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Earthquake Damage Mapping and Overall Assessment of Ground Surveys and VHR Image Change Detection after L'Aquila 2009 Earthquake

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ABSTRACT: Earth Observation (EO) data are used to map mostly affected urban areas after an earthquake generally exploiting change detection techniques applied at pixel scale. However, Civil Protection Services require damage assessment of each building according to a well-established scale to manage rescue operations and to estimate the economic losses. Considering the earthquake that hit L'Aquila city (Italy) on April 6, 2009, this work assesses the feasibility of producing damage maps at the scale of single building from Very High Resolution (VHR) optical images collected before and after the seismic event. We considered the European Macro seismic Scale 1998 (EMS-98) and assessed the possibility to discriminate between collapsed or heavy damaged buildings (damage grade DG equal to 5 in the EMS-98 scale) and less damaged or undamaged buildings (DG < 5 in the EMS-98). The proposed approach relies on a pre-existing urban map to identify image objects corresponding to building footprints. The image analysis is carried out according to many different parameters with the objective of assessing their effectiveness in singling out changes associated to the building collapse. Features describing texture and colour changes, as well statistical similarity and correlation descriptors, such as the Kullback Leibler Distance and the Mutual Information, were included in our analysis. Two supervised classification approaches, respectively, based on the use of the Bayesian Maximum A Posteriori (MAP) criterion and on Support Vector Machines (SVM), were compared. In our experiment, we considered the whole L'Aquila historical centre comparing classification results with the ground survey performed by the Institute Nazionale di Geofisica e Vulcanologia (INGV). The work represents one of the first attempts to detect damage at the scale of single building, validated against an extensive ground survey. It addresses methodological aspects, highlighting the potential of textural features computed at object scale and SVMs, and discusses potential and limitations of EO in this field compared to ground surveys.

KEYWORDS: Earthquake, Disasters, Edge Detection, Survey.

I. INTRODUCTION

The reported occurrence of natural disasters, such as earthquakes, floods, and cyclones, is on the rise leading to increased public awareness of the impact of catastrophic events. In the short term, the occurrence of such events cannot be reduced by immediate human actions, whereas long-term trends may be influenced for events that are tentatively linked to climate change. To understand and possibly mitigate the impact of such catastrophic events on human beings and their environment, research is being carried out for each of the characteristic phases of such events, i.e., before the event (early warning systems, risk assessment, preparedness), the moment the event occurs (disaster-alerting systems), and after the event (emergency response, impact assessment).

Rapid impact assessment after a catastrophic event is crucial for initiating effective emergency response actions. The acquisition of field data, supporting the aforementioned impact assessment, in areas hit by severe earthquakes is indeed a hard task, mainly due to the restricted physical accessibility of the affected areas (i.e., unpredictable road conditions, landslides and soil fractures, panic, growing of diseases, lack of food and water, hazards due to instable buildings). To cope with the accessibility and time constraints issues, data in earthquake contexts, especially for damage assessment purposes, has been widely proposed and a number of results have been presented after every event. Other damage assessment case studies include the 2004 Central Indian Ocean tsunami and the 1999 Izmir, Turkey, 2003 Bam, Iran, and 2006 Java, Indonesia, earthquakes.



Paper is organized as follows. Section II describes about related work and proposed methodology is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. RELATED WORK

The use of remote sensing technology is, for a number of reasons, becoming increasingly wide spread following natural disasters. On a policy level, international initiatives such as the 2000 Charter on Space and Major Disaster (International Charter, 2003) constitute a significant commitment towards the use of space facilities for emergency management. In terms of data accessibility, programs including the ESA Earth Watching Service now freely distribute satellite disaster coverage (ESA, 2003). Remote sensing also has a proven track record in the aftermath man-made events like the World Trade Centre attack (Huyck and Adams, 2002) and Columbia space shuttle disaster (NOAA, 2003) These factors, combined with investment in applied research from organizations such as the Multidisciplinary Centre for Earthquake Engineering Research (MCEER), are facilitating its deployment through progressive end-users, like the Earthquake Engineering Research Institute (EERI) reconnaissance team (see Adams et al., 2004).

III. METHODOLOGY

MODULES

Input Images (Pre and Post): Collecting different type of data set of area images before and after earthquake.

Edge enhancement: Sharpening the image using the required filters.

Edge based image segmentation: Segmentation technique, this divides the image into smaller regions.

GLCM feature extraction: Extracting the features of the images with different types of parameters.

Random forest-based feature classification: This algorithm is a group of decision trees, takes an average and can deal with more than 2 classes.

Damage assessment: Better accuracy can be obtained by the RF algorithm, highly affected, moderately affected and unaffected areas.

ALGORITHM

RANDOM FOREST:

Random Forest is a supervised learning algorithm. Like you can already see from its name, it creates a forest and makes it somehow random. The forest it builds is an ensemble of Decision Trees, most of the time trained with the “bagging” method. The general idea of the bagging method is that a combination of learning models increases the overall result. One big advantage of random forest is, that it can be used for both classification and regression problems, which form the majority of current machine learning systems. Random Forests are also very hard to beat in terms of performance. Feature Importance of it is another great quality of the random forest algorithm is that it is very easy to measure the relative importance of each feature on the prediction.

CANNY EDGE DETECTION ALGORITHM:

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. Canny also produced a computational theory of edge detection explaining why the technique works. The general criteria for edge detection include: The edge point detected from the operator should accurately localize on the centre of the edge. A given edge in the image should only be marked once, and where possible, image noise should not create false edges. Detection of edge with low error rate, which means that the detection should accurately catch as many edges shown in the image as possible.

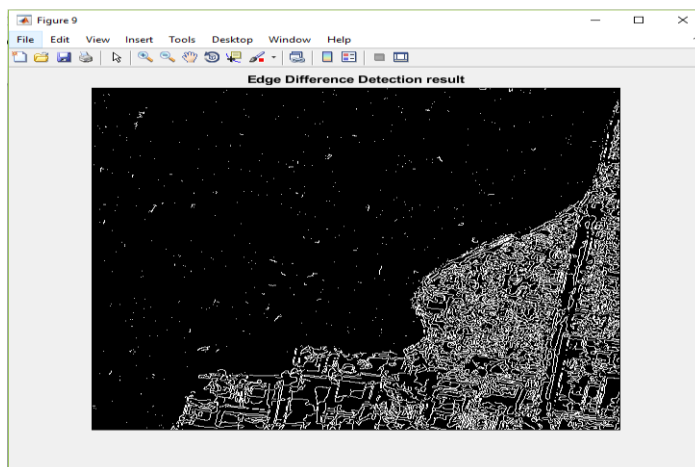
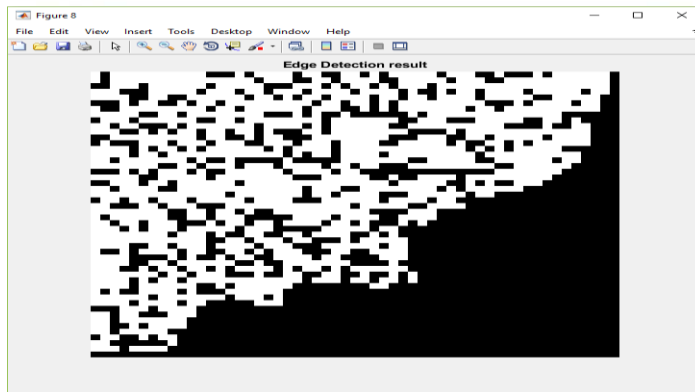
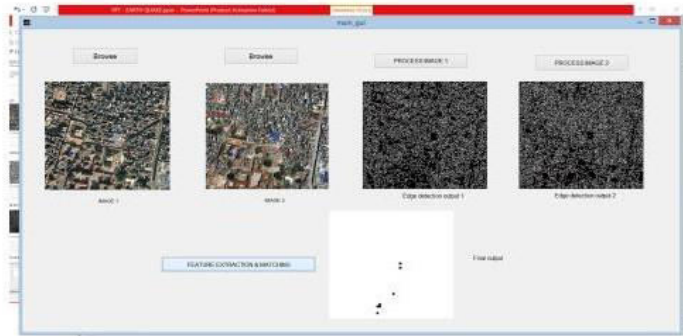


IV. EXPERIMENTAL RESULTS

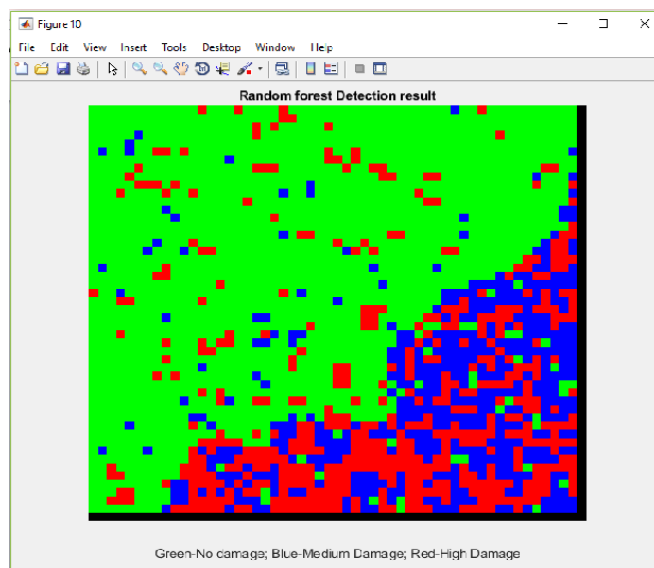
Edge Detection results:

Edge Difference Detection Results:

FINAL EARTHQUAKE DETECTION



V. RANDOM FOREST DETECTION RESULT



VI. CONCLUSION

In this paper, we have presented a novel damage assessment method for single (isolated) rectangular buildings using pre-event and post-event images. The method is tuned to work at the individual building level and determines whether a building is completely destroyed (collapsed) after a catastrophic event or whether it is still standing.

If we adopt this pattern, proper remedies can be taken accordingly and the percentage of damaged cost can be reduced. Further classification can be done accordingly, for better accuracy results to be obtained. Extremely important to get 100% accurate results else severe consequences need to be faced by humans.

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