

# Analysing the Effect of Disaster

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**Abstract.** Analysing the damage area is the critical task for recovery and reconstruction for the urban area after the disaster. The proposed method is developed to detect the damage areas after the disaster using the satellite images. Most countries are exposed to a number of natural hazards such as Tsunami, Cyclone and landslide. It needs to estimate the destroying areas using the change detection techniques. In this approach, the pre and post satellite images are used to detect the damage areas. The main focus of the paper is to develop an approach that estimates the destroying areas combining the Morphological Building Index (MBI) and Slow Feature Analysis (SFA). The system output the change map for the damage area. The results indicate that the proposed approach is encouraging for automatic detection of damaged buildings and it is a time saving method for monitoring buildings after the disaster happened.

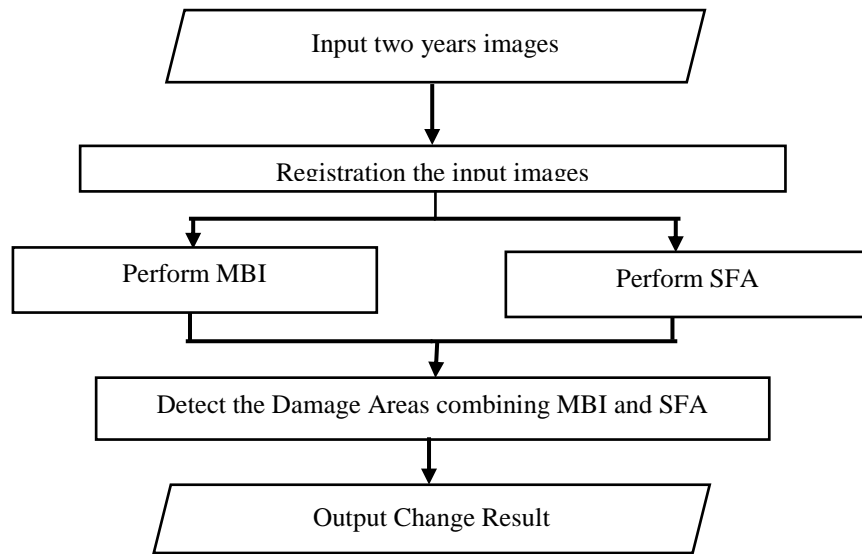
**Keywords:** Morphological Building Index, Change Detection, Disaster Effect, Slow Feature Analysis.

## 1 Introduction

Natural disasters such as earthquakes, land-slides, floods, fires and storms have increased in frequency and intensity over recent years. Observation of damaged buildings is vital for emergency management professionals, helping them for directing the rescue teams in short time to right location. Remote Sensing (RS) and Geographic Information Technologies (GIS) are an efficient tool for rapid monitoring of damaged buildings in urban regions [6, 9]. Satellite data has been used since 1970's. Today Climate changes and urban growth effect increasing pressure around the world wide. The results are: urban growth, intensified agriculture, decreases of forested areas, loss of biodiversity accelerated land degradation and soil erosion. The great demands are introduced on land use planning. Remote sensing data and techniques, and geographic information systems (GIS), provide efficient methods for analysis of land covers/uses. [1,7] Image registration is required in remote sensing (multispectral classification, environmental monitoring, change detection, image mosaicing, weather forecasting, creating super-resolution images, integrating information into geographic information systems (GIS), in medicine (combining computer tomography (CT) and NMR data to obtain more complete information about the patient, monitoring tumor growth, treatment verification, comparison of the patient's data with anatomical atlases), in cartography (map updating), and in computer vision (target localization, automatic quality control), to name a few. Some useful applications of this subject are; updating of geographic information system (GIS) databases, urban city planning and land use

analysis [11]. In order to solve this complex problem, integrating the power of multiple algorithms, cues, and available data sources is also implemented recently to improve the reliability and robustness of the extraction results [12]. Recent researches in this area focus on automatic and unsupervised extraction of buildings. Mahak Khurana and Baishali Wadhwa proposed modified grab cut partitioning algorithm that detect the buildings in image which will take input from the previous objective and rather than min-max evaluation used in grab cut. They use bio inspired optimization which will find a global optimal solution for maximum energy better than min max algorithm. X.Huang et. al, [13], proposed a novel building change index for automatic building change detection from high-resolution remote sensing imagery.

For analyzing the effect of disaster, the damage area detection system is developed based on the simultaneously taking the advantage of MBI (Morphology Building Index) and SFA (Slow Feature Analysis). In this paper, this proposes a set of novel building change indices (BCI) for the automatic building change detection. This paper is organized as follows: The system overview is discussed in section 2 and Methodology is expressed in Section 3. In section 4, experiments can be seen and section 5 gives the discussion and conclusion.



**Fig 1. Overview of the proposed system**

## 2 Change Detection of Damage Areas

In recent year, Myanmar is exposed to flooding and landslides during raining season and drought during dry season. It needs to estimate changing the building areas after the disasters and to know how much building areas are reconstructed in the progress of natural hazard relieving cycle. The propose system is divided into five parts. They are

1. input the two successive images
2. preprocessing such as image registration
3. Morphological Building Index (MBI)
4. Slow Feature Analysis (SFA)
5. Output the change result.

The two successive years images are applied in the proposed system, the flow chart for the proposed system is shown in figure 1.

## 2.1 Image Registration

Image registration is a crucial step in most image processing tasks for which the final result is achieved from the combination of various resources. The general 2D affine transformation can be expressed in the following equation.

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} t_x \\ t_y \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}$$

where  $(x_2, y_2)$  is the new transformed coordinate of  $(x_1, y_1)$ . The matrix  $\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$  can be rotation, scale or shear. The scale of both  $x$  and  $y$  axes can be expressed as

$$Scale = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \quad (1)$$

The shear is represented by

$$Shear = \begin{bmatrix} 1 & u \\ 0 & 1 \end{bmatrix} \quad Shear = \begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix} \quad (2)$$

## 2.2 Morphological Building Index

The basic idea of MBI is to build the relationship between the spectral-structural characteristics of buildings and the morphological operator, which are brightness, local contrast, size and directionality and shape. In order to solve this problem, modified MBI is proposed as the following steps:

### *Step 1: Enhancement of Image*

The input low resolution registered image is transformed to high contrast image by applying with only red intensity value and stored as the brightness value which is computed by Eq. 4.

$$g = T(f_R(x, y)) \quad (4)$$

where  $f_R(x, y)$  is the intensity transformation of red color-space image,  $g$  is the result of enhanced red band image using histogram adjust In [6].

### Step 2: Construction of MBI

The spectral-structural characteristics of buildings (e.g., contrast, size and directionality) are represented using the Differential Morphological Profile (DMP). The construction of MBI contains three steps.

(i) *White top-hat by Reconstruction* can be computed by Eq. 5.

$$W_{TH}(d, s) = g - \gamma_b^{re}(d, s) \quad (5)$$

where  $\gamma_b^{re}$  represents the opening-by-reconstruction of the brightness image, and  $s$  indicates a flat and disk-shaped linear structuring element (SE), respectively.

(ii) *Morphological Profiles (MP)* of the white top-hat is defined as Eq. 6 and 7.

$$MP_{W_{TH}}(s) = W_{TH}(s) \quad (6)$$

$$MP_{W_{TH}}(s) = 0 \quad (7)$$

(iii) *Differential Morphological Profiles (DMP)* of the white top-hat is calculated as Eq. 8.

$$DMP_{W_{TH}}(s) = |MP_{W_{TH}}(s + \Delta s) - MP_{W_{TH}}(s)| \quad (8)$$

where  $\Delta s$  is the interval of the profiles and  $s_{\min} \leq s \leq s_{\max}$ .

MBI is defined as the average of the DMPs of the white top-hat profiles defined in eq. 9 and 10 since buildings have large local contrast within the range of the chosen scales. Thus

$$MBI = \frac{\sum_s DMP_{W_{TH}}(s)}{D \times S} \quad (9)$$

$$S = \left( \frac{s_{\max} - s_{\min}}{\Delta s} \right) + 1 \quad (10)$$

where  $D$  and  $S$  denote the numbers of disk and scale of the profiles, respectively [5,6].

### Step 3: Building extraction

The final building extraction step is decided by using predefined threshold value in order to classify these  $MBI(x)$  pixels because of different resolutions and image capturing time.

$$IF MBI(x) \geq t_1, THEN map_1(x) = 1 ELSE map_1(x) = 0$$

where  $MBI(x)$  and  $map_1(x)$  indicate the value of  $MBI$  and the initial label for pixel  $x$ .  $t_1$  is threshold value and set  $t_1=5$  for the best result for the system [1, 2].

### 2.3 Slow Feature Analysis

Given a bitemporal spectral vector pair  $x^i = [x_1^i, \dots, x_N^i]$  and  $y^i = [y_1^i, \dots, y_N^i]$ , where  $i$  indicates the pixel number and  $N$  is the dimension of the band, the input is normalized with zero mean and unit variance, expressed as equation (11) and (12);

$$\hat{x}_j^i = \frac{x_j^i - \mu_{x_j}}{\sigma_{x_j}} \quad (11)$$

$$\hat{y}_j^i = \frac{y_j^i - \mu_{y_j}}{\sigma_{y_j}} \quad (12)$$

where  $\mu_{x_j}$  is the mean and  $\sigma_{x_j}$  is the variance for band  $j$  of image  $X$ .

The SFA algorithm is reformulated with the normalized multi temporal pairs and rewrite in equation (13) as

$$\frac{1}{P} \sum_{i=1}^P (g_j(\hat{x}^i) - g_j(\hat{y}^i))^2 \text{ is minimal} \quad (13)$$

where  $P$  is the number of bitemporal spectral vector pairs in the input data set[15]. The constraints of original SFA are written in equation (14), (15) and (16) by replacing the time series with the average over the data set of the bi temporal pairs.

$$\frac{1}{2P} [\sum_{i=1}^P g_j(\hat{x}^i) + \sum_{i=1}^P g_j(\hat{y}^i)] = 0 \quad (14)$$

$$\frac{1}{2P} [\sum_{i=1}^P g_j(\hat{x}^i)^2 + \sum_{i=1}^P g_j(\hat{y}^i)^2] = 1 \quad (15)$$

$$\frac{1}{2P} [\sum_{i=1}^P g_j(\hat{x}^i)g_l(\hat{x}^i) + \sum_{i=1}^P g_j(\hat{y}^i)g_l(\hat{y}^i)] = 0 \quad (16)$$

The optimization problem can be written as

$$\frac{1}{P} [\sum_{i=1}^P (\hat{x}^i - \hat{y}^i)(\hat{x}^i - \hat{y}^i)^T] = \Sigma_{\Delta} = A \quad (17)$$

$$\frac{1}{2P} [\sum_{i=1}^P (\hat{x}^i)(\hat{x}^i)^T + \sum_{i=1}^P (\hat{y}^i)(\hat{y}^i)^T] = \frac{1}{2}(\Sigma_x + \Sigma_y) = B \quad (18)$$

where  $\Sigma_{\Delta}$  is the covariance matrix of the temporal difference and  $\Sigma_x, \Sigma_y$  is the covariance matrix of each bitemporal input. With (17) and (18) can be reconstructed as

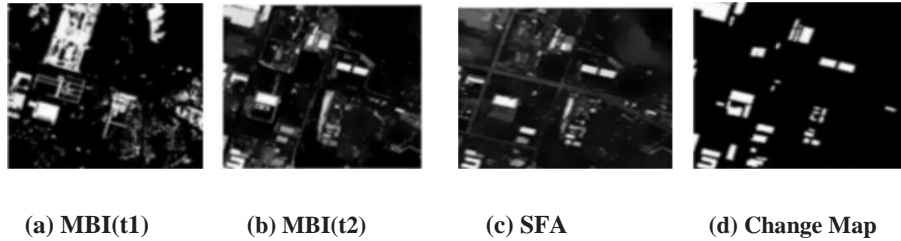
$$\frac{w_j^T A w_j}{w_j^T B w_j} = \frac{w_j^T \Sigma \Delta w_j}{w_j^T \frac{1}{2}(\Sigma_x + \Sigma_y) w_j} \quad (19)$$

Essentially, (19) means that the SFA change detection algorithm aims to find a function that obtains the lowest covariance of the difference values between the temporally invariant samples across different times while containing the most information[5,10]. Finally, the SFA variable shown in equation (20) is computed as

$$SFA_j = w_j \hat{x} - w_j \hat{y} \quad (20)$$

### 3. Detect the Change of Damage Area combining MBI and SFA

In Morphological Building Index (MBI), it leads to a number of false alarms involving non-building urban structures such as soil and roads. In Slow Feature Analysis (SFA), it lonely is not suitable for building change detection since it provides high commission error..



**Fig 2. The Result of Combining MBI and SFA**

The result of MBI and SFA are compared to detect the change of the damage areas. Decreasing damage building Area are estimated by comparing with *MBI* ( $t_2$ ) and *SFA*. *MBI* ( $t_1$ ) and *MBI*( $t_2$ ) represents building components extracted by *MBI* for time  $t_1$  and  $t_2$ , respectively as shown in figure 2.

## 4. Experimental Results

### 4.1 Dataset

The aerial images Tacloban, Philippines are taken after the Typhoon Haiyan. The figure 4 shows the reference map of Tacloban City. In this figure the color rectangle can be seen to classify the settlements types, transportation and hydrology. The blue rectangle represents water regions; brown, pink, light green, grey shows residential settlement, educational settlement, and recreational settlement, respectively.



**Fig 3. Tacloban City, Philippine**



**Fig 4. Reference Map of Tacloban City**

Then lines of blue and yellow presents the costal and roads of Tacloban city. The damage area can be calculated comparing the result of  $MBI(t_1)$ ,  $MBI(t_2)$  and SFA. The damage area of the specified types of settlement are classified by comparing the reference map of Tacloban City.



**Fig 5. Tacloban City Before Haiyan Cyclone**   **Fig 6. Damage Area After Haiyan Cyclon**

## 4.2 Results

The effectiveness of the SFA and MBI is assessed on the Google Earth images of the Tacloban City, Philippine. The following figure shows the damage area of Tacloban City after Haiyan Cyclone in 8 November, 2013. After the image registration, two- year images are set to the Morphological Building Index (MBI) and Slow Feature Analysis (SFA).



**(a) Original image**   **(b) Building Extraction**   **(a) Original image**   **(b) Building Extraction**

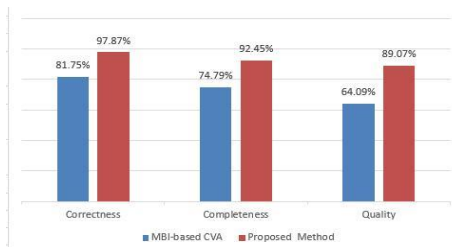
**Fig 7. Tacloban City (before Haiyan Typhon)**   **Fig 8. Tacloban City (after Haiyan Typhon)**

The figure 7 and figure 8 show MBI of building areas before and after the Haiyan Typhoon. To test the performance of the proposed system, we use these evaluation measures (completeness, correctness, quality) in Figure 9.

$$Correctness = \frac{TP}{TP + FP}$$

$$Completeness = \frac{TP}{TP + FN}$$

$$Quality = \frac{TP}{TP + FP + FN}$$



**Fig 9: Accuracy assessment of the proposed method**

## 5. Conclusions

In this study, the combination of MBI and SFA method is proposed for automatically extracting the damage areas of the urban region. This system can solve the various satellite images only with three spectral colors without using multispectral band images. Since the proposed method uses unsupervised technique, the training data is not required. So it can save the time for the training samples than other supervised method. But the errors may sometimes occur when many crowded cars on the road lead to miss building extraction because the urban downtown area is our research area. In the future we will propose the change detection system to know the increasing and decreasing rate of the building areas of the urban regions.

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