MULTITEMPORAL ANALYSIS OF FLOODS AND TSUNAMI EFFECTS : ANNOTATIONS AND QUANTITATIVE ANALYSIS

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ABSTRACT

This paper addresses the problem of multitemporal analysis of an available TerraSAR-X data time series covering the Sendai region in order to assess flood extent and damages caused by Tohuku-oki tsunami. Over the last decade the use of Earth Observation satellites to support disaster and emergency relief has considerably grown. In order to fully exploit highresolution satellite images a method based on patches (each image is divided into non-overlapping tiles) is proposed to extract relevant contextual information. The local features of each patch act as a compact content descriptor.

Further on, considering the available descriptors, the next step is to cluster the data in order to find similar semantic classes. The concept of query by example is implemented by the mean of SVM classifier. The results include well-defined semantic classes, derived through semiautomatic methods thus developing an effective approach of multitemporal analysis which perfectly completes the classic rapid mapping services.

DESCRIPTION OF THE EVENT

On 11th March 2011 the earthquake in northern Japan and the tsunami that followed left thousands persons dead or missing. The epicenter was at 129 km away from Sendai, the largest city in the Northeast area of Japan, at 38.297N, 142.372S. The destructive tsunami, generated by the earthquake hit the coastline several minutes after the earthquake causing huge causalities, damages and the crisis at the Fukushima Daiichi nuclear plant. Particularly, on March 12, the Sendai region was partially clouded so that only the use of microwave data SAR data, capable to penetrate clouds, allows a detailed and complete evaluation of the region.

CLASSIC RAPID MAPPING APPROACH

Rapid Mapping services provide information support during response and immediate post-response by delivering rapid mapping products emphasizing the extent and impact of the event. Center for Satellite Based Crisis Information (ZKI) extracted maps summarize information regarding inundation extent, floating debris, agriculture, settlements, etc. ZKI imagery used : Rapid Eye - (6.5m), TerraSAR-X (2.5m) and WorldWide-2 (0.5m).

The inundation extent (Fig.1) was derived by semiautomatic image analysis of TerraSAR-X imagery acquired on March 12; 2011. The covered area is of 120.68 square kilometers.

The approach proposed in this paper opens new perspectives considering the "meaning" of Earth Observation data content, respectively the semantic concepts, much wider and harder to be formalized.

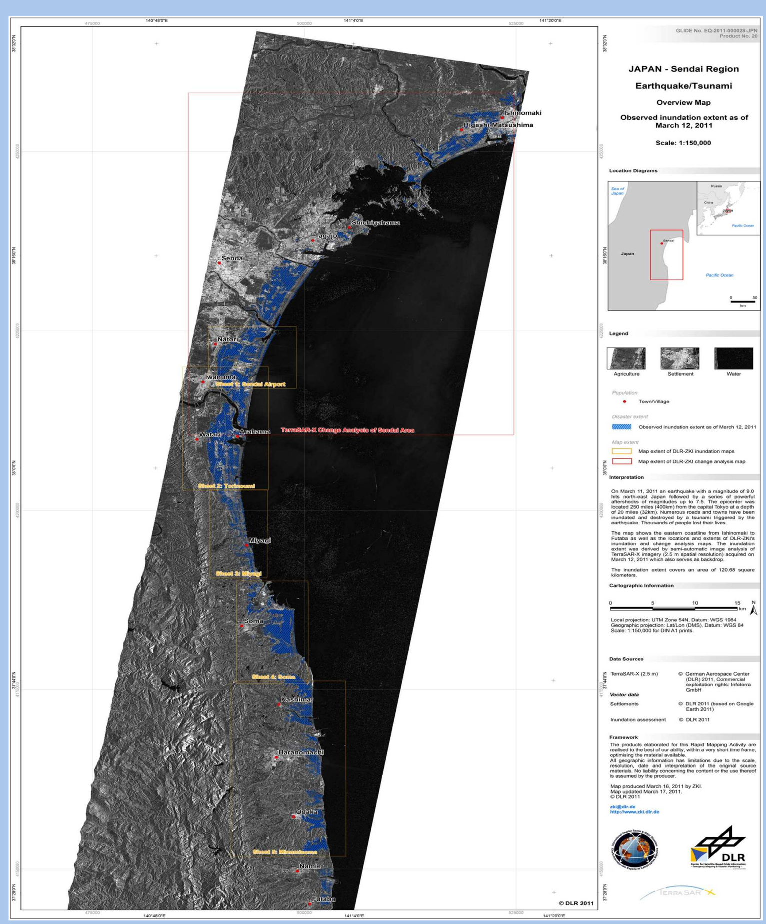


Fig.1 ZKI Rapid Mapping Product revealing observed inundation extent.

MULTITEMPORAL ANALYIS FOR MONITORING DISASTER'S IMPACT

To pursue our goal two radiometrically enhanced TerraSAR-X images acquired before (20.10.2010) and after (12.03.2011) the tsunami were used. For each TerraSAR-X product, the image is tiled into non overlapping patches (14700 items), the size of the patch (100 x 100 pixels) ensuring that the extracted features capture the local properties of a region rather than the global properties of the image.[2]

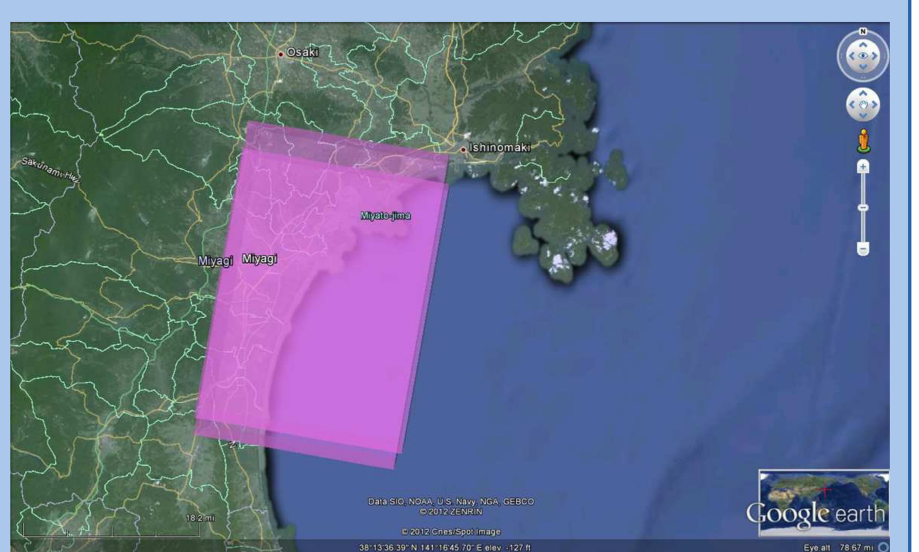


Fig. 2 Overlay in Google Earth of the two TSX Products Before (20.10.2010) and After (12.03.2011)

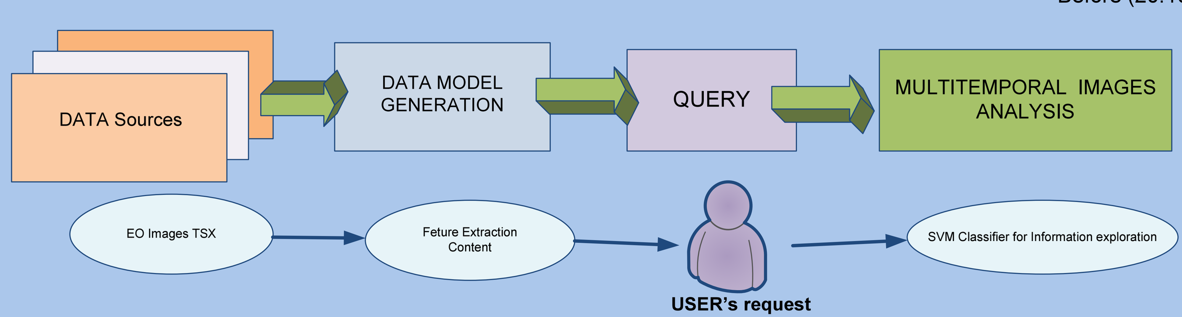


Fig.2 Knowledge discovery components for Earth Observation images.

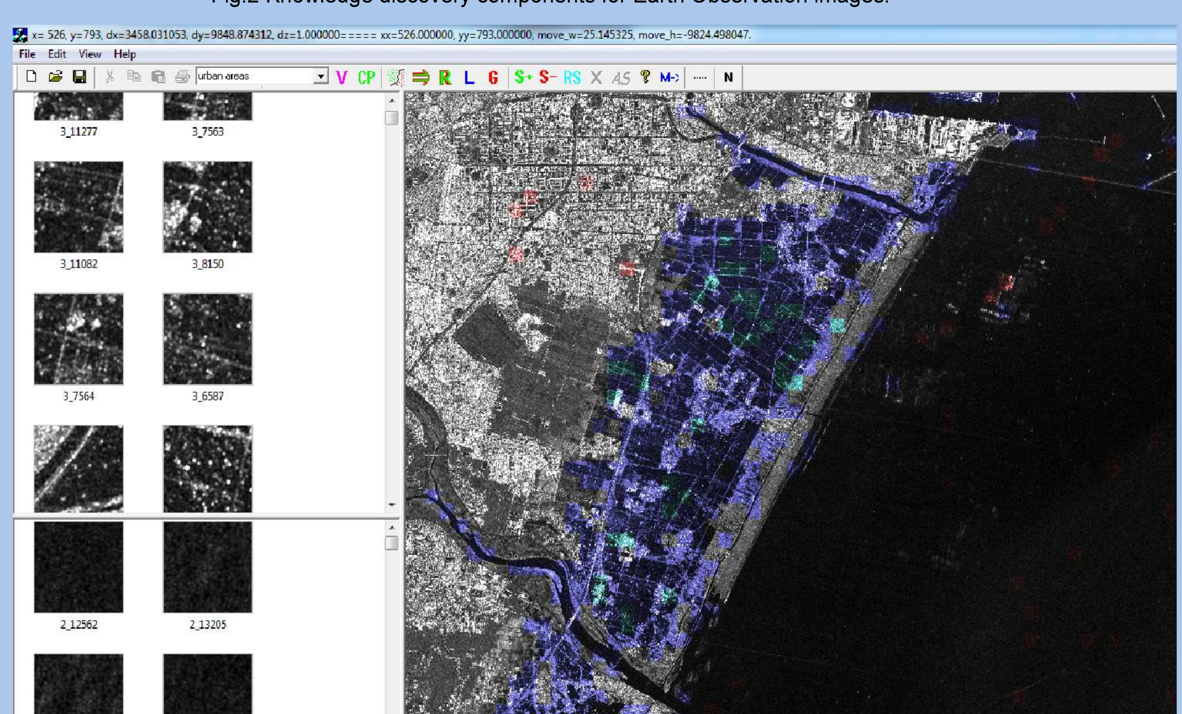
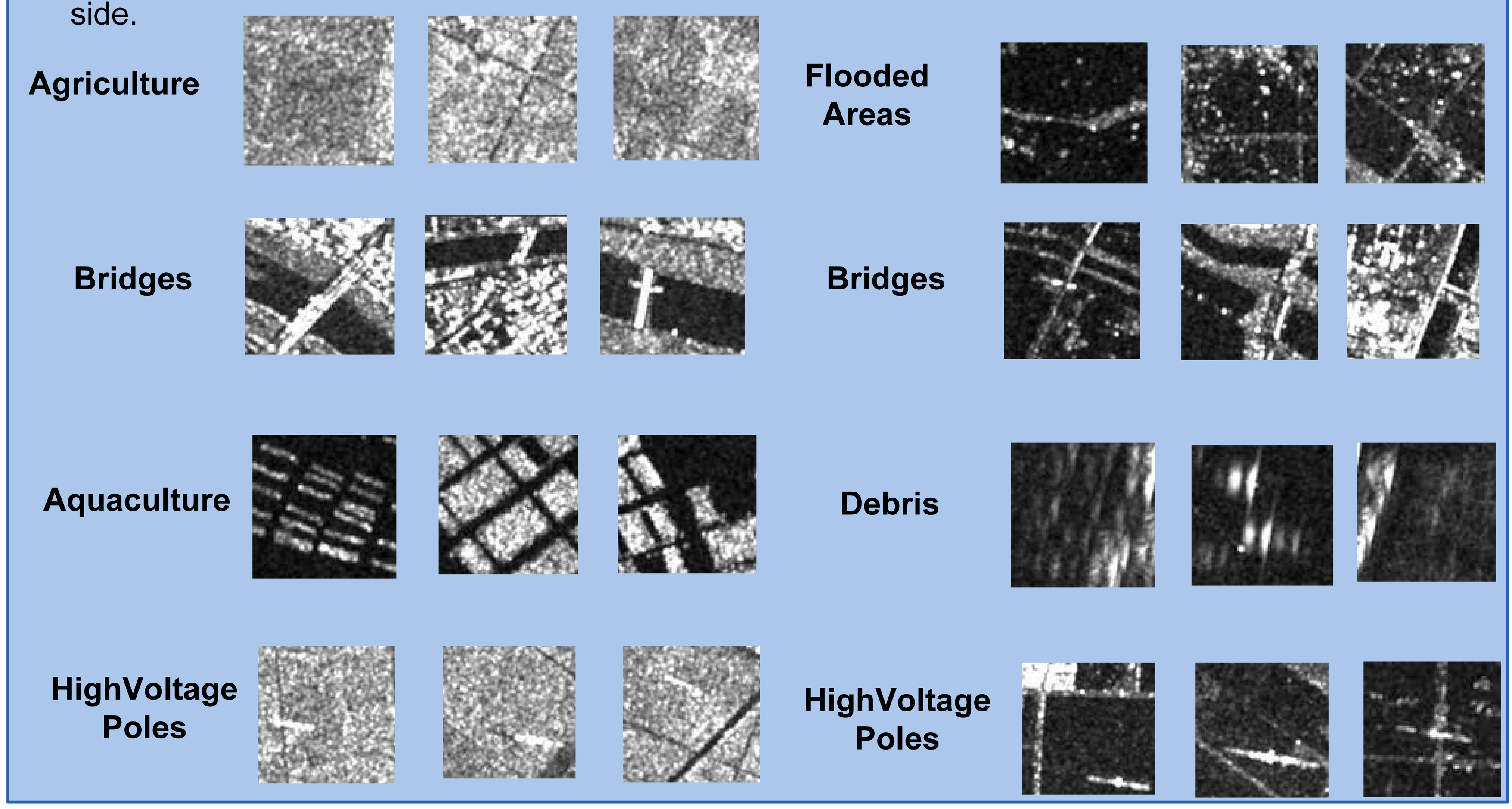


Fig.4. Instant of the SVM classifier highlighting in blue the semantic label "flooded areas" obtained in one iteration by giving positive (in green) and negative examples (in red) directly on the image. In the upper left corner of the screen all the patches similar with the given examples "agriculture" are revealed while in the lower left corner of the screen the similar negative example (like "ocean") are presented.

At the next level, these patches are converted into local features to be further used as content descriptors, in order to characterize image structures.[3] Considering the extracted descriptors the next step is clustering, which aims to dissociate recognized classes. Further on an active learning stage is mandatory in order to semantically label the classes. The classifier is able to almost completely retrieve all the similar patches belonging to the same semantic label.

SEMANTIC CATEGORIES EXTRACTED FROM TerraSAR-X PRODUCT (20.10.2010) BEFORE & (12.03.2011) AFTER

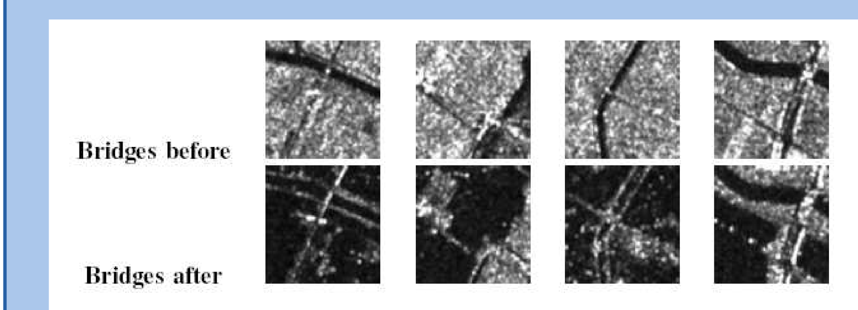
Typical semantic classes extracted from both TSX images (before and after the tsunami) are presented below. In classes before tsunami (left-part), it can be clearly observed delimited structures and it is easy to delineate i.e. urban areas, agriculture regions and even aquaculture of brown seaweed. The changes after the tsunami are presented in the semantic classes at the right side.



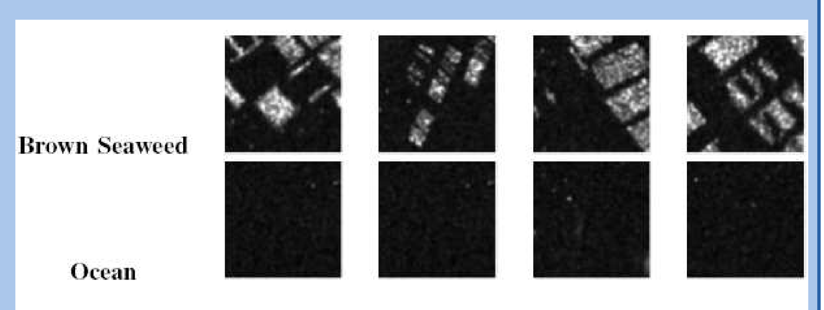
QUERY EXAMPLES CONSIDERING SEVERAL SCENARIOS

In the following figures, some examples of queries using the image content are presented. These queries are the basics for the post disaster evaluation.

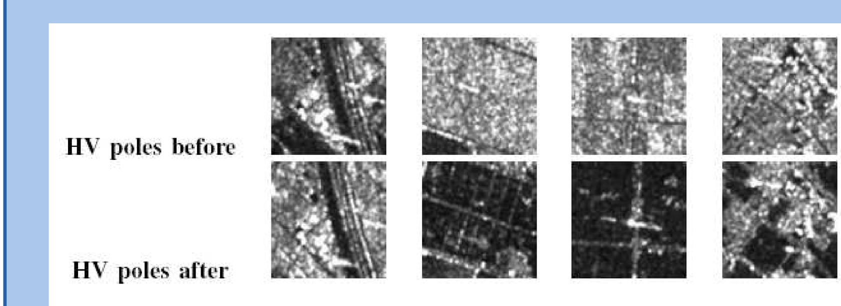
A) Assessment of transportation infrastructure, high risk of discontinued roads caused by damaged bridges



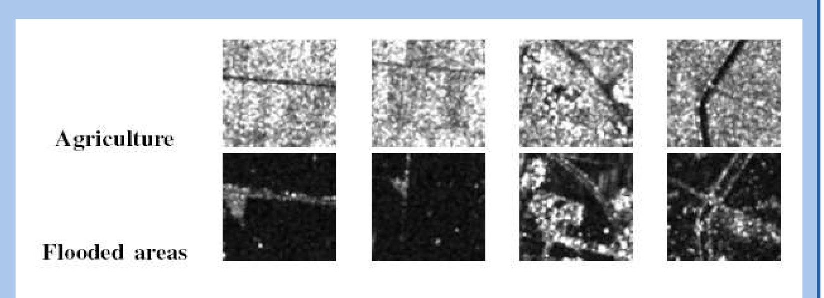
C) Assessment of aquaculture areas



B) Possible energy loss due to the damaged high voltage poles, if any



D) Assessment of ariculture areas, damaged crops and loses estimation



CONCLUSIONS

The scenarios described above consider knowledge discovery from pre and post disaster EO images by mapping the extracted primitive features into semantic classes and symbolic representations like urban areas, agriculture, mountains ,bridges, aquaculture, high voltage pylons, flooded areas, etc. The results of the query includes well-recognized patches sharing the same semantic label. Thus it is possible to determine tsunami effects on several levels: assessment of transportation infrastructure post disaster, possible power outages due to the damaged high voltage pylons, flooded urban regions, evaluation of agricultural fields, damaged crops and estimation of loses and so on. In adition, query results can be quantitatively evaluated and further used to estimate the impact that tsunami had over the Sendai region. Through multitemporal images analysis this kind of approach complements the rapid mapping products providing the ability to detect changes using the user's experience and knowledge along the entire process of data mining.

REFERENCES

[1] C. Vaduva, D. Faur, A. Popescu, I. Gavat, M. Datcu, "Semantic Map Generation from Satellite Images for Humanitarian Scenarios Applications", Proceedings of ACIVS 2008, pp.808-817.
[2] Daniela Espinoza-Molina and Mihai Datcu, Earth-Observation Image Retrieval based on content, semantics and metadata, IEEE Transactions Geoscience Remote Sensing,to be published.
[3] C.O. Dumitru and M. Datcu, "Information Content of Very High Resolution SAR Images: Study of Feature Extraction and Imaging Parameters", IEEE Trans. Geoscience and Remote Sensing.

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