (FE) model furnishes the description of its mechanical and structural behaviour. This first step of the procedure is completed by the acceleration measurements acquired by the deployed WSN which are used to identify the main modal characteristics of the bridge, usable for the updating of FEM. After this initial process, the design of a permanent structural monitoring system can be pursued and automatic or semi-automatic evaluation of the bridge condition [6] based on damage detection can be exploited. The paper deals with the description of an integrated procedure for damage detection based on processing of images and accelerations.

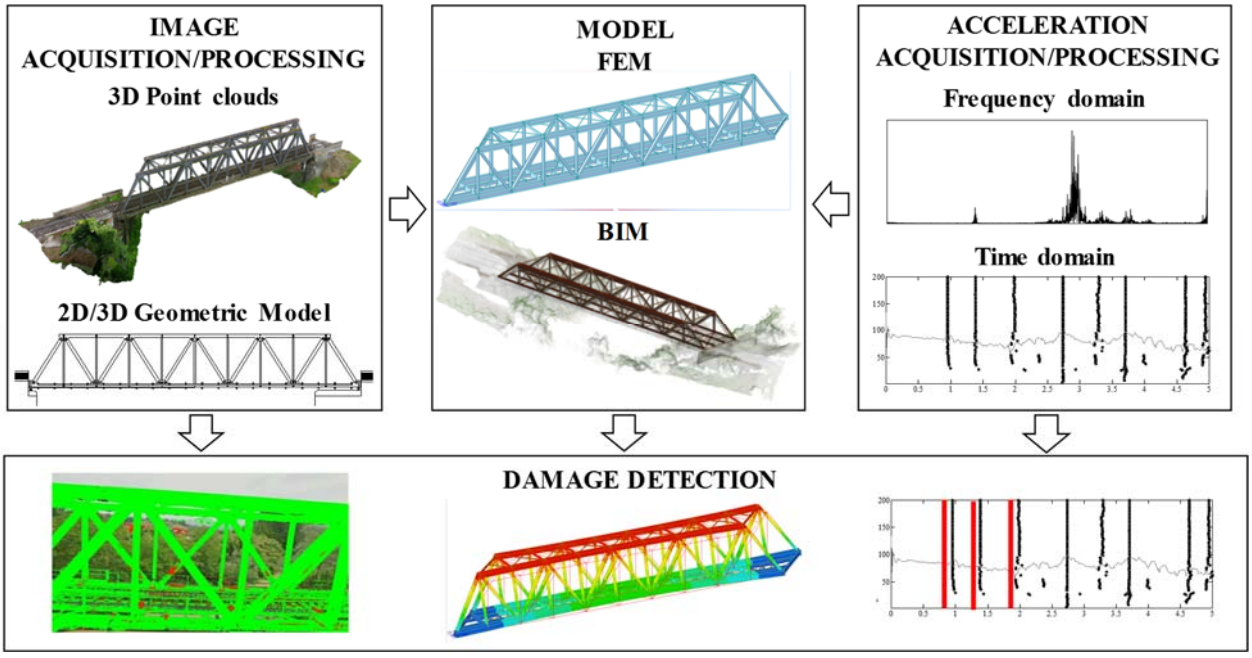

Fig. 1. Block diagram of an integrated procedure for damage detection.