

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 purposed 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). He system output the Tchange 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.

Object detection in satellite images has been an important research topic in computer vision for many years. Some useful applications of this subject are; updating of geographic information system (GIS) databases, urban city planning and land use analysis. 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 [11]. Recent researches in this area focus on automatic and unsupervised extraction of buildings. Lizy Abraham and Dr. M. Sasikumar [10] introduced an approach to the problem of automatic and unsupervised extraction of building features irrespective of rooftop structures in multispectral satellite images. The algorithm instead of detecting the region of interest, eliminates areas other than the region of the interest which extract the rooftops completely irrespective of their shapes. 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 [12].

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 purposes 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 Sect. 2 and Methodology is expressed in Sect. 3. In Sect. 4, experiments can be seen and Sect. 5 gives the discussion and conclusion.

2 Change Detection of Damage Areas

In recent year, most countries are 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 damaged building areas are reconstructed in the progress of natural hazard relieving cycle.

The purpose system is divided into six 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 years images are applied in the proposed system, The flow chart for the purposed system is shown in Fig. 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 ground control point

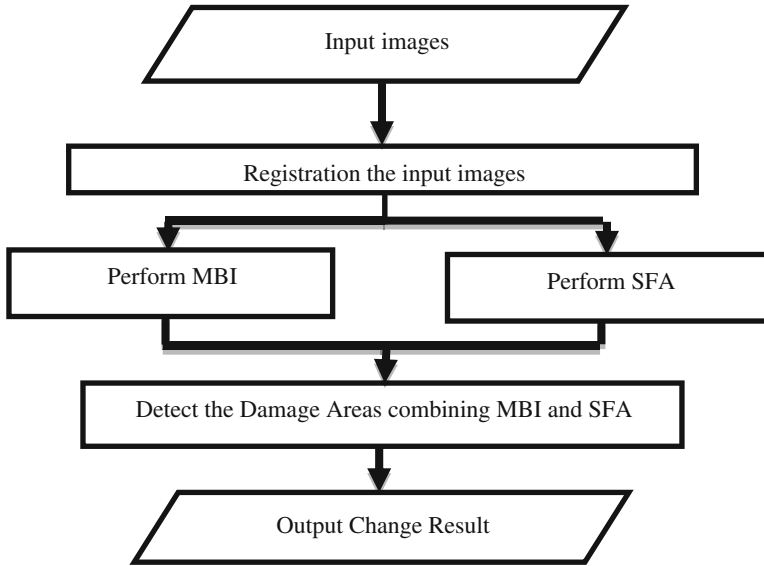


Fig. 1. Overview of the proposed system

is used to register the input successive images using image pixel addresses in terms of a map coordinate base. The most commonly used registration transformation is the affine transformation which is sufficient to match two images of a scene taken from the same viewing angle but from different position. It can tolerate more complex distortions. Affine transform can be categorized based on the geometric transforms for a planar surface element as translation, rotation, scaling, stretching, and shearing. The general 2D affine transformation can be expressed as shown in the following equation.

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} t_x \\ t_y \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} \tag{1}$$

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

$$Scale = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \tag{2}$$

The two shear factors are represented on a and b are the shear factor along the x axis and y axis, respectively.

$$Shear = \begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}, Shear = \begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix} \tag{3}$$

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 summarized as follows.

- Brightness
- Local contrast
- Size and Directionality
- Shape

This method uses multispectral bands for high resolution images. Now we use low resolution image of three band color. The modified MBI is defined by describing the characteristic of building feature especially color of building roof and image intensity value. 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], Original MBI is applied in multispectral band images of high resolution satellite images.

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 γ_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 Eqs. 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 Δs 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 Eqs. 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.

$$\begin{aligned} & \text{IF } MBI(x) \geq t_1, \\ & \quad \text{THEN } map_1(x) = 1 \\ & \quad \text{ELSE } map_1(x) = 0 \end{aligned}$$

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 Eqs. (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 μ_{x_j} is the mean and σ_{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 Eq. (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.

Finally, the SFA variable can be represented as

$$SFA_j = w_j \hat{x} - w_j \hat{y} \quad (14)$$

Where

$$\frac{w_j^T A w_j}{w_j^T B w_j} = \frac{w_j^T \sum_{\Delta} w_j}{w_j^T \frac{1}{2} (\sum_x + \sum_y) w_j}. \quad (15)$$

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. Its accuracy is related to the radiometric conditions of the image. In Slow Feature Analysis (SFA), it alone is not suitable for building change detection since it provides high commission error. It is not only related to the change of buildings, but also to other urban structures.

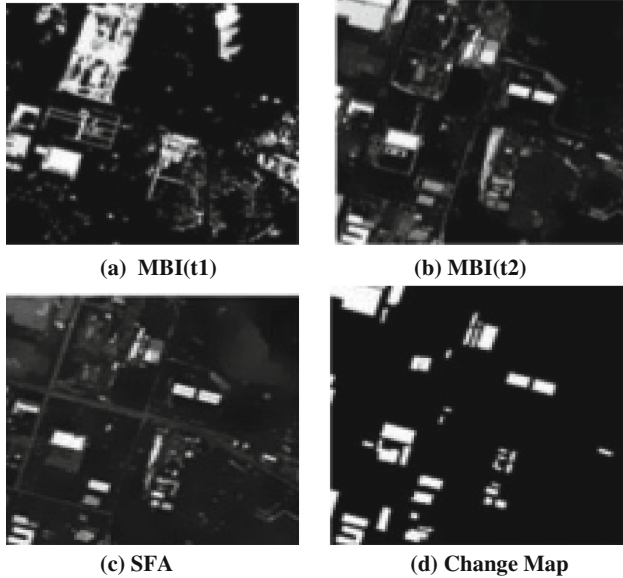


Fig. 2. The Result of Combining MBI and SFA

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 Fig. 2.

4 Experimental Results

In this paper the study area was located in coastal city of Tacloban, Philippines. The aerial images are taken after the Typhoon Haiyan. The proposed method is applied to detect the damage building area. The Fig. 3 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. 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 is obtained as Fig. 5 by comparing the reference map of Tacloban City



Fig. 3. Reference Map



Fig. 4. Before Haiyan Cyclone

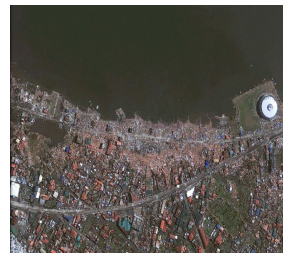
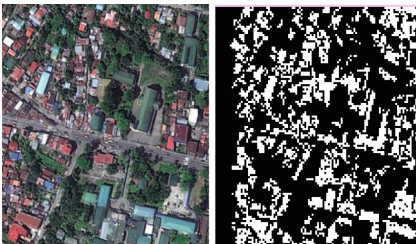
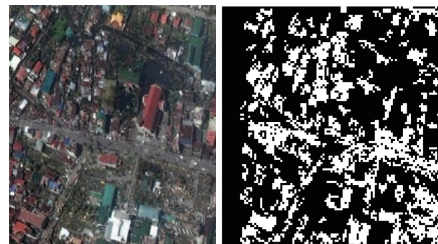


Fig. 5. Damage Area After Cyclone



(a) Original image (b) Extraction



(a) Original image (b) Extraction

Fig. 6. Tacloban City (before Haiyan Typhon)

Fig. 7. Tacloban City (after Typhon)

The effectiveness of the SFA and MBI is assessed on the Google Earth images of the Tacloban City, Philippine. The following Fig. 7 shows the damage area of Tacloban City after Haiyan Cyclone in 8 November, 2013. To test the performance of the proposed system, we use these evaluation measures (completeness, correctness, quality) in Fig. 8.

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

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

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

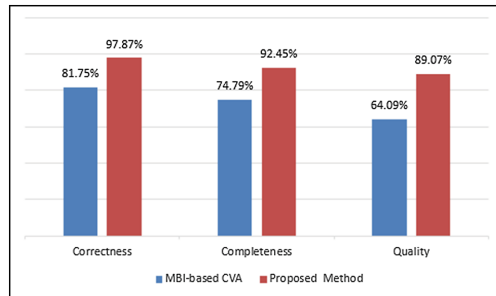


Fig. 8. Accuracy assessment of the proposed method

5 Conclusions

In this study, the combination of MBI and SFA method is purposed 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 purposed 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 of the urban downtown area is our research area. Besides the purposed method is used manual threshold value in extracting the building area so it costs time to set the manual threshold value. In the future we will purpose the change detection system to know the increasing and decreasing rate of the building areas of the urban regions.

References

1. Nwe, N.M.M., Sein, M.M.: Detecting the environmental changes from satellite image. In: The Proceedings of the third Malaysian Software Engineering Conference, ACRS 2007, November 21–24 (2007)
2. Nwe, N.M.M., Sein, M.M.: Detecting the environmental changes area of satellite image. In: Proceedings of the Sixth International Conference on Computer Application, Yangon Myanmar, pp. 232–236 (2008)

3. Moe, K.C., Sein, M.M.: Detection the changes of urban area in yangon within ten years. In: Proceedings of the 1st International Conference on Energy, Environment and Human Engineering (ICEEHE), Yangon, Myanmar (2013)
4. Moe, K.C., Sein, M.M.: Automatic building change detection and open space area extraction in urban areas. In: Proceedings of the 12th International Conference on Computer Applications (ICCA2014), Yangon, Myanmar, pp. 291–296 (2014)
5. Moe, K.C., Sein, M.M.: An unsupervised technique for building change detection in urban areas. In: International Journal of Computer Application(IJCA), November on (106_18), New York, pp. 31–35, November 2014
6. Moe, K.C., Sein, M.M.: Building area extraction of urban region based on GIS. In: Proceedings of the 13th International Conference on Computer Applications (ICCA2015), Yangon, Myanmar, pp. 329–334 (2015)
7. Moe, K.C., Sein, M.M.: Urban growth detection using morphology of satellite image. In: Proceedings of International Conference on Science, Technology, Engineering and Management (ICSTEM,2015), Singapore, pp. 43–47 (2015). ISBN: 978-93-84209-89-6
8. Moe, K.C., Sein, M.M.: Urban growth detection using morphology of satellite image. Int. J. Adv. Electornics Comput. Sci. (IJA ECS) **2**(3), March 2015
9. Moe, K.C., Sein, M.M.: Urban build -up building change detection using morphology based on GIS. In: International Journal of Genetic and Evolutionary Computing (ICGEC), Myanmar, 26–28 August 2015
10. Abraham, L., Sasikumar, N.: Unsupervised building extraction from high resolution satellite images irrespective of rooftop structures. Int. J. Image Process. (IJIP), **6**(4) (2012)
11. Bhadauria, A.S., Bhadauria, H.S., Kumar, A.: Building Extraction from Satellite Images **12**(2), 76–81 (2013). e-ISSN: 2278-0661, P-ISSN: 2278-8727
12. Doxani, G., Karantzalos, K. Tsakiri, M.: Automatic change detection in urban areas under a scale-space, object-oriented classification framework (2009)