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IDRTS Method for the Detection of Damaged Buildings in Crisis Areas Using SAR Images

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ABSTRACT: *Following a natural disaster the authorities need to know information such as location and extend of affected areas. Visual interpretation of the affected area can provide sufficient information but it is a difficult and time consuming task. Here comes the importance of remote sensing. Remotely sensed images is increasingly becoming an important source of information for detecting building damages . Both medium resolution and high resolution satellites can be used for obtaining the images. This paper presents a new method for the detection of damaged buildings by integrating image difference, ratio, texture segmentation and change detection based on segmentation for producing change map. Hence the name Integrated Difference Ratio Texture Segmentation (IDRTS) method.*

Keywords- *CEST method, Damage detection, Remote Sensing, Texture Segmentation ,VHRS,*

I. INTRODUCTION

Natural hazards have always been associated with disasters and can be understood as an unpredictable acts of nature. To recover from the crisis, one need to determine the extent of damage occurred as early as possible. This makes damage assessment of buildings a critical issue. Here comes the importance of remote sensing that provide wide coverage of the affected area .Now a days, many different types of remote sensing data are available and accordingly various methods are emerging for building damage assessment. Medium resolution satellites such as SPOT, Landsat and ERS can be used and they provide the extent of damage in an affected area. IKONS and Quickbird are the very high resolution satellites available that, deliver the required data at a faster rate.

For building damage detection, the input image obtained using a satellite, has to undergo a number of preprocessing operations. The preprocessed images are then analyzed for detecting the changes that has occurred. As a final step, change maps are created for indicating areas with change/no change. In order to detect the damages, one should have information about the buildings that existed in the area of study before the crisis. Hence to perform damage assessment we need both pre-event image and post-event images acquired by using a suitable satellite.

1.1. Image Preprocessing

As the input to the damage assessment system comprises of two images of the same area taken at different time, angle and may be by different satellites, a number of preprocessing operations has to be performed on both images for removing noise and for better interpretability of the data. The following subsections describe pre-processing operations to be performed before making the change detection decision. Richard J. Radke[1]in his paper has proposed two main preprocessing steps :

1.1.1. Geometric correction: Since the two images of the same scene are taken at different times, from different angle, and/or by different sensors, it is required to geometrically align the two images-the reference and sensed images. Image registration is defined as a process of determining a geometrical transformation that correctly aligns points in one view of an object with the corresponding points in another view of the same object.An ample survey of image registration methods was published by Manjusha P. Deshmukh and Udhav Bhosle[2]. Jim Thomas in his thesis has explained the registration methods consisting of the following four steps: Feature Detection, Feature Matching, Transform Model Estimation, Image Resampling and Transformation

1.1.2. Radiometric/Intensity Adjustments: As change detection requires two different images, intensity variations in images caused by changes in characteristics of light sources in the scene have to be considered to obtain accurate results. There are several techniques that attempt to pre-compensate for illumination variations between images including Intensity Normalization, Homomorphic Filtering ,Speckle Noise removal ,histogram matching etc.

1.2. Damage Interpretation

In order to detect the damaged objects from the remotely sensed images, we need to interpret and analyze the images to identify the target (buildings).This task can be performed manually or may be assisted by image processing techniques. For the human eye, it is very simple to recognize similar objects in two images and to detect change, and also to identify whether it is building or not. Although visual interpretation is a powerful tool and has a high degree of reliability but it is a subjective and time consuming process, which is of critical importance in the time of emergency. Automation could be a way for eliminating the time-consuming procedures, which are usually carried out by human operators. In general, the change detection-based method, are used for identifying changes in the crisis areas.

Change detection is the process of identifying transformations in the state of an object or phenomenon by observing it at different times. Change detection makes use of multitemporal data sets (images before and after the event) to analyze changes. The standard change detection technique available are explained in detail by P.Coppin [3],Hofman[4],D.Lu,E.Moran,P.Mausel[5].

II. IDRTS (INTEGRATED DIFFERENCE RATIO TEXTURE SEGMENTATION) METHOD

As we had already seen that , the existing change detection techniques failed to produce accurate results we propose a change detection technique that uses a combination of the existing change detection techniques here we use a combination of four change detection techniques

A common characteristic of urban area images is the presence of shadows, which depend on the height of the buildings and on the illumination conditions. Tall buildings casts long shadows on relatively small features, such as roads, small buildings, bridges, and trees , thus resulting in loss of radiometric information in the affected areas. This can result in incorrect detection of features or false extraction of buildings.

The proposed shadow detection begins with converting the input image from RGB space to HSV space, since shadow behavior remains invariant in the HSV space. Otsu's thresholding is then performed on the resulting image which produces a binary image showing the shadow regions. For compensating the shadows, the non-shadow area around the shadow region, buffer area, is to be determined which can be obtained using morphological gradient operator. The pixel values in the shadow area can be replaced with either the mean value of the buffer area or the pixel values in the buffer area itself. On the shadow compensated image, geometric registration and radiometric enhancement are performed. Here registration based on normalized correlation is being used followed by histogram matching and Lee filtering for removing speckle noise. The following sections describes the four change detection techniques used in this paper.

2.1. Image Differencing

As we are dealing with manmade objects, initially we have to suppress the background areas, using a suitable thresholding method. Thereafter edge detection is applied on both the images. Since the best results for natural images are obtained by the Canny edge detector ,it is used here. To avoid small registration errors morphological closing is used before subtracting the scenes from each other; afterwards a morphological opening is applied. The resulting images are then subtracted to produce the change map.

2.2. Image Ratioing

During change detection process, there is a chance of misinterpreting rough textured area as debris areas, To manage this situation GLCM feature dissimilarity(DIS) is calculated for the post event image. For debris and for buildings having rough roofs, the DIS value will be very high thus making it difficult to interpret collapsed building by usingonly post event DIS. For handling this situation, both prevent DIS (PR_DIS) and post event DIS (PO_DIS) is calculated. Then, the difference (D_DIS) and ratio (R_DIS) between PR_DIS and PO_DIS are found. Now, the median value of PO_DIS, D_DIS and R_DIS will be serving as the resulting value, Based on this, a change map will be generated.

2.3. Texture Based Change Detection

If edges remain intact, however, textural features may be used for change analysis. For the calculation of texture parameters, we make use of the Haralick features .To highlight edges associated with building collapse and debris, a Laplacian filter was applied to each image. Experimentation indicated that a 9x9 filter was optimal.The GLCM texture features energy is computed. Based on the energy of both the images, change map is generated indicating collapsed and unchanged structures.

2.4. Change Detection based on segmentation

Segmenting an image seems to be an excellent pre-analysis tool, especially for images of very high resolution. Consequently, we developed a segmentation procedure to be used for change detection. The segmentation method that we use here are watershed segmentation method. After an independent segmentation of the images at dates T1 and T2, the segments of T1 are selected and used also for the T2 image. For each segment, the T1-T2 correlation coefficient is calculated. The result is assigned to each pixel in the segment. A new layer with the result of this segmentation is then created. Segments with a high correlation represent no changes. Segments with a low correlation represent changes Each of the above four methods will produce change maps , which can then be combined using the logic of decision tree for obtaining final change map.

III. Experimental Results

IDRTS detection and change map generation methods are now applied to two selected study sites . Red indicates damages in the crisis area and green denotes unchanged structures in the change map.

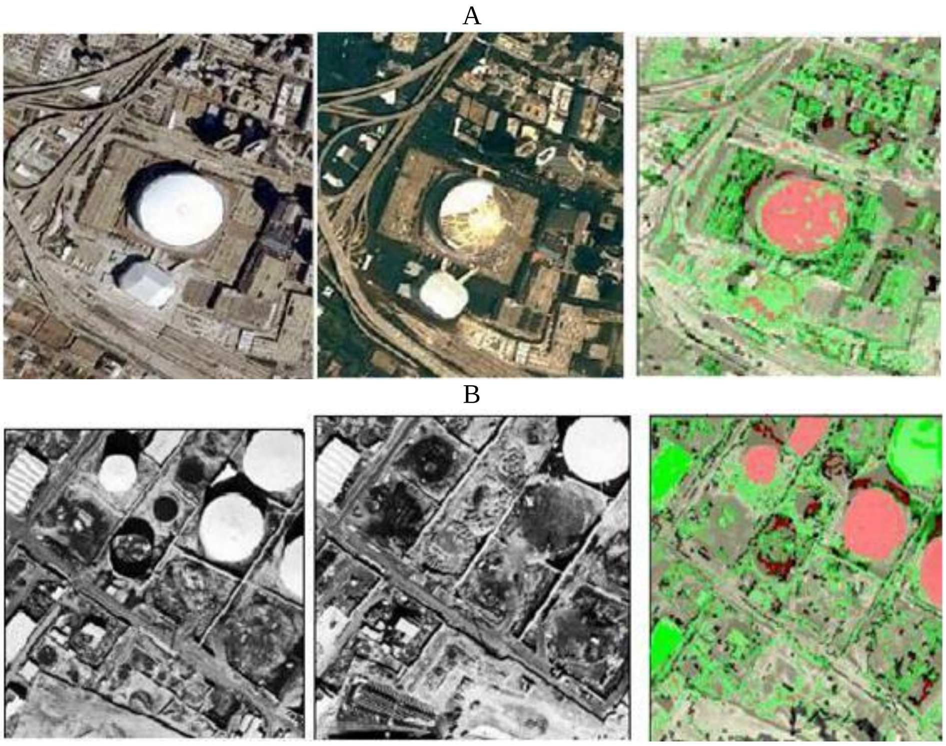

Fig 3.1.a. Pre-event image, b. Post-event image , c.Change Map

3.1 Comparison with existing methods

In the following section, the classification results of the standard methods and the new IDRTS method is presented. The proposed method was tested against image difference, image ratio method and CEST method and the results show that IDRTS method produces better result than existing change detection techniques. Accuracy is calculated by finding True positive rate and false positive rate .

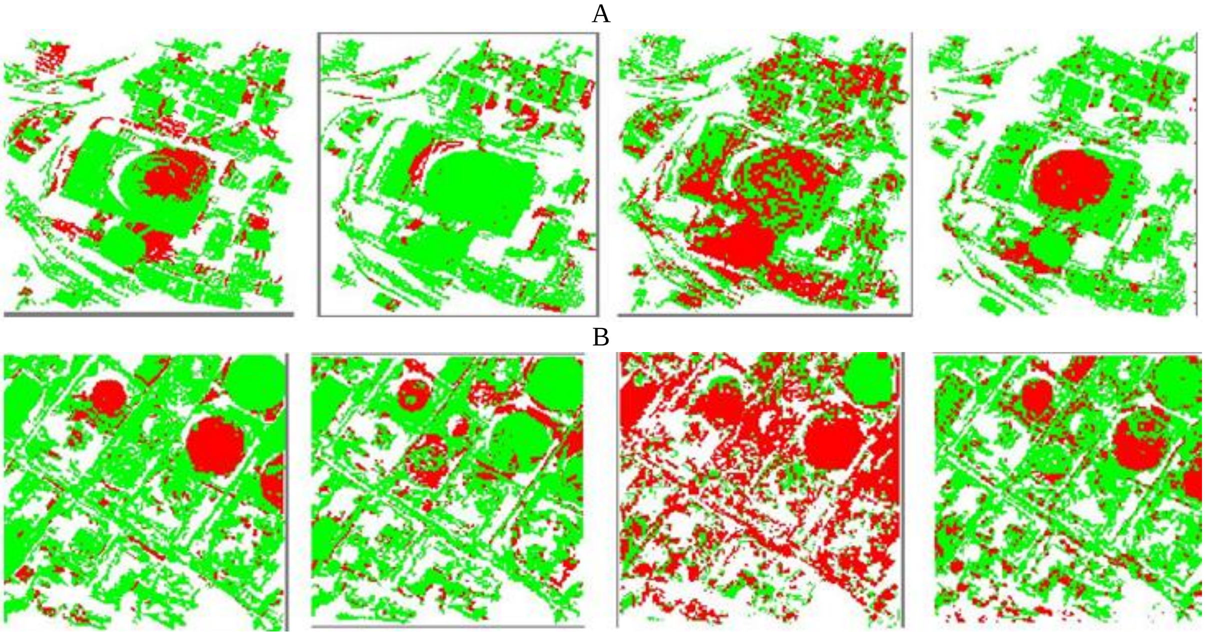

Fig 3.2. a.Image Difference , b.Image Ratio , c.CEST , d.IDRTS method

Fig 3.2a shows the result of applying image difference, ratio,CEST and IDRTS method on Fig.3.1.a respectively. Similarly Fig 3.2.b is obtained by using image Fig 3.1.b. Visual interpretation of the results, reveal that misclassification of buildings are more in the standard techniques. Image difference ,ratio and IDRTS method provided an accuracy of 75% ,70,and 77% respectively. Our IDRTS method provides an accuracy of 86%. Thus ,it is clear that, IDRTS provides better damage detection.

IV. CONCLUSION

Damage assessment, following a major disaster is often conducted using satellite images. This assessment must be conducted rapidly after the disaster, to help rescue teams and local government. The automatic damage detection system is reliable and could be used in emergency situations. It could also be combined with manual visual interpretation to accelerate the planning of humanitarian rescues and reconstruction.

In this paper, a new method that uses a combination of existing change detection techniques is used for detection of damage structures in crisis areas. Furthermore, the preprocessing step includes shadow detection and compensation , thus providing correct extraction of building . The new method is compared with differencing , ratioing and CEST method and the results were quite encouraging. An overall accuracy of 86% was computed for our method. Obtained results prove the ability of proposed method in damage detection.

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