OPERATIONAL EVALUATION OF DAMAGES IN FLOODED AREAS COMBINING COSMO-SKYMED AND MULTISPECTRAL OPTICAL IMAGES

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1. EXTENDED ABSTRACT

Floods are among the costliest and deadliest natural hazards, and their impacts are clearly accentuated by the climate change [1]. During the period 1975-2006 floods around the world were the major disaster in term of people affected and value of the damage [2].

The management of a flood event requires singling out the affected area, quantify and localize the affected people and goods and program an effective rescue plan. This activity needs rapid and easy access to all the geographical and observational information available for the area affected by the flood. Often these areas have very large extension and a rapid survey of them to gather all the needed information is a very difficult task, for many reasons, not least the difficult access to the existing information and resources. This commonly leads towards unacceptable delays in rescue activities. Even if rapid and reliable detection of areas hit by a flood are available, the usefulness of these information can be undermined by the lack of an updated picture of the state of these regions, in terms of risk-prone people and infrastructures and detailed information about their vulnerability.

This means that for effective flood risk management, the a-priori monitoring phase of the flood risk prone areas is of fundamental importance.

Remotely sensed data, such as Cosmo-SkyMed and high resolution multispectral optical observations, can provide timely and extensive information for operational flood risk management, both during the a-priori monitoring and crisis phases.

High resolution optical imagery can provide sufficiently detailed information to virtually survey the flood prone areas, allowing the identification of land uses, critical infrastructures and the extraction of important information to quantify the actual vulnerability of the area. In this case, the main advantage of the use of satellite imagery is the possibility to update the information with very high refresh rates, when compared to classical methods, based on in-situ surveys.

With an updated picture of the system, when floods occur, the detection of flooded areas allowed by SAR observations such as those provided by Cosmo-SkyMed, helps in rapid and effective evaluation of the damage and organization of the management of the crisis.

The effective use of remotely sensed data depends, of course, on their accessibility but also on their accordance to several parameters defining user requirements. These parameters concern the minimum spatial and temporal resolution of the images, as well as the maximum delay between the occurrence of the event and both the observation and the delivery of the data. These parameters, if not matched, make impossible the use of the data in an operational context.

Here we present an integrated system developed by the team of the Italian Space Agency pilot project "Opera". "Opera" is a project aiming to test the effectiveness of the use of remotely sensed observations into operational flood forecasting modeling chains. The added value of the remote sensing is evaluated comparing the

performance of the selected operational chains with and without Earth observation products, with special focus on Cosmo-SkyMed proucts.

The system presented here, named X-3D, allows the end user to integrate multispectral high resolution imagery and Cosmo-SkyMed products, in a 3-D environment, providing all the tools to virtually survey the observed area, These tools allow extracting quantitative information for any feature relevant for the assessment of the vulnerability of flood prone areas.

The system is able to manage all the phases, from data procurement to product delivery to the end user to

- produce land use maps from high resolution multispectral imagery
- map all the infrastructures hydraulically significant from high resolution multispectral imagery
- merge high resolution multispectral imagery with SAR derived DTMs, to produce high resolution 3-D images of the observed area
- derive the vulnerability to floods of the observed areas, combining land use and infrastructures information.
- produce maps of flooded areas from Cosmo-SkyMed observations
- merge maps of flooded areas and vulnerability to evaluate damages produced by a flood occurring in the observed area.

For each of these products, specific algorithms, managed with suitable user interfaces by the system, have beed developed.

For the monitoring phase, semi-automatic procedures for the detection of features such as vertex or shadows related to the structures of interest, are of much interest. They can be extracted from satellite optical images, and play a support role in the generation of 3D models. For this purpose, a colour segmentation algorithm has been implemented to extract connected regions corresponding to structure roofs. These regions are then used for the vertexes identification and for the location of the corresponding shadows, required in the structure height measurements.

For the detection of flooded areas two main products have been delivered within the Opera project, dealing with fast-ready map display and detailed flood map generation, respectively.

Various image pre-processing and segmentation techniques can be used to generate the two products starting from multi-temporal Cosmo-Skymed acquisitions of the same area.

A fast-ready flooding map consists in a display able to focus the attention on flooded areas while enhancing the changes occurred as well as the steady water. For a better human interpretation, colours are used by combining the SAR images of the temporal sequence, after an appropriate, automatic pre-processing step.

Detailed maps are generated thanks to a multi-temporal image segmentation. After the user has manually localized a few points corresponding to water in one image, the classes of flood, steady-water and no-change areas are detected. The processing allows the detection of connected regions, then the raster to vectorial format transformation become possible.

For the definition of vulnerability, a particular function has been implemented: it associates high resolution land use maps derived from satellite and some specific parameters of the buildings inside each land unit with same use, estimated with the support of the 3-D model of the area.

The system has been tested after a flooding event occurred on April 28th, 29th and 30th 2009 in the Tanaro river basin, near the city of Alessandria, in Northwestrern Italy. Here the compliance of all the available images from different satellite platforms with end-user requirements (namely civil protection decision makers) has been tested. In this case Cosmo-SkyMed imagery demonstrated particularly effective in the detection of flooded areas, allowing reliable quantitative evaluation of the damage produced by the flood. The resolution, acquisition and delivery time of the images allowed to deliver to the end-user, if actually used in a operational context, reliable quantitative estimation of the extension of flooded areas and amount of damage just few hours after the occurrence of the event.

2. REFERENCES

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