TSUNAMI DAMAGED BUILDINGS ASSESSMENT USING HIGH-RESOLUTION SATELLITE IMAGERY, GIS & GPS DATA

U.Abdul Bari[1],P. Chandana Dinesh[2], Mazayuki Tamura[3], P.B. Ranjith Dissanayake[4]

[1]MSc Student in Disaster Management, Faculty of Engineering,
University of Peradeniya, Peradeniya
[1]E-mail: uabdulbari@yahoo.com
[2] Doctor Student, Department of Urban and Environmental Engineering,
Graduate School of Engineering, Kyoto University, Japan
[2]E-mail: dinesh.c@ky4.ecs.kyoto-u.ac.jp; dineshchandana@gmail.com
[2]Telephone: +94-11-2650567-8 (Ext.2006 - 2001); Fax: + 94-11-2651216
[3]Professor, Graduate School of Global Environmental Studies,
Kyoto University, Japan
[4]Professor, Department of Structural Engineering,
University of Peradeniya, Peradeniya.

Abstract

This paper presents a methodology and results of evaluating damaged building extraction using an object recognition task based on Differential Morphological Profile (DMP) for Very High Resolution (VHR) remotely sensed images. The proposed approach involves several advanced morphological operators among which an adaptive transforms with varying size, shape and gray level of the structuring elements. IKONOS-2 Satellite images consisting of pre and post 2004 Indian Ocean Tsunami site of Kalmunai area in east cost of Sri Lanka were used. Morphological operation of opening and closing by constructions using structural element are applied for segmented images, then derivative of the opening profile is defined as the vector. ISODATA algorithm is used for the feature extraction and the results comparison with ground truth data. This result appeared to have high accuracy, the confidence measures produced of completely destroyed structure gives 60% and 86% by object base and pixel base respectively after the tsunami in one segment of Maruthamunai GN Division.

Keywords: Differential Morphological Profile, IKONOS, Building Extraction, Tsunami

1. Introduction

Due to an increase of natural hazard in coastal area, satellite remote sensing has been an important tool used for recognizing, rescuing, and recovering and reconstruction tasks in the event of a Tsunami. This paper presets a methodology and results of damaged buildings detection algorithms using an object recognition task based on Differential Morphological Profile (DMP) for Very High Resolution (VHR) remotely sensed images in an event of tsunami hazard. The remote sensing applications include both urban and rural mapping, natural disasters, and change detection. Automatic extraction of damaged and undamaged man-made structures is a fundamental task in image processing field. In the past decade, many kinds of methods have developed especially for geometric classification and feature extraction using high-resolution imagery. According to different manners, these methods can be summarized in to different kinds: automatic and semi-automatic according to the iteration extent of human; single view and multi views, according to different principles, region-based and edge-based according to the principle elements acquired manners. Among these methods, region base segmentation, edge detection and mathematical morphology have already proved to be effective for many applications in remote sensing. This research also focused on region based classifications. In this research, IKONOS satellite panchromatic (1m resolution band 450-900 nm) gray color images consisting of a pre and post tsunami damaged site of Kalmunai area in Sri Lanka and earthquake site of the Sichuan area in China were used.

In this research, we extracted buildings position using IDL program in images are located in the site of Maruthamunai G.S division under the Kalmunai Divisional secretary area in east coast of Sri Lanka (see Figure1).

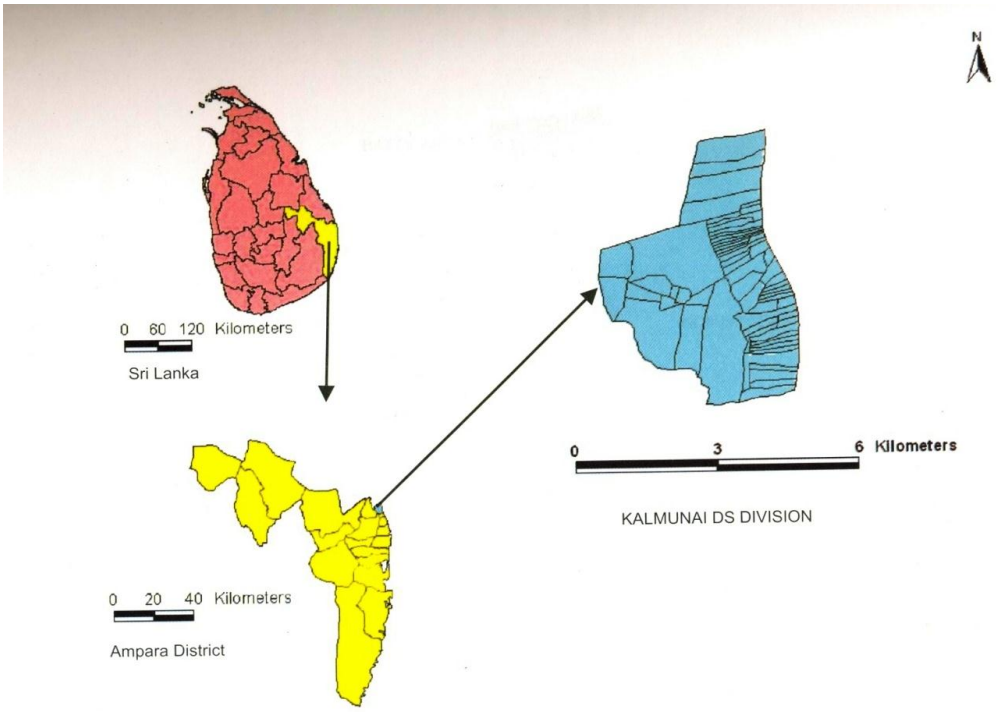


Figure 1: *Research location map*

2. Objective

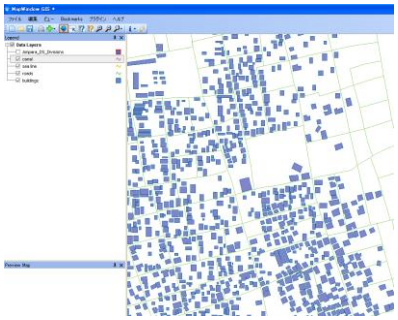
Objective of this study is to develop techniques for post-tsunami damage extraction, based on the satellite images acquired before and after the 2004 Indian Ocean tsunami and to carry out a damage assessment of damaged buildings and vulnerable area mapping. Finally to produce damage maps to assist the short and long term reconstruction using Morphological operation of opening and closing with constructions are applied for segmented images. This work is being extended to extract shadows and non building objects for better classifications of building roof footprints.

3. Methodology and Extraction

The Differential Morphological Profile (DMP) was developed by feature detectors attempts to identify buildings, shadows, roads and it is constructed using morphological opening and closing by reconstruction operators. Mathematical morphology employs a set of image operators to extract and analyze image components based on shape and size of quasi-homogeneous regions in the image. This concept is used to create a feature vector from a single image and it is based on the repeat use of the opening and closing operators, which are commonly used in mathematical morphology. Opening and closing by reconstruction is obtained following by erosion and dilation under the original image. The derivative of the morphological profile is defined as a vector where the measure of the slope of the opening-closing profile is stored for every step of an increasing SE series. The morphological filter theory was designed for a series of gray-level images. The images were smoothed using median filter for removal post classification procedures like “salt-and-paper” and other visual enhancement procedures. IDL programming language and ENVI 4.7 commercial software package is used for image processing and classification of this research.

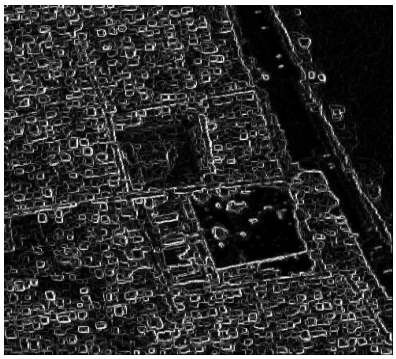
The building shadows are easy to extract using their low reflection value. Mask for shadows is built up using the reflection value between 0 and 60. The structures with similar scale to the SE diameter give high responses when SE in DMP value with bright structures in opening portion and dark structures in closing portion of the profile. For each pixel in the image, the position of the maximum responses within the DMP vector, indicate both the SE size that best characterize the structure that the pixel resides within and whether the pixel is part a structure that brighter or darker than the surrounding region. The maximum DMP response indicates with well a matched SE value that the pixel resides within. There are 8 differential morphological profiles were created using disc shaped morphological elements with radius increasing 7 to 15m (step size is equal to 4m). The SE that are less than 7m are not reliable for use because of the consists of small shadows, trees and wrecks of buildings. Those figures give noise for the classification results, we used SE more than 7m to detect for remain Buildings. Most of the bright building roof is gives the maximum response with opening differential profile and dark color roof, shadows are with closing differential profile. Unsupervised ISODATA Classification way is used for the classification and identification the structures, which most sophisticated algorithm which allows the number of clusters to be automatically adjusted during the iteration by merging similar clusters and splitting clusters with large standard deviations. Combining morphological operations is carried out for remove pixel errors that occurred due to delineation of image objects with DMP before classification.

Original Image

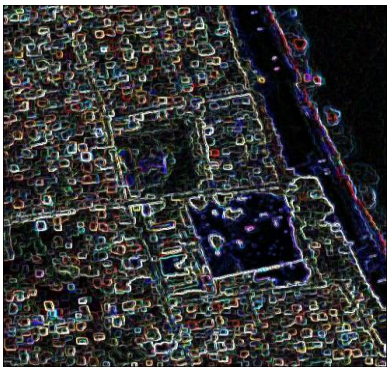


GIS ground truth Data

Subset Image



Convert to Vector



Extract Buildings Edges

Figure2. *The Research flow images*

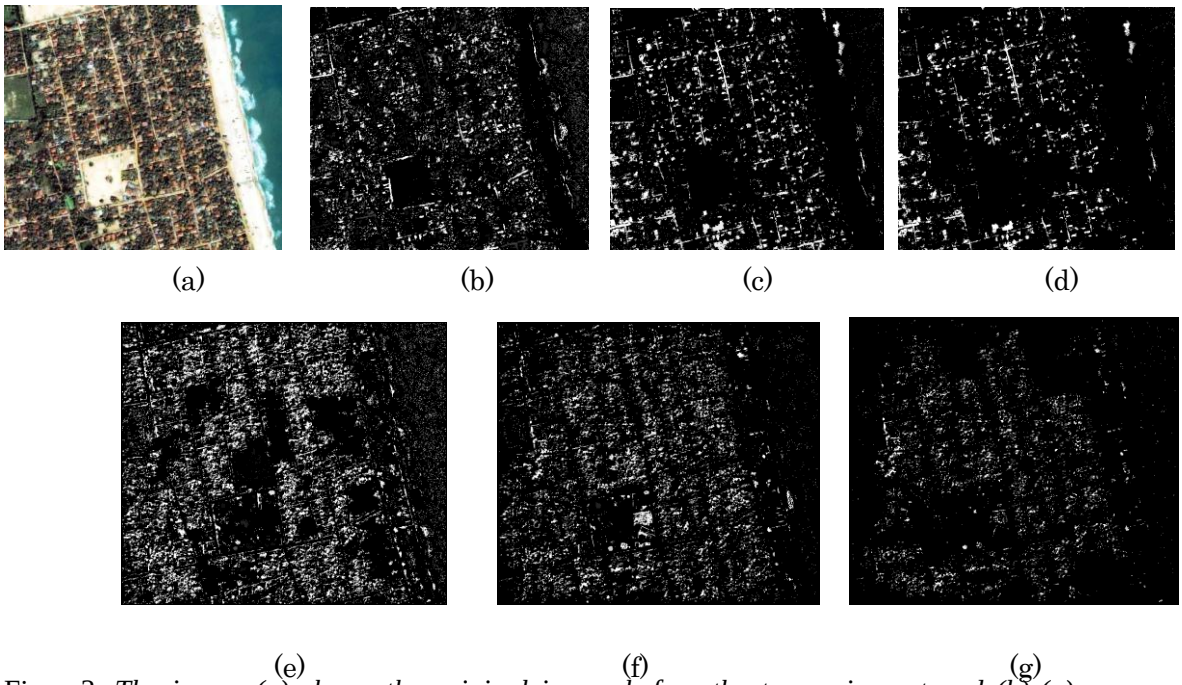


Figure3. *The image (a) shows the original image before the tsunami event and (b)-(g) represents structural decomposition of the image using differential morphological profile. The images have been visually enhanced. The derivative has been calculated relative to a series generated by six iterations of the elementary SE with radius from 7-15m. Derivative of the opening profile with r=(b)7, (c)11, (d)15 and closing profile with r=(e)7,(f)11,(g)15 are shows above respectively.*

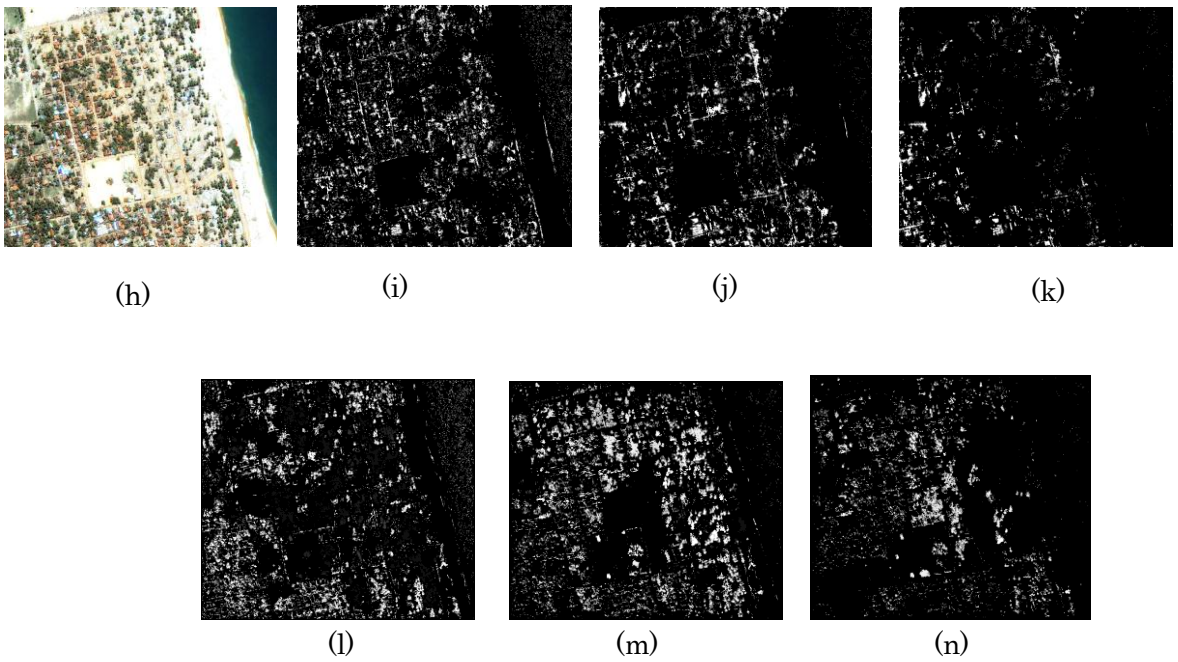


Figure 4. *The image (h) shows the original image after the tsunami event and (h)-(n) represents Structural decomposition of the image using differential morphological profile. The images have been visually enhanced. The derivative has been calculated relative to a series generated by six iterations of the elementary SE with r (radius) from 7-15m. Derivative of the opening profile with r=(i)7, (j)11, (k)15 and closing profile with r=(l)7,(m)11,(n)15 are shows above respectively.*

4. Results

The results have shown the usefulness of the proposed method during detection of various types of damaged building, as illustrated by the portions given this paper. The research area contained various kinds of roofs with different colors and shapes before the tsunami. Accuracy of extracted results calculated on object based and pixel basis. Although this result appeared to have high accuracy, the confidence measures produced of completely destroyed structure gives 59.6% and 86.48% by object base and pixel base respectively. According to manually labeled buildings as ground truth data, research area before the tsunami gives 65.16% and same area extracted after the tsunami gives 78.36% buildings extraction on object based accuracy for the research area. The result for is compared with ground truth GIS data after a field investigation.

(a) (b) (c)

Figure 5. *Building extraction results. (a) IKONOS image of the pre-tsunami area. (b) Manually labeled buildings as ground truth. (c) Result of the building extraction according to approached method.*

(r) (s) (t)

Figure 6. *Building extraction results. (r) IKONOS image of the post-tsunami area. (s) Manually labeled buildings as ground truth. (t) Result of the building extraction according to approached method.*

Table 1: Extraction of houses before the tsunami

	Object base	*Pixel base*
Correctly extracted building roof	*460*	*12639*
Total Area of the segment	*706*	*357760*
%	*65.16*	*3.55*

Table 2: Extraction of houses after the tsunami

	Object base	*Pixel base*
Correctly extracted building roof	*163*	*10948*
Total Area of the segment	*208*	*356562*
%	*78.36*	*3.07*

Table 3: Completely destroyed structures in the image

	Object base	*Pixel base*
Correctly extracted building roof	*297*	*1691*
Total Area of the segment	*498*	*356562*
%	*59.60*	*86.48*

5. Conclusions

We applied a method for extraction of remaining structures and fully damaged estimation using very high resolution satellite images. The first step was to segment structural information using morphological opening and closing by reconstruction operators. IKONOS-2 satellite gray level images of pre and post tsunami event were applied to morphological operators. Then, the building footprint were extracted in hazard region using connected components analysis to the pixels selected according to their morphological profiles, obtained using increasing structural element sizes for 7 to 15m for opening and closing operators. From the analysis of the extracted building disaster area before the tsunami gives 65.16% and same area after the tsunami gives 78.36% buildings detection on object based percentage according to the applied method. Further increase the accuracy of pixel base fully destroyed tsunami damaged building 86.48% is estimated.

6. References

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