Title: **AUTOMATIC INFORMATION RETRIEVAL FROM METER AND SUB-METER RESOLUTION SATELLITE IMAGE DATA IN SUPPORT TO CRISIS MANAGEMENT**

Author: Martino Pesaresi, Thomas Kemper, and Guido Lemoine

Affiliation: European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, Global Security Unit. Via E. Fermi 2749 TP 267 Ispra (VA) Italy. Tel: +39 0332 786547 Fax: + 39 0332 786547

Email: martino.pesaresi@jrc.ec.europa.eu Web: http://isferea.jrc.ec.europa.eu

Abstract

This paper reports about the recent-years experiences of using meter and sub-meter satellite image data in support to the crisis management activities carried out by the European Commission and international partners as World Bank and UN agencies. These activities are focused on the monitoring, reporting, modeling, and forecasting of the effects or the impact of the natural disasters and conflict-related crisis on population and the socio-economic assets. The information about human settlement with different characterization (formal/informal, stable/temporary, developed/slum, etc), specific vulnerability, and eventually post-crisis damage and reconstruction changes, are extracted from meter and sub-meter satellite image data and used in the policy-making process. The point of view emphasized in this paper is related to the lessons learned about the automatic information extraction from meter and sub-meter satellite image data in real crisis scenarios, including the typical constraints of this application field. Technical-scientific and conceptual gaps are reported and some ways forward are suggested, including examples extracted from recent crisis where EC JRC was involved. Finally, some conclusions and recommendations are drafted with the goal of contributing to an effective methodological development of automatic image information extraction in support to crisis management.

The tremendous development of the space technologies in the last decade has opened new possibilities to use the satellite remotely-sensed data in support to new application areas. The meter or sub-meter spatial resolution available now in satellite sensors allows the observation, recognition and reporting about targets and phenomena present on the ground that were impossible to detect few years ago with a spatial resolution of about 5-10 meters or more. Satellite image data sets with meter and sub-meter spatial resolution can represent a precious source of information in support to all the cycle of the crisis management activities, including risk assessment, disaster preparedness, warning, alerting, damage assessment, needs assessment, emergency response, rehabilitation and reconstruction, and development. In particular, while the hazard or disaster impact area (for example wind, flood, fire, earthquake) is often observable also using moderate resolution satellite data eventually combined with modeling techniques, the

evaluation of the impact on the population goes necessarily trough the extraction of information related to the status of the human settlements (built-up structures and infrastructures), and these information are detectable only using meter and sub-meter resolution image data.
Unfortunately, the development of the sensor technology is not fully aligned with the development of the methodology used for automatic information extraction from these new satellite imageries. This fact is generating the paradoxical and unexpected effect of the decrease of the capability to extract automatically information with the increase of the quality of the image source, namely the spatial detail of the sensor.
The main technical challenges to be faced are regrouped in two items: i) issues related to the image data preparation and ii) issues related to the proper information extraction. Regarding the data preparation we point the attention on the systematic insufficient available information, DTM and CGP for effective geo-coding of the image data. This fact generates the effect of image data having systematically a displacement error greater than the pixel size, leading to unavoidable spatial inconsistency of the image dataset that has to be handled by the subsequent image processing steps.
From the point of view of the automatic information extraction, we spot the attention on i) the dramatic increase of the data volume and complexity, including the necessity to handle 3D geometry (parallax, panoramic distortion) and spatial imprecision, ii) the increasing of complication and then of instability of the inferential models used for information extraction with a general effect of decreasing of robustness and generality, and then iii) the geometric increase of the computational capacity needed for effective image processing.
The technological challenges listed above are related to the nature of the new satellite image data source and they interact significantly with a set of constraints that are typical of the “crisis management” application area. These constraints can be summarized as follows i) the need of globally consistent approach (action anywhere, anytime, multi-scale; ii) the need of multi-temporal analysis (pre/post event, analysis of trends); iii) the need of rapid or time-critical assessment (hours, days) on sometime large areas; iv) and the fact that very often basic information is missing, making difficult some basic image processing steps (geo-coding, building the image interpretation keys, validation).
Some examples are given of methodological options that seem to be promising because contributing to overcome part of the above mentioned challenges and constraints. In particular, issues related to information generalization and spatial uncertainly, “object-based” image information retrieval, and multi-scale structural image information exploitation, including morphological image decomposition are addressed.

Conclusions are that the automatic exploitation of meter and sub-meter satellite image data is relevant for “external relations” and “security” EU policies including crisis management. There is a gap between the characteristics of the new image data and the available methods for automatic image understanding. There are additional constraints related to the “security” application areas. In many relevant cases still only recognition by visual interpretation is feasible in real scenarios as best compromise between reliability and adaptability. It is emphasized a strong need of new approaches for automatic image understanding on RS data bridging the gap between visual and automatic image interpretation

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