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Contextual patterns discovery in post disaster evaluation of 2011 Japan Tsunami using TerraSAR-X products

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ABSTRACT

This poster proposes a post disaster evaluation of the damages produced by the tsunami in the Tohuku-oki region considering knowledge discovery from TerraSAR-X (TSX) products, by mapping extracted primitive features into semantic classes, thus assuring an interactive technique for productive information mining.

Knowledge discovery from Earth Observation images implies mapping low level descriptors (primitive features) extracted from the image into semantic classes in order to provide an interactive method for effective image information mining. In the frame of information theory a communication channel is considered between remote sensing imagery and the user who receives existing information in the data sources, coded as image semantic content. This channel has three components - Data Source Model Generation, Query and Data Mining. Data Source Model Generation uses image content analysis to generate a set of scene's content descriptors. Further, the Query component involves the user and performs an image retrieval based on image content as query parameter. The query component relies on the Support Vector Machine classifier which is able to group descriptors into relevant semantic classes. The classifier supports rapid mapping scenarios and interactive mapping.

The envisaged data mining process includes three stages: data annotation, data query and quantitative analysis of the results.The Data annotations step considers dataset description, data preparation and data classification in order to perform user annotations.

Some query examples considering several scenarios include: Assessment of the transportation infrastructures, highrisk of broken roads caused by damaged bridges, debris detection, assessment of aquaculture areas, and possible energy loss due to the damaged high voltages poles or assessment of agriculture areas, damaged crops and estimation of losses.

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 poster opens new perspectives considering the "meaning" of Earth Observation data content [1], respectively the semantic concepts, much wider and harder to be formalized.

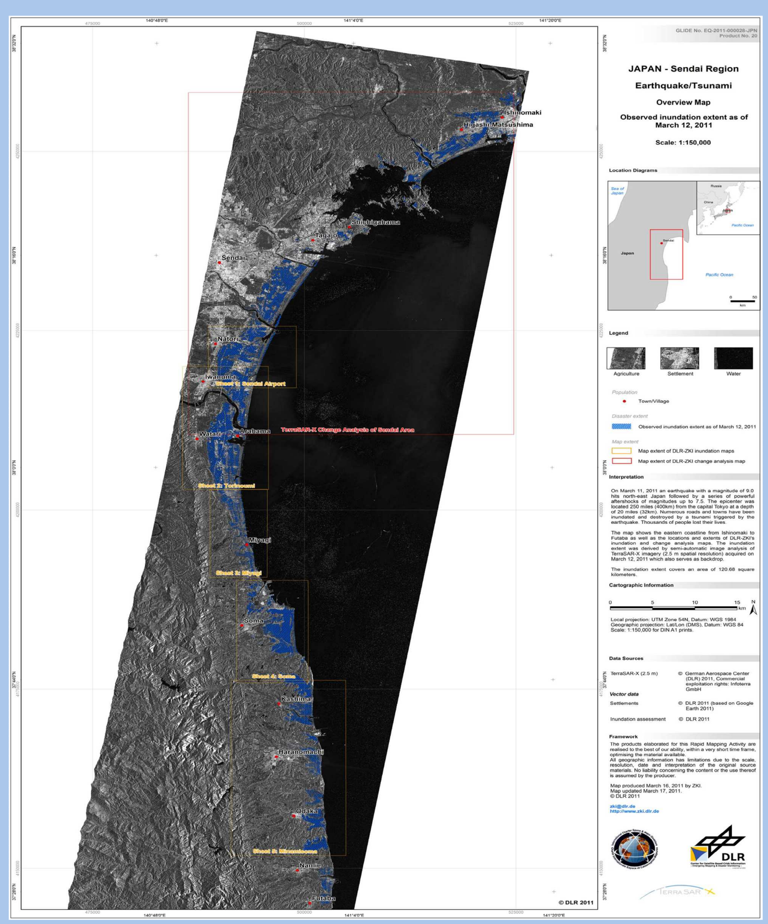


Fig.1 ZKI Rapid Mapping Product revealing observed inundation extent.

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, 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.

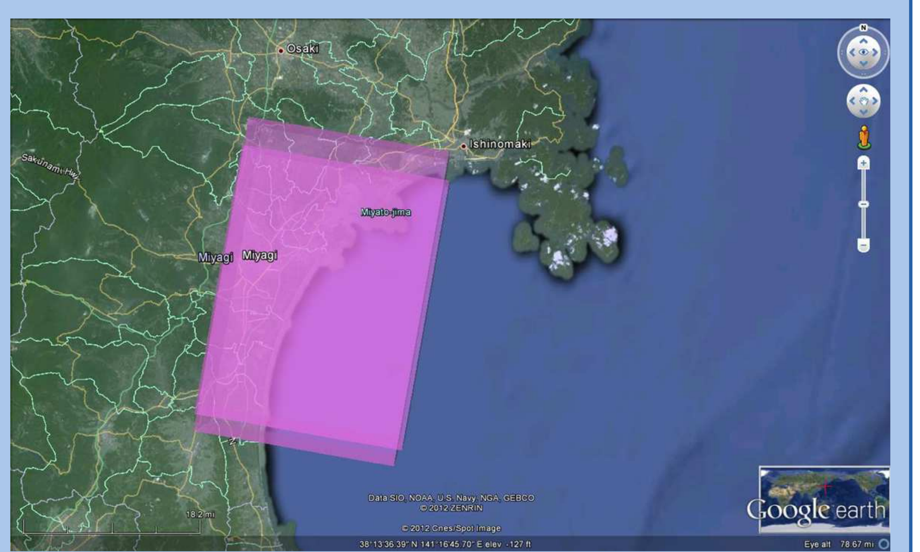


Fig. 2 Overlay in Google Earth of the two TSX Products :Before (20.10.2010) and After (12.03.2011)

PROPOSED POST DISASTER SCENARIO IN THE FRAME OF DATA MINING

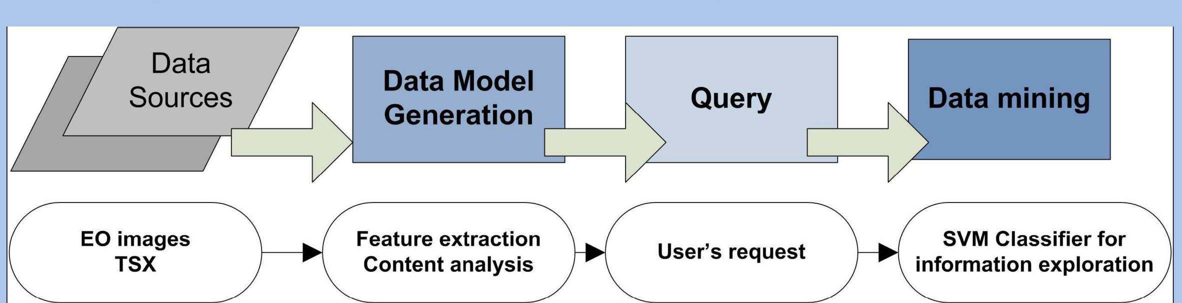


Fig.3 Knowledge discovery components for Earth Observation Images.

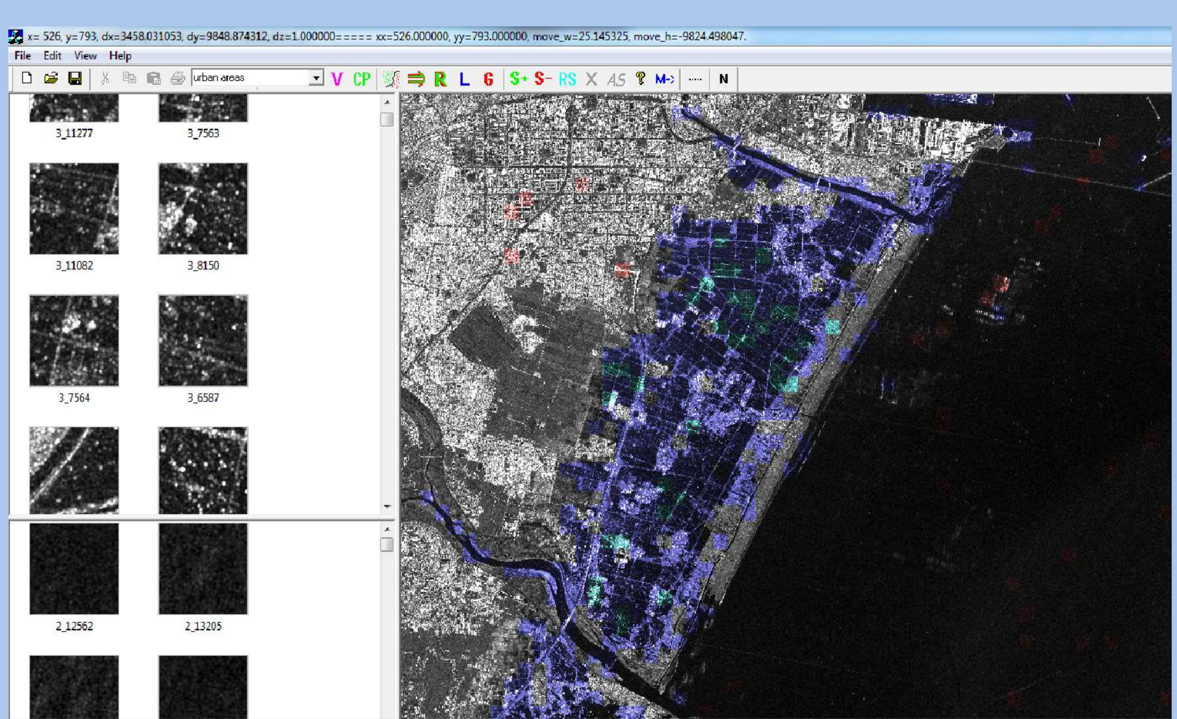
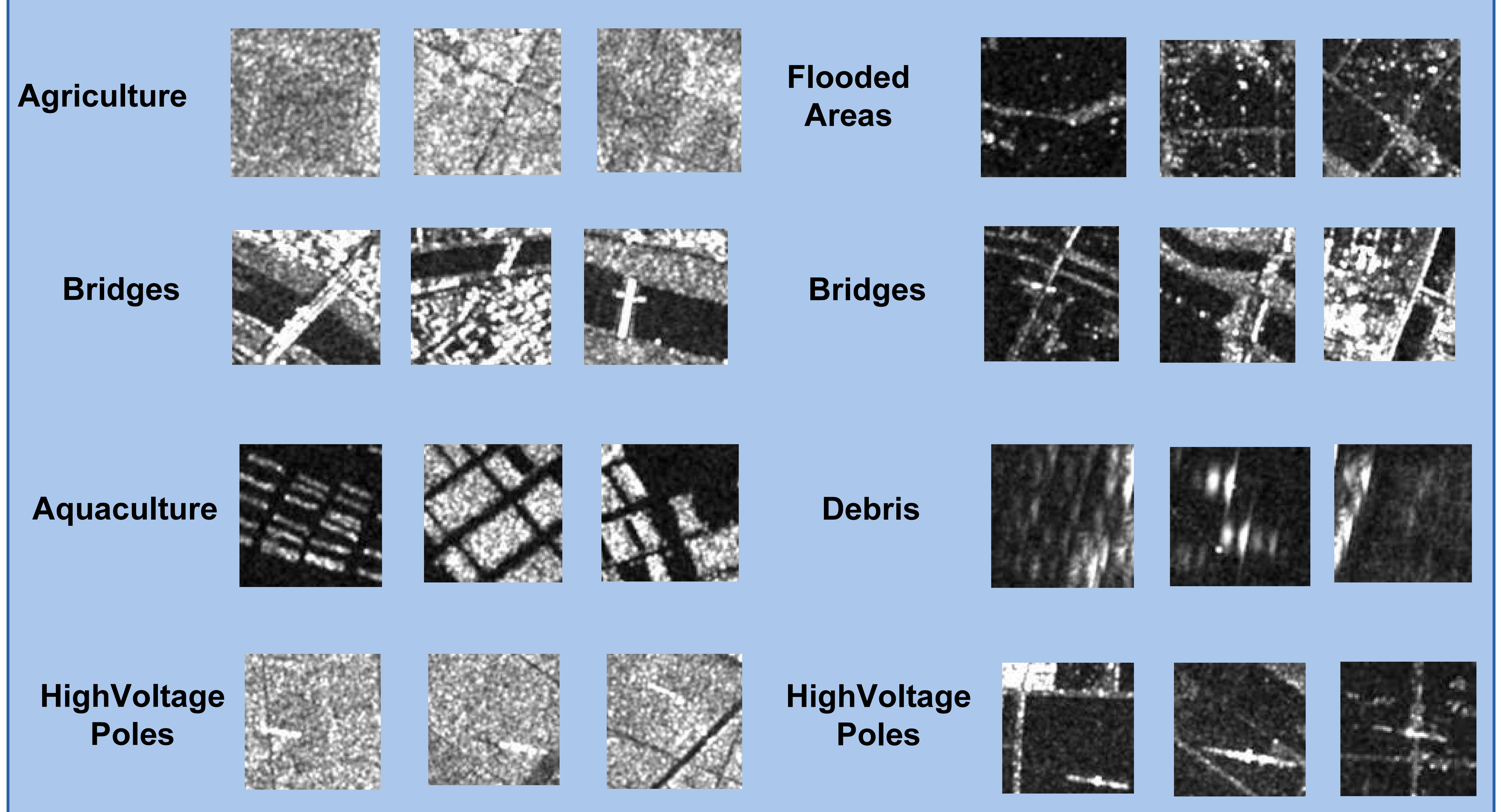


Fig.4. Instant of the SVM classifier highlighting in blue the semantic label "flooded areas" obtained in one iteration by giving positive (in green) and negative examples (in red) directly on the image. In the upper left corner of the screen all the patches similar with the given examples "agriculture"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

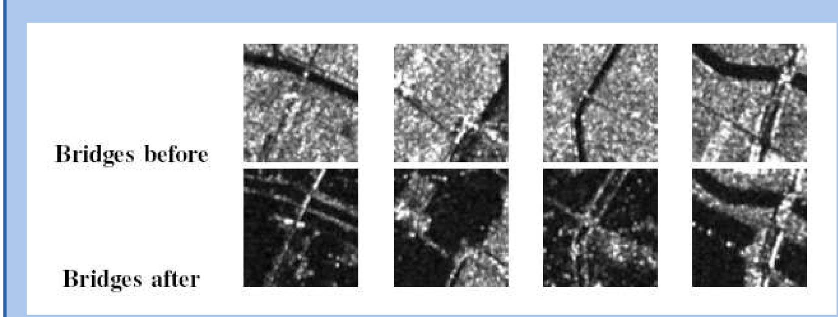
At the next level, these patches are converted into local features to be further used as content descriptors, in order to characterize image structures.[3] Considering the extracted descriptors the next step is clustering, which aims to dissociate recognized classes. Further on an active learning stage 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

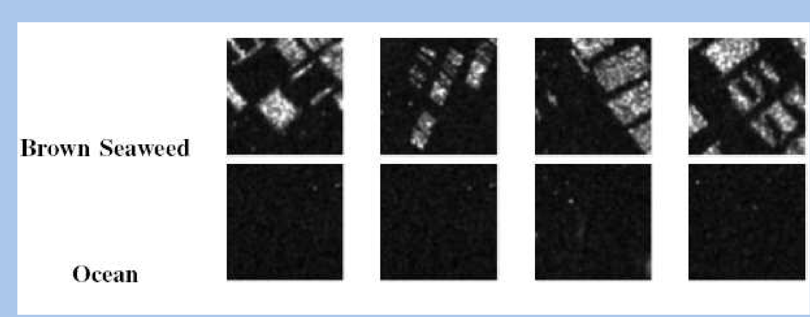


QUERY EXAMPLES CONSIDERING SEVERAL SCENARIOS [2]

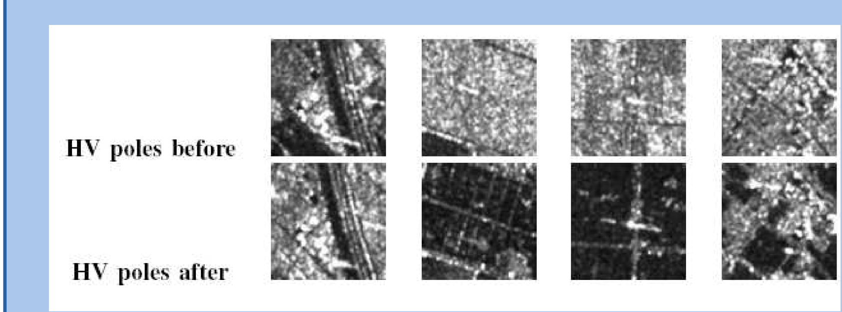
A) Assessment of transportation infrastructure, high risk of discontinued roads caused by damaged bridges



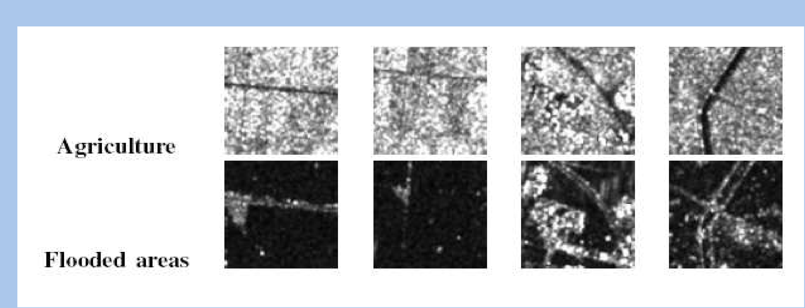
C) Assessment of aquaculture areas



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 described scenario makes use of the SVM classifier to generate semantic learning in a Content Base Image Retrieval approach. The results include detailed semantic categories for rapid mapping obtained using semi automatic methods. For example using only one query through the entire database (29400 patches size of 100 x 100 pixels, from both images, before and after tsunami) it is possible to detect all the regions affected by tsunami. Moreover, searching in the database for the semantic label "flooded areas", the results are not only the patches annotated with this label in the post disaster image but the initial semantic label of those patches (before the event).

Unlike the traditional rapid mapping approach the proposed data mining scenarios result in an effective and precise evaluation of damages thanks to human feedback embedded in the analysis.

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