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Damage Detection caused by Natural Disaster using Image Processing Technique

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Abstract— Earthquakes are among the foremost grievous geological disaster that may cause loss of life and property harm. One of the censorious issues after earthquakes or natural hazard is damage detection. Damage recognition of destructed area by human being eyes not to be so effective since it takes longer time to grasp damage by inspection patrolling. But satellite images as well as image processing technique play crucial role in detecting damage because of their easy and rapid processing capacities. Now those more and diverse types of remote sensing and satellite data become accessible and various methods are applied for better damage detection. This work includes a comprehensive review of this method one type of damages- linear type damage in which changes to be evaluated in- between pre and post event data.

Keywords- *Image processing, earthquake, edge extraction damage detection, connected component.*

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1. Introduction

Natural disasters are acute, sudden events caused by environmental factors that injure people and damage property. Earthquakes, tornado, tsunami, landslides, windstorms, floods, volcanic emission and other geologic actions all strike anywhere on earth, often without warning. Our study is focused on disaster specially caused by earthquake. Earthquakes are one of the most miserable natural destruction have an impact on humanities [1]. A geological catastrophe such as earthquake can generate loss of life or goods destruction, and typically leaves some financially destruction in its rouse, the seriousness of which depends on the affected population's resilience, or capability to recover.

To detect a geographical damage from natural catastrophe, a traditional way is to grasp damage by facility inspection patrol, even if we ignore small damage and focus on serious damage. But it takes longer time to grasp. When a wide-area natural disaster such as a vast earthquake happened, the span and graveness of its destruction should be immediately observed in order to take a decision for Life/property supporting activities. With human works only, it is hard to approximate the destruction in a global view [4]. This is main reason because of that we scrutinize usability of image processing techniques implemented to aerial photographs. However, whether this technique is truly beneficial for the purpose depends on crucially the accuracy of the outcomes of image processing.

The objective of this study is to determine the damaged extents from given input images of Japan earthquake using morphological function with thin operation, edge extraction method, and label connected component method. A component-based damage detection method was proposed. The implementation of the approach was carried out using MATLAB which is a high-performance language for technical computing.

2. PREVIOUS STUDIES

Many methods have been introduced for destruction recognition. These processes can be predominantly divided into two categories, first, methods that recognize changes in middle of pre-event data and post-event data. And second, methods that explain only post-event data.

The leading dissimilarity between these two categories of methods lies in their quality and applicability of the consequences. Compared to methods using only post-event data, more exact outcomes can be acquired by those using pre- and post-event data.

W. Liu & F. Yamazaki (2004) proposed a method but two preprocessing approaches were applied to the images before extracting damaged buildings. First, the three TSX images were transformed to a Sigma Naught ($\sigma 0$) value, which represents the radar reflectivity per unit area in the ground range. After the transformation, the backscattering coefficients of the images were between -35 dB and 25 dB. Then, an enhanced Lee filter (Lopes *et al.*, 1990) was applied to the SAR data to reduce the speckle noise. To minimize the loss of information contained in the SAR intensity images, the window size of the filter was set as 3 × 3 pixels.

Author proposed a method in which they first damaged and washed-away buildings were detected from the changes of backscattering coefficients shown in figure 2.16. Next the average value for the change factors in the outline of each building was calculated and used to judge the damage status of the building.

Then the resulting classifications were compared with a GIS damage map produced by visual interpretation. The proposed method also estimated the buildings height according to the length of layover in SAR images.

Kensuke Shiraki et al. (2002) consider here the case that only aerial photographs after the earthquake are available hence they used post-occasion pictures only. To evaluate damage author perform some steps. They first detected damaged areas from the aerial photographs by some image processing methods to be described in later. Next the aerial image and the detected damaged areas pictures are mapped onto the digital map in the GIS. Then each damaged area detected is converted from a set of pixels to a polygon. At last they compare detection areas with the real damage.

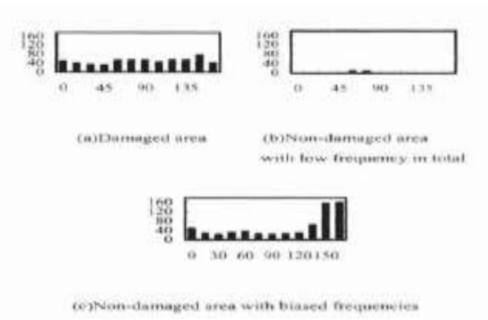


Figure-1 typical histograms of edge directions

Authors also calculate the histogram of the directions of the edges. Figure 2.15 shows typical examples of histograms of the edge directions for a damaged area region and a non-damaged area region.

Thomas Oommen et al. (2010) used two different methods to detect damaged areas these are: pixel-based change detection and object-based change detection. The pre- and post-event images were analyzed using Erdas Imagine, image processing software. There after images were co-registered using the Imagine auto sync workstation. Then co-registered images were used for the pixel-based and object-based change detection studies.

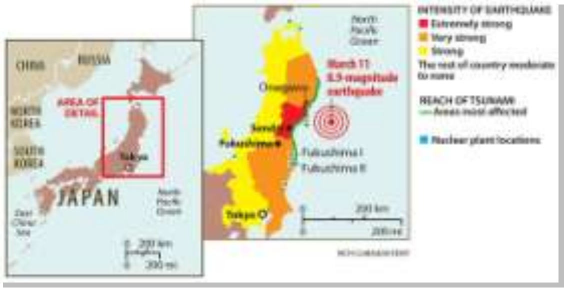
In pixel-based change detection technique author detect damage by calculating image difference. Image differencing is the simplest form of pixel based change detection and it involves subtracting two images acquired on two different dates to generate a different image. Author considered that, image differencing results in positive and negative values represents areas of change and near zero values represents areas of no change.

In object-based change detection method, the Discriminant Function Change (DFC) is a new algorithm for change detection between two co-registered images, shown in figure 2.13. The advantage of DFC is that the two images can have a different number of bands and wavelength characteristics. It characterizes the natural spectral clusters in the pre-event image by unsupervised classification/clustering. These clusters are used to compute the Mahalanobis Distance (MD) of the post-event image. Further, the MD is converted to a probability value. The resultant is a probability image with pixel values 0.0 to 1.0 with a value of 0.0 representing no change (darker regions).

E. Sumer et al. (2005) proposed concept of detecting damage and different methods to recognize damages of building. The proposed damage assessment method is illustrated in Figure 2.1. First to provide better discrimination between the building and their shadows they are using histogram equalization technique for pre-processing of post-event aerial photograph of the area. Next, by using of vector building boundary information, one-by-one the building were selected. Then, the shadow-producing edges were calculated for each building. For that purpose, a simple algorithm was developed. They used illumination angle which was available from a previous study conducted by San (2002) as 135^0 from the x-axis. Along the shadow edges of the buildings, a buffer zone was generated. By the execution of the watershed segmentation algorithm this was followed. For each building, a binary-colored output representing the shadow and non-shadow areas was generated. Finally, by comparing the analyzed buildings with the reference data, the accuracy assessment was carried out.

3. STUDY AREA AND DATA

To assess routines and acknowledging quantitative results, datasets were gotten from satellite pictures. In our examination, Fukushima, North of Sendai, Sendai, Onagawa and Iwaki range are chosen as study locales. (Figure-2)



Figur-2 earthquakes 2011 in Japan

A Sendai and Fukushima seismic tremor was a significant quake in Japan. On March 11, 2011, at 2:46 p.m. neighborhood time (05:46 Universal Time, or UTC), a greatness 9.0 quake struck off the east bank of Japan, at 38.3 degrees North scope and 142.4 degrees East longitude. The epicenter was 130 kilometers east of Sendai, and 373 kilometers upper east of Tokyo. In the event that starting estimations are affirmed, it will be the world's fifth biggest tremor following 1900 and the most noticeably awful in Japan's history. An aggregate of 12,431 individuals were affirmed dead by National Police Agency, while 15,153 were missing.

An arrangement of photos, which were taken prior and then afterward the tremor was arranged. The pre- and post - occasion pictures were obtained by GeoEye-1 satellite. The satellite collects images at .41-meter panchromatic (black-and-white) and 1.65-meter multispectral resolution. Altitude of GeoEye-1 is 681 kilometer, sensor resolution Panchromatic: 41 cm GSD at nadir Black & white: 450-800 nm, dynamic range is 11-bits per pixel and retargeting agility: time to slew 200 kilometer: 20 sec.

4. METHODOLGY

The proposed component-based damage detection method basically detects the damaged extents on the basis of number of connected components avail in image. Execution of proposed method is divided into two phases which is illustrated in fig 3 and fig 4 as below.

Phase-I - The main steps followed in this phase is illustrated in Figure 3. First, the pre-occasion and post-occasion Geo Eye photograph of the extent was sharpen using unsharp masking technique to produce an image or a sequence of images of better quality. Because original image can be blurry, noisy, of pixel resolution or even be the corrupt during pre-processing. Next, the extent was selected one-by-one and applied morphological technique with 'thin' operation after getting the binary image to remove the pixels so that an object without holes shrinks to a minimally connected stroke, and an object with holes shrinks to a connected ring halfway between each hole and the outer boundary. Then, for each extent we calculated label connected component, that method groups image pixels into the components based on pixel connectivity that means all pixels in a connected component share similar pixel intensity values and are in some way connected with each other.

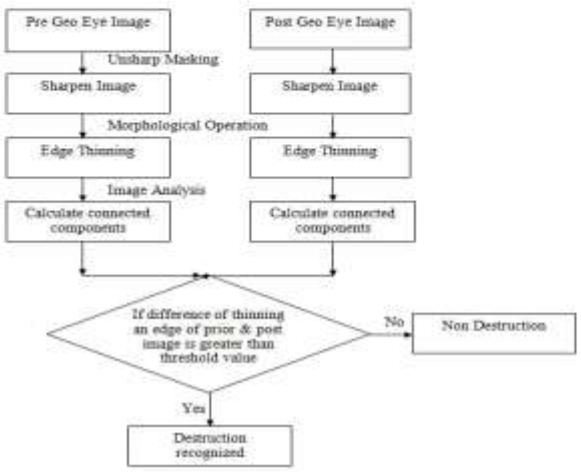


Figure-3 flow diagram of proposed method using edge thinning

Then we find out the difference of number of connected components of thinned pre and post occasion picture and compare with threshold value. Finally, destruction recognized when difference greater than threshold value. The accuracy assessment was carried out by comparing the analyzed extent with the reference data. Similarly as above phase 2 (figure 4) also performed all steps, but in the place of edge thinning it performed edge extraction operation.

Step-1 Pre and post Geo Eye image - In the first step of proposed approach, the pre-occasion and post-occasion Geo Eye images are taken as inputs. The pre-occasion Geo Eye images are captured before happening natural catastrophe while post-occasion Geo Eye images are captured after happening natural catastrophe.

Step-2 Sharpen Image - In the wake of applying both pre and post occasion Geo Eye pictures, this step produce sharp picture utilizing "imsharpen" MATLAB function. This function return an upgraded rendition of the grayscale or truecolor (RGB) input picture, where the picture features, for example, edges, have been sharpened utilizing the unsharp masking strategy.

Step-3 Edge Thinning - After getting sharpen image from above step proposed methodology apply edge thinning operation on that. This step produces thinned picture from sharpen image utilizing "bwmorph" MATLAB function with 'thin' operation. Thinning is basically a morphological operation which is utilizing to eliminate or remove selected forefront pixels from binary pictures.

Step-4 Calculate connected components - After thinning the images, methodology calculate label connected components to know total number of connected components in the image. This step calculates connected components from thinned image by utilizing "bwlabeln" MATLAB function. This function returns a label matrix containing labels for the connected components in binary thinned image.

Step-5 Comparison and Result - At long last after getting connected component of both pre and post-occasion Geo Eye images we simply compare to them, If difference of thinning an edge of prior & post image is greater than threshold value then image is recognized as destructed extent otherwise non destructed extent.

Phase-II - This phase is illustrated in Figure 4 performed all above steps again with Edge extraction instead of Edge thinning. After getting sharpen image from second step proposed methodology apply edge extraction operation on that. This step produces extracted edge picture from sharpen image utilizing "edge" MATLAB function with 'canny' operation. Where the function takes a sharpen image as its input, and return a binary image, with 1's where the function finds edges in input and 0's elsewhere.

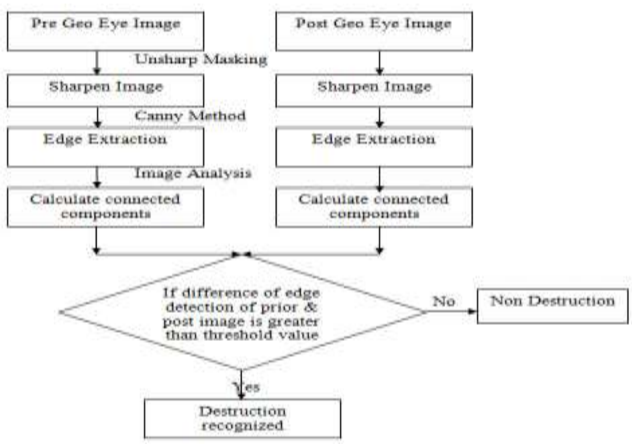


Figure 4.2 flow diagram of proposed method using edge detection

Further output from phase-1 and phase-2 are used to calculate accuracy. We calculated precision and recall for both phases and calculate recognition rate by using output of both phase.

5. RESULT

After applying all functions total numbers of destructed extents are obtained from first phase and second phase. Further by using total number of destructed extents we find out accuracy of methodology for that we calculate:

Recall: - Recall can be described as the fragment of relevant sample that are retrieved. In other words it presents how many destructed images are selected.

Recall = Number of destruction selected/ Total number of destruction

Precision: - Precision can be described as the fragment of selected items that are relevant. In other words it presents how many selected items are destructed.

Precision = Number of destruction selected/Total number of selected item

Recognition rate: - Recognition rate can be defined as the fragment of presented destructed items that are recognized. In other words it shows how many presented destructed items are recognized.

Recognition rate = Number of destruction recognized/ Number of destruction presented

I. After compare we obtain following result:

In the first case total 12 destructed images are recognized correctly

In the second case total 16 destructed images are recognized correctly

II. On the basis of above data we calculate:

Precision_thin = 0.5
Recall_thin = 0.6
Precision_edge = 0.50
Recall_edge = 0.80
Recognition rate = 0.70

From the result among the selected thinned images, 50% images are destructed.

Among the presented thinned destructed images, 60% images are recognized as destructed.

Among the selected edged images, 50% images are destructed.

Among the presented edged destructed images, 80% images are recognized as destructed.

Our method gives 70% recognition rate that means it recognized 70% relevant extents.

6. CONCLUSION

Based on analysis and execution measures done in the methodology section, this part concludes the proposed methodology of recognizing the damaged extent from given inputs utilizing MATLAB function such as enhancement, edge, thinning and label connected component. Additionally, as the exploration era has come in more extensive aspects accordingly no research work stops. Each work has a few disadvantages or has the extent of future work or both. Thus, in this part extent of future work has likewise been examined.

The above approach was implemented on 40 Geo Eye images that include 20 pre images and 20 post images treated as test images which were given as an input data file to the system. The proposed methodology can detect 50% images as destructed from the selected thinned images. Among the presented thinned destructed images, methodology can recognize 60% images as destructed. Among the selected edged images, 50% images can be detected as destructed. Among the presented edged destructed images, 80% images are recognized as destructed. Our method gives 70% recognition rate that means it recognized 70% relevant extents. The efficiency of the methodology was found to be near about 75%.

7. ACKNOWLEDGMENT

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