Change Detection of the Building Areas in Urban regions

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Abstract

Myanmar is exposed to a number of natural hazards, some of which have caused devastating damage in the recent past. According to the UN Risk Model, Myanmar ranks as the 'most at risk' country for natural disasters. Coastal regions, particularly Rakhine State and the Ayeyarwady Delta Region, are at high risk for cyclones, storm surges and tsunamis. As Myanmar falls on one of the two main earthquake belts in the world, much of the country is prone to earthquake. After the disaster occurred, we cannot classify completely the building areas on widely damaged urban areas many years later. Urban growth is the critical feeds for the city planning and directly effects on the country development. The modified Morphological Building Index (MBI) is applied to extract building areas to know how much area has change. Then, matching-based change rule is applied to obtain changes areas. In the experiments show that the proposed method can achieve satisfactory correctness rate by comparing with Change Vector Analysis (CVA).

Keyword: modified MBI, change rule, CVA

1. Introduction

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, decrease 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. [8] 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. [2] The fundamental challenges that drive much of the research in this field are the edge or line extraction problems and segmentation problem, which is finding a desired object and separating it from the background in the presence of distractions caused by other features such as surface markings, vegetation, shadows, and highlights. [10] A large variety of building detection techniques and algorithms have been reported in the literature, but most detection algorithms rely on edge-based techniques that consist of linear feature detection, grouping for parallelogram structure extraction, and building polygons verification using knowledge such as geometric structure, shadow, and so forth. 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.

Recent researches in this area focus on automatic and unsupervised extraction of buildings. A.S. Bhadauria, H.S. Bhadauria and Anuj Kumar proposed a solution to extract rectilinear buildings by using hypothesis. Hypothesis generation is accomplished by using edge detection and line generation methods. [3]
Lizy Abraham and Dr. M. Sasidumar [1] introduced an approach to the problem of automatic and unsupervised extraction of building features irrespective of rooftop structures in multispectral satellite images. The algoritnm 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. [6]
X.Huang, T.Zhu, L.Zhang, Y.Tang, purposed a novel building change index for automatic building change detection from high-resolution remote sensing imagery. In this paper, This purposes a set of novel building change indices(BCI) for the automatic building change detection by simultaneous -sly taking the advantage of MBI (Morphology Building Index) and SFA (Slow Feature Analysis).[7]
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.

2. Change Detection of Building Areas

In recent year, Myanmar is exposed to flooding and landslides during raining season and drough and fire during dry season. It needs to estimate changing the building areas after the disasters. It also need to know how much building areas are reconstructed in the progress of natural hazard relieving cycle. The pseudo code for the purposed system is as follow:

Step 1: Input the images
Step 2: Perform the preprocessing the imput images
- Remove the noises
- Image registration

Step 3: Examine the changed/unchanged result using Hue color histogram
- Output a threshold value T_{hch}

Step 4: If user predefined threshold value s is greater than T_{hch}
Output “Two images are unchanged”
Step 5: Extract the building Areas
Step 6: Output the change result

The purpose system is divided into three parts. They are 1) input images 2) preprocessing such as image registration 3) Extract the building features and detect the changing of the building areas and 4) Output the change results. The proposed system is illustrated in Figure 1.

3. System Methodology

It contains three parts: Image registration, modified Morphological Building Index and Change rule.

3.1. 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 is used to register ten years successive images using image pixel addresses in terms of a map coordinate base.

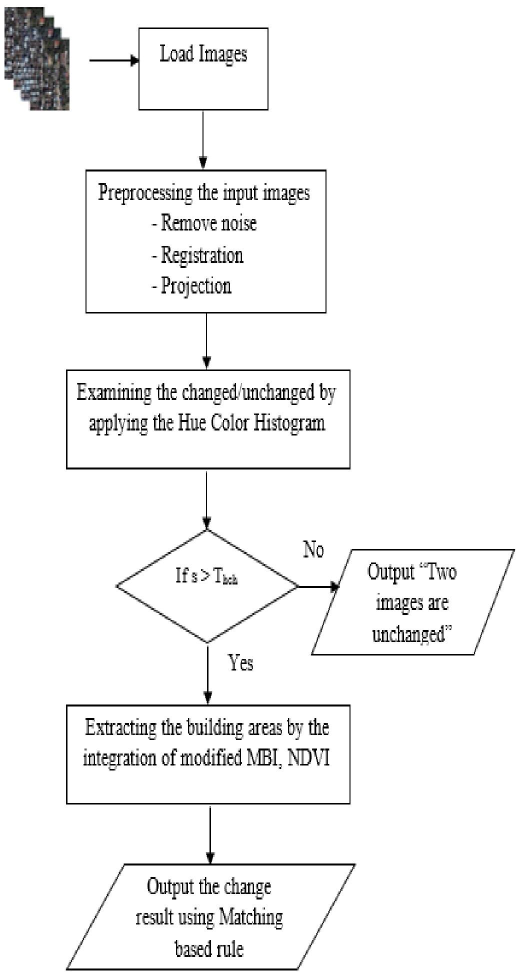


Figure 1: Overview of the proposed system

Firstly, the image is grabbed from Google Earth with latitude and longitude coordinate. The area of 0.087 km^2 is for one region with the range of ten second by ten second partitioning of lat/long coordinate. The four ground control points are selected in one region to register successive reference images. Secondly, these obtained lat/long coordinate control points are changed from degree/minute/second format to decimal format. Finally, the coming points are converted by using coordinate conversion method to get XY coordinate. Then, affine transformation is applied to register.

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.

Obtained control points of image coordinate that is converted from geometric coordinate, building the mapping function and get the affine transformation parameters to resample the sensed image and perform image registration. The general 2D affine transformation can be expressed as shown in the following equation. [2]

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

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

$$Scale = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \quad (2)$$

The shear is represented by

$$Shear = \begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix} \quad , \qquad Shear = \begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix}$$

(3)

3.2. Modified 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. The system runs on low resolution satellite images so their resolution and brightness of intensity values are very low. In order to achieve 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.

$$f_R(x, y)$$
$$g = T ¿ \qquad (4)$$

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 [9], Original MBI is applied in multispectral band images of high resolution satellite images. They used enhancement process by using brightness value from this multispectral band. Now our method gives for both high and low resolution of various satellite images with the use of only red color enhancement.

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.

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

(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.

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

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

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

$$DMP_{W_{TH}}(s)=\left|MP_{W_{TH}}(s+\Delta s)-MP_{W_{TH}}(\ldots\right.$$

` (8)

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

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

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

(9)

$$S=\left(\frac{S_{max}-S_{min}}{\Delta S}\right)+1 \qquad (10)$$

where *D* and *S* denote the numbers of disk and scale of the profiles, respectively.

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 $MBI(x) \ge t_1$,

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.

3.3. Change rule

After building only areas are extracted by modified MBI in two images, matched-based change rule is applied to get final change/increase building areas.

end

$$i \in 1,2,3,\ldots,N$$

where $map_1(i)$ and $map_2(i)$ are the output value(0 and 1) of modified MBI method. '0' means no building and '1' means building. The *i* is the same pixel of first and second images and N is the number of pairs of the corresponding building objects where *C (i)* represents whether the object *i* is changed, with 0 and 1 for non-change and change, respectively.

4. Experimental Result

4.1 Dataset

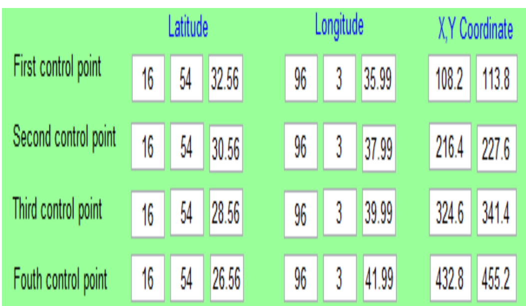
In this paper the study area was located in Yangon City (Urban area) extracted from Google earth within ten years. These images include three visible bands such as red, green and blue. Because, urban area characterized by higher population density and very attached buildings. So that we have taken urban region image. Besides the Satellite images by DigitalGlobe of Tacloban City are used to demonstrate some situations of the purposed system.

4.2 Results

The effectiveness of the modified Morphological Building Index is assessed on the Google Earth images of the Hlaing Tar Yar Township, Yangon. The following figure shows the user interface of the urban change detection system.

Figure 2: Input Areas (Hlaing Tar Yar Township)

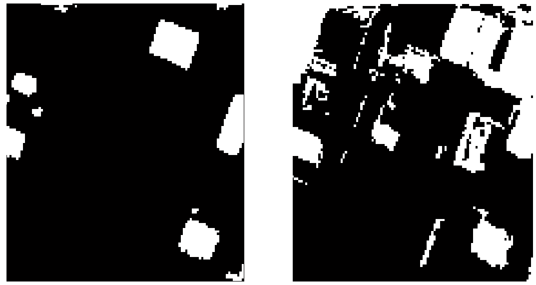
After the image registration, ten year images are set these four control points with their deviation of camera angle.



	Latitude			Longitude			X,Y Coordinate	
First control point	16	54	32.56	96	3	35.99	108.2	113.8
Second control point	16	54	30.56	96	3	37.99	216.4	227.6
Third control point	16	54	28.56	96	3	39.99	324.6	341.4
Fouth control point	16	54	26.56	96	3	41.99	432.8	455.2

Figure 3: Geometric transformation of four control points for one image

In the figure 4 building areas are extracted using modified MBI. In these figures, white area and black areas mean building areas and open space areas, respectively. In figure 5, the final result is the built-up building area of the specified township.



(a) 2009 image **(b) 2015 image**

Figure 4: Extraction of built-up Areas

Figure 5: Output of the purposed change detection result

Building extraction rate for Hlaing Tar Yar Township is approximately shown in figure 6 which is extracted by using the modified Morphological Building Index method. The building area developing rate is shown in figure 7 by the use of the Matching-based Change Rule.

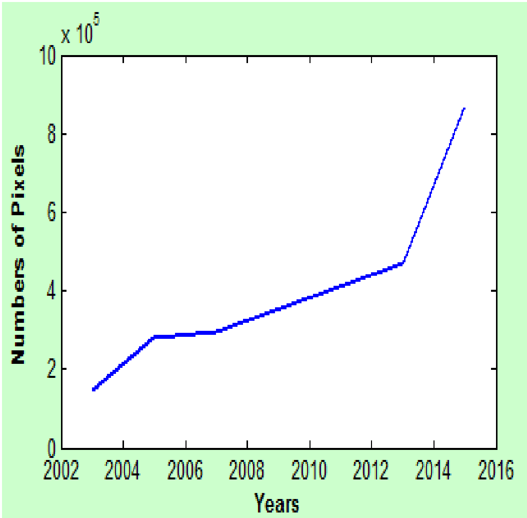


Figure 6: Building extraction rate of Hlaing Tar Yar Township within ten years period

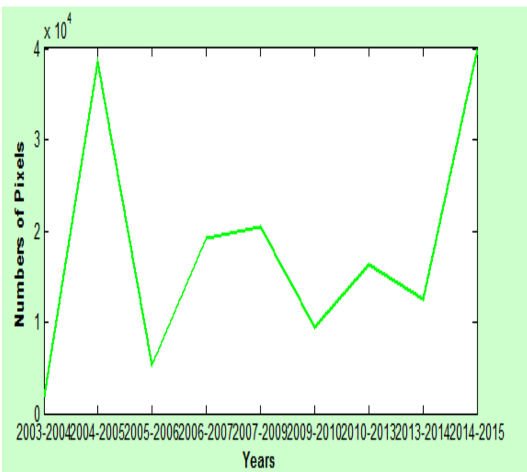
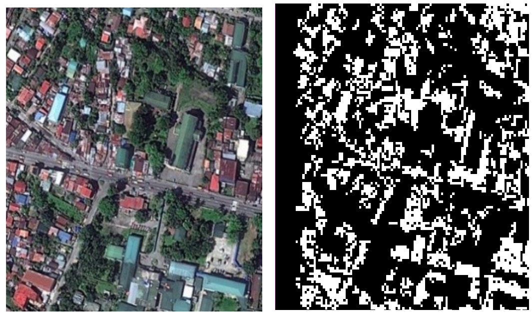


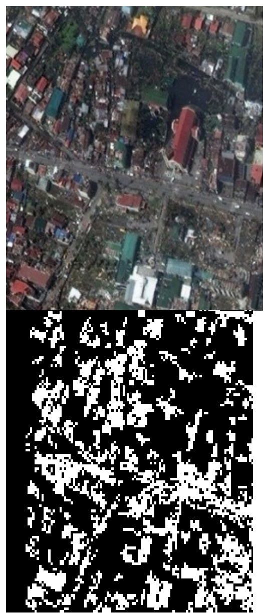
Figure 7: Area Change Detection of Hlaing Tar Yar Township within ten years period

Otherwise, the satellite images by DigitalGlobe is tested with purposed system.



(a) Original image (b) Building Extraction

Figure 8: Tacloban City (before Haiyan Typhon)



(a) Original image (b) Building Extraction

Figure 9: Tacloban City (after Haiyan Typhon)

In the previous purposed system [9], we cannot detect the building changing area as shown in figure 8 and figure 9. Sometimes the purpose method extract the missing building built-up areas after the disaster occurs.

To test the performance of the proposed system, we use these evaluation measures (completeness, correctness, quality) in Table 1.

$$Correctness = \frac{DB}{RB}$$

$$Completeness = \frac{RF}{DB}$$

$$Quality = 100 * \frac{TP}{TP + FN + FP}$$

TP (True Positive): number of buildings detected both manually and with the automatic approach.
FP (False Positive): number of buildings detected by the automatic approach but not manually.
TN (True Negative): number of buildings detected manually but not by the automatic approach.
FN (False Negative): number of undetected buildings.
DB: detected buildings at least partially overlapped with the reference buildings.
RF: reference buildings overlapping the detected buildings.
The correctness value indicates the percentage of the detected building objects that are at least partially overlapped with the reference buildings.
The completeness value refers to the percentage of reference buildings overlapped the detected buildings.
The quality measures the absolute quality of the detection model

Table 1: Accuracy assessment of the proposed method

Quantitative measures	MBI-based CVA	Proposed Method
Correctness	81.75%	97.87%
Completeness	74.79%	92.45%
Quality	64.09%	89.07%

5. Conclusion

In this study, modified MBI method is purposed for automatically extracting the built-up building areas of the urban region. This system can solve the various satellite images only with three spectral colors without using multispectral band images. Original MBI is only for the multi-temporal high-resolution imagery. 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 crowed 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. The purposed method only detect the built-up building areas but not detect the decreasing building areas of the urban region. 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.

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