ACQUISITION OF THE DISTRIBUTION OF TSUNAMI-GENERATED DEBRIS

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ABSTRACT: The aim of this study is to propose a method for creating a tsunami inundated area map by using tsunami-generated debris as a marker. This will be done not only visually but also by spectrum analysis in a high resolution optical satellite imagery taken before and after the event. This paper explains how remote sensing technology can be used to indicate tsunami inundation line and how debris are extracted from satellite image. While some debris were successfully identified, some were left undetected.

1. INTRODUCTION

1.1 Backgrounds and Objective

The whole picture of the damage caused by tsunamis takes time to grasp due to its vast area of destruction. While the tsunami inundation line can be used to speculate the damage, this has had to be done manually. Therefore, one of the most important and basic data for understanding tsunami damage takes time to produce. In the case of the East-Japan earthquake, it took a full week before the Geospatial Information Authority of Japan published an inundation line map of the entire affected region.
The objective of this study is to propose a method of creating a quick and accurate tsunami inundated area map automatically for a prompt damaged area identification and decision making support.

2. METHODOLOGY

2.1 Framework

Figure 1 shows the flow of the study up to the acquisition of tsunami inundation line map. In this paper, the area surrounded by the broken line will be discussed. Inundation line acquired manually from an orthorectified and projection transformed aerial image is compared with a ground truth line and line acquired automatically from detecting tsunami generated debris on a high-resolution satellite image.

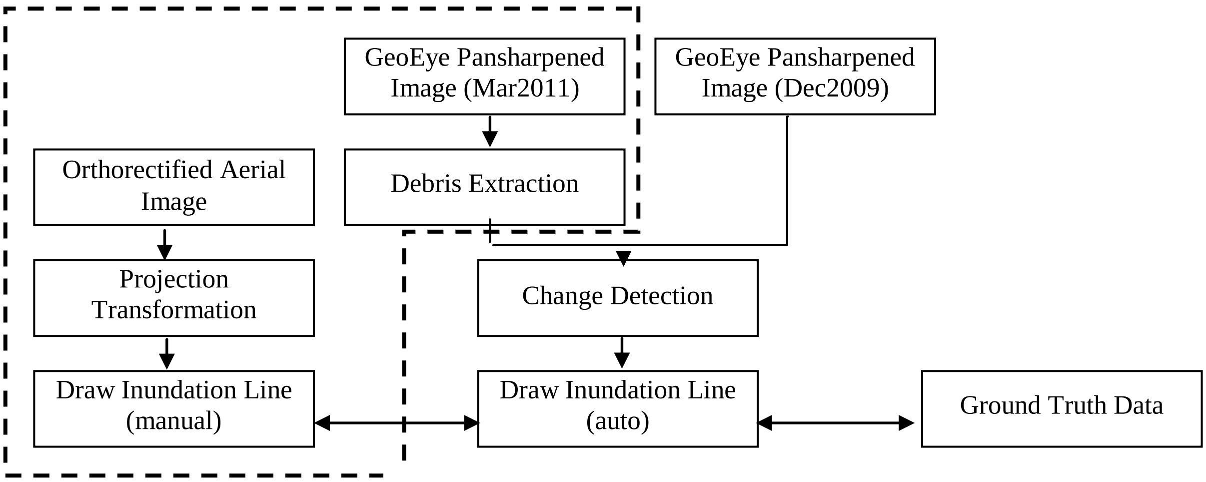

Figure 1. Flowchart of the acquisition of tsunami inundation line map

2.2 Study Area and Data

The study area for this research is Yamamoto City in Tohoku Region Japan, about 30km south of Sendai City. The percentage of inundated habitual land in Yamamoto City was the highest of all affected cities. Table 1 describes the images which were used in this study. Ground truth data of the inundation line gathered by the city office is also used.

Table 1. Image data used in this research

	Aerial image (post tsunami)	GeoEye-1 (post tsunami)	Geo Eye-1 (pre tsunami)
Acquisition	Mar. 12, 2011	Mar. 12, 2011	Dec. 10, 2009
Resolution	80cm / 8bits RGB	50cm / 11bits RGB+NIR	50cm / 11bits RGB+NIR

The aerial image taken one day after the tsunami by orders of the Geospatial Information Authority of Japan is used to detect the tsunami inundation line visually. The GeoEye image taken two days after the tsunami is used to detect the inundation line digitally. Image taken before the tsunami will also be used to increase accuracy. Finally, the ground truth data gathered within three days after the disaster will be used to verify the accuracy of the result.

2.3 Aerial Image Visual Inspection

The aerial image's projection is transformed and imported to Google Earth. Using the path feature, the inundation line is drawn onto the map manually.

2.4 Satellite Image Debris Extraction

To detect the inundation line, this research focuses on tsunami generated debris. Areas covered by debris and areas between the debris and the shoreline will be considered to have been inundated. Figure 2 shows how the debris pixels are extracted, and figure 3 shows the test site near Sakamoto intersection in true color, false color, NDVI, saturation, and value. Debris can be seen mainly on the upper and lower right.

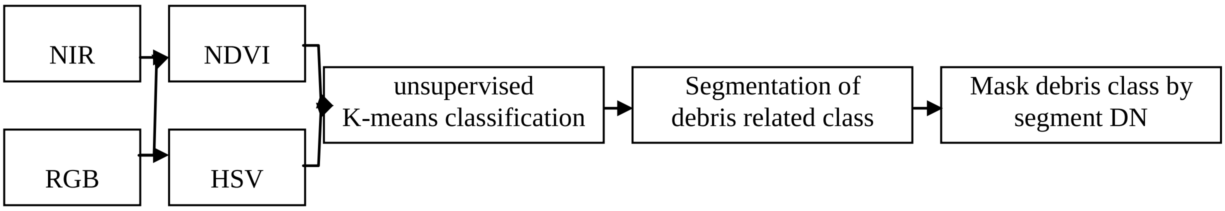

Figure 2. Flowchart of acquisition of debris from GeoEye image

Figure 3. Clockwise from left: test site in true color, false color, NDVI, Sat., Val.

First, the RGB bands (R: 450 to 510nm, G: 510 to 580nm, B: 655 to 690nm) are converted to HSV (Hue, Saturation, Value) and the NDVI is also calculated. The saturation and the value are combined with the NDVI for an unsupervised K-means 10 class classification. The debris related class is then segmented and each segment is applied a unique DN value. Finally, the debris is extracted according to the DN value.

3. RESULTS AND DISCUSSIONS

3.1 Visual Inspection by Aerial Image

Figure 4 shows the inundation line as drawn manually from the aerial image (yellow) and the ground truth data (blue). The area including the test site in the center is on the left and a simpler site is shown on the right.

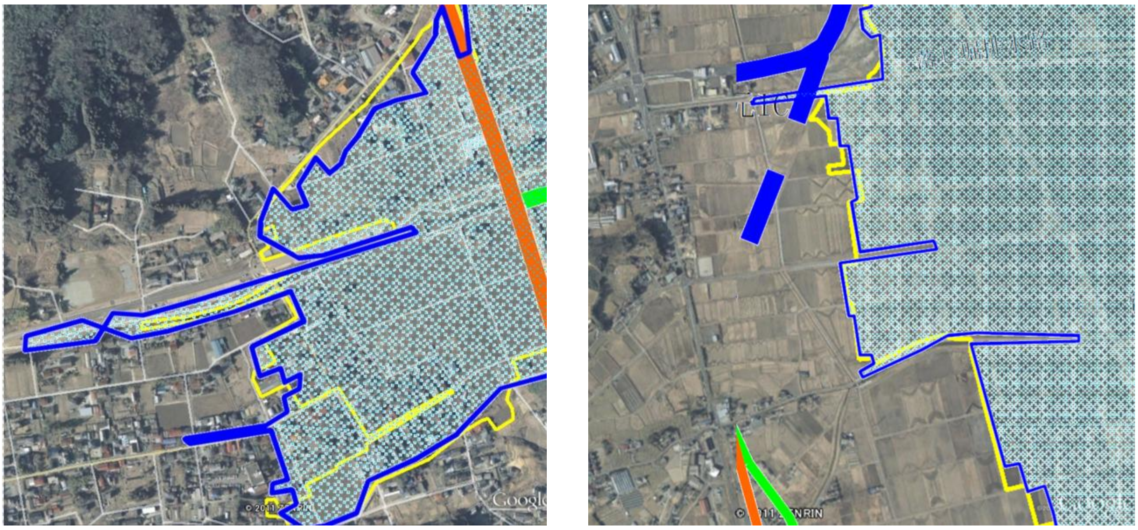

Figure 4. Ground truth (blue) and visually acquired inundation line (yellow)

3.2 Debris Extraction from Post Disaster GeoEye Image

Figure 5 shows the test site classified by K-means clustering into 10 classes and then masked by NDVI. Figure 6 shows the segments of debris related classes. The darkness of the shades represents a DN unique to that segment.

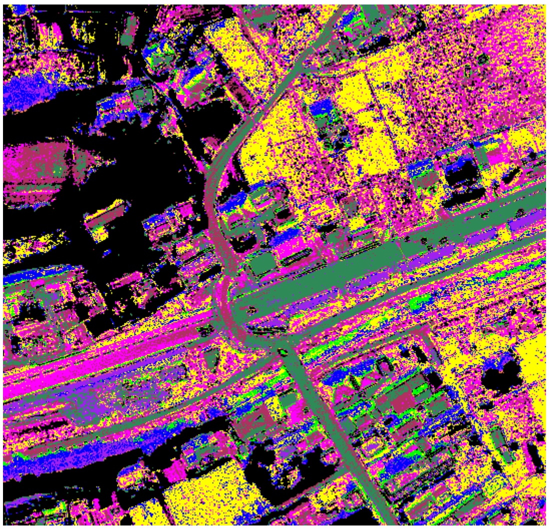

Figure 5. Classified image

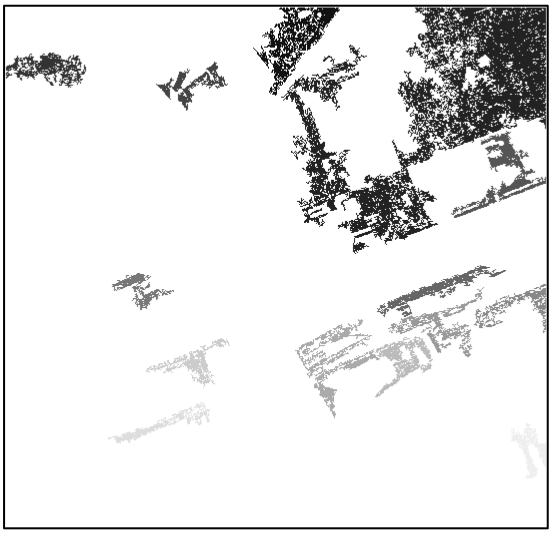

Figure 6. Segmentation of image

Figure 7 shows the test site in false color and figure 8 shows the image of the site with the extracted debris overlaid on a true color image. The debris on the upper right corner is extracted but the debris on the lower right corner has not been identified.

Figure 7. False color image

Figure 8. Extracted debris

4. CONCLUSIONS AND FUTURE WORKS

The acquisition of the tsunami inundation line by visual inspection of an 80cm resolution aerial photo is effective enough in simple terrains if the image is taken shortly after the tsunami. However, on surfaces with buildings crowded together, the resolution is not enough. This issue may be solved if higher resolution images can be obtained. As for the extraction of debris through satellite image, so far the debris is under-detected.
Future works include making sure that debris are not under-detected. Any over-detected debris may be removed through comparing the post-tsunami image with the pre-tsunami image. After successfully detecting the tsunami-generated debris, the inundation line should be created with the terrain and elevation in mind.

5. REFERENCE

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