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Real-time identification of disaster areas by an open-access vision-based tool

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ABSTRACT

Structural damages caused by natural catastrophic events cover a wide area and it is convenient to supervise the event consequences by vision tools. The aim of this paper is to supply a rapid damage detector designed as a way to aid in risk assessment, damage control and disaster prevention as well as a way to speed the examination of catastrophic effects for emergency studies. The satellite pictures covering the area of interest represent the required bits of information to manage the developed telematics tool. A case study is discussed in order to provide experimental evidence of the proposed procedure potential. Moreover, a multi-view image/video fusion system is integrated in the image process to detect the damage levels of structures to overcome the limitations on the vertical information provided by a satellite. In synthesis, this study shows how a GIS-based real time monitoring system can be effectively used for a rapid evaluation of structural damage and disaster management.

1. Introduction

There is not the time to forget the consequences of the last one that a new catastrophic event reminds, to the actors involved in natural risk management, the importance of a rapid damage assessment for providing a suitable emergency response. Indeed the entity damages caused by an earthquake also depends on the delay and inadequacy of the rescue interventions. For this reason, a post-disaster damage assessment can be achieved by integrating, within a single user interface environment, existing database information, GIS technology and image processing techniques. In literature there are several contributions along this line [1–6]. The software adopted by the authors for this purpose is QuantumGIS (QGIS). QGIS is an Open Source Geographic Information System that is developed using the Qt toolkit and C language. It has a pleasant, easy-to-use graphical user interface (GUI). QGIS is also released under the GNU General Public License: this means that everybody can inspect and modify the source code. In conclusion, QGIS guarantees access to a GIS program that is free of cost and can be freely modified [7].

This paper outlines the main steps of a procedure to locate quickly those structures, which have been affected by damage as a consequence of a natural disaster. First, a wide overview related to the state of art is provided. A detailed documentation on the architecture of the informatics tool set up for damage and loss estimation in emergency follows. Finally, the proposed procedure is applied to a case study.

2. Current technology framework

Remote sensing is often used to obtain information. It is founded on the collection of data with the devices used to collect the data, which are not in direct contact with the object of the study. Satellites, which are the main platforms utilized in remote sensing, have a wide range of sensors and can also study the weather and the landscapes of natural disasters, with the possibility of acquiring images also in the night light. In addition to dedicated sensors, satellites also mount devices able to acquire images, which are quite different from a simple camera picture only able to provide the same information that can be acquired by the eyes. Finally, the satellite pictures are digital images that are composed by several squares blocks (called pixels) and, when a picture is analyzed, each pixel is associated with a value corresponding to the intensity of radiation reflected from the observed object within the range of wavelength where the sensor is active [8,9]. Fig. 1 summarized the process of image capturing by a satellite.

For the purpose of the subsequent analysis of the collected information, geographic information systems (GIS) are used. They

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0965-9978/

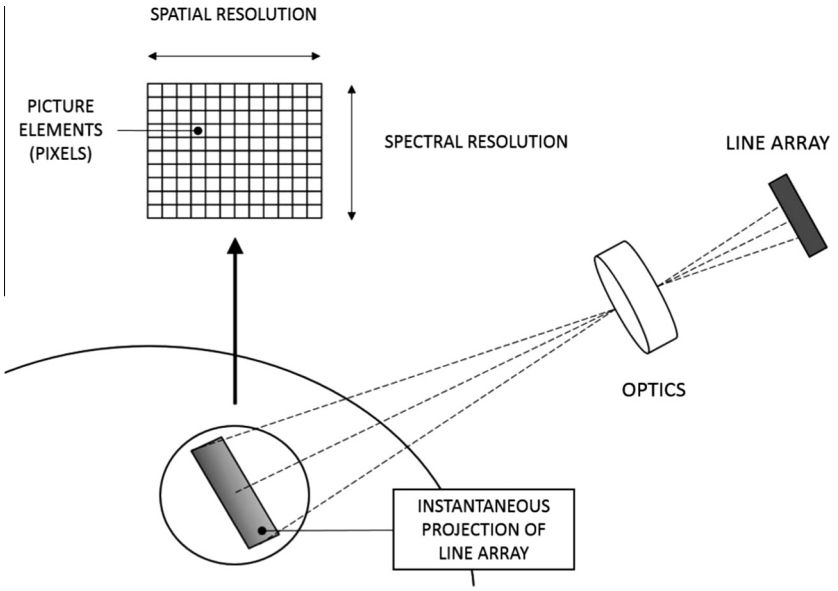

Fig. 1. Satellite view for remote sensing.

integrate hardware, software and geographical data in order to capture, manage and analyze all forms of geographically referenced information. These systems allow the operator to view, to ask, to understand and to interpret data in many ways in order to reveal relationships, patterns and trends in the form of maps, globes, reports and charts. A GIS stores geographic information as a collection of theme layers that can be related each to the other through connection and geographical overlap. Moreover, these layers can be acquired using the vector mode or the raster mode. In the vector mode information on points, lines and polygons is encoded and stored as series of coordinates (x, y). By contrast, in the raster mode, it consists of a grid of pixels, which represents a specific value, with each pixel characterized by its own grid position (row number and column).

3. System architecture

The implemented system architecture, provided pre-event and post-event satellite images are available, can be summarized in six steps as follows:

- load the pre-event image;
- create the pre-event layers;
- load the post-event image;
- create the post-event layers;
- compare the layers relating the two images;
- integrate data that comes from multi-view image/video fusion applications.

The first step is realized using a plugin, based on Google Maps, that permits to automatically georeference the satellite image. After loading the addresses, the creation of layers over the pre-event satellite image follows. These layers are made by general geometric entities as points, lines and polygons that are gathered as shape file. An operation of this kind in QGIS results very simple through the "Border Detection Tool" that is designed to select areas of the image based on color similarity. It is based on ideas already implemented in different image managed software, but imported and modified in the QGIS environment. This tool is called "Magic Wand" and is good for selecting every object with sharp edges

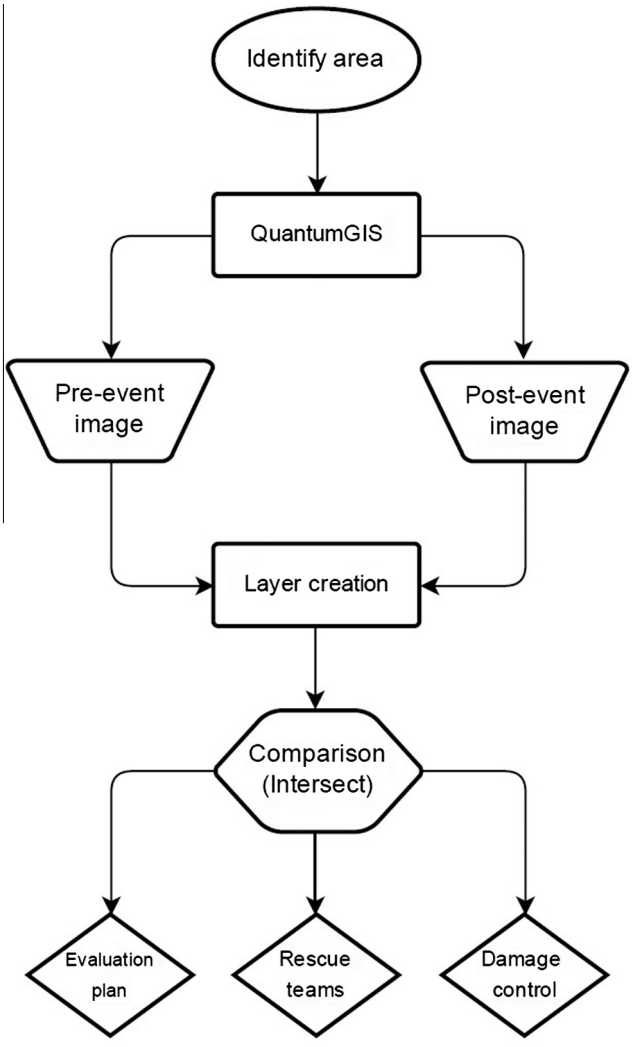

Fig. 2. System architecture.