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Automated unsupervised change detection technique from RGB color image

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Abstract. Change detection is an important process for many applications such as monitoring the effects of environmental hazards, landslides, rock fall and city development projects. RGB images are commonly used as commercial sources of data for monitoring changes visually because they have powerful descriptive information for different features. Automation of detected changes from two RGB images is a challenge because the two images are usually captured in different environments, as temperature, sun angle, clouds, capturing time …etc. The objective of this research is to introduce an automated technique for detecting changes from RGB image based on color channels. The image pixel is represented as a set of its color channels values, R, G and B which is called color signature of image pixel. A real data is used to fulfil the research objective without pre-knowledge about the changes. The correlation coefficients are calculated between color signatures of each two associated pixels from two different registered high resolution satellite images for the same area of study. The detected pixels of changes are identified based on specific correlation value that is identified based on degree of change sensitivity. The degree of sensitivity is based on the importance of detection procedure that is considered as a main part of decision making for risk and crisis management system. The proposed technique is unsupervised and fully automated. It can be applied through a real time process based on the processing capabilities, size and resolution of input images. This technique is easy to use and gives accurate results with neglecting the effects of atmospheric effects.

1. Introduction

An RGB image is composed of three color channels red, green and blue that produce powerful An RGB image is composed of three color channels red, green and blue that produce powerful feature descriptive of different features, which can be identified visually from RGB images. All color channels have the same dimension, number of rows, and number of columns. Mathematically, an RGB image is represented as a matrix of dimension 1000 x 1000 x 3 [1, 2]. Change detection is the process of detecting changes that are happened in the area of interest due to natural or industrial effects. The change detection is a post processing mission that is applied on images of interested area that are captured in different times. The change detection technique has to be insensitive to illumination brightness changes[3]. The pixel based change detection algorithms need pre-processing methods as image registration and radiometric corrections. Image registration is useful to rapid search for the two conjugate pixels in input images. Radiometric correction can be performed using many techniques and it needs more computations[4]. These conditions represent the motivation of investigating change detection technique that is represented in this research paper. There are many techniques used in detecting changes from RGB and high resolution images based on data image pixel without need of extracting features or objects [4-8]. Hayes and Sader, 2001 investigated the Normalized Difference Vegetation Index from RGB Image (RGB-NDVI) as an accurate pixel based representation for monitoring tropical forest clearing and vegetation regrowth [5]. Pacifici and Frate, 2010 investigated an unsupervised change detection approach based on Pulse-Coupled Neural Networks (PCNN) algorithm. The changes are detected by calculating the correlation between the image signatures of two images that are captured at different times. Although, this approach is not sensitive to scale or orientation of input images. The changes are detected as a global change for whole image that means the image has changes or not [7]. Minu and Shetty, 2015 introduced a comparative study among four different change detection algorithms in MATLAB, Image Differencing, Image Ratioing (IDIR), Change Vector Analysis (CVA), Tasseled Cap Transformation (TCT) and Principal Component Analysis (PCA) [8]. There are different techniques for change detection based on image segmentation and object classification [9-12]. Lou et.al, 2002 proposed an algorithm based on classification of image into background and foreground. It needs more techniques, classification and segmentation of image pixels to be able to detect changes [13]. Knudsen and Olsen, 2003 proposed a change detection algorithm of updating database of digital map. The proposed algorithm has limitations of detecting buildings with felt roof covered that could not be distinguished from roads [10]. Olsen, 2004 enhanced the previous method and presented a change detection method for updating maps but the research failed in detecting building with roof tops that have not specific color bands [11]. Domenech and Mallet, 2014 introduced a change detection technique for updating Land Use/Land Cover (LULC) database. This technique needs spatial information for the area of study from Light Detection and Ranging (LiDAR) data [12]. Adak, 2014 introduced a change detection technique based on rough clustering of the image pixels. The proposed technique gives acceptable results when it was applying on different aerial, satellite, X-ray and medical images [14]. There are different change detection techniques based on a combination between pixel and object based methods [15, 16]. Desclée et al, 2006 introduced an approach from a combination of multiple image analysis techniques as, image segmentation, image differencing and analysis of multi spectral signals to extract object reflectance. OB-Reflectance method gives results more slightly accurate than RGB-NDVI pixel based method for forest change detection application [15]. Ehlers et al, 2012 introduces a fast change detection technique based on combination of texture analysis in frequency domain and edge detection in spatial domain. The proposed technique tested the correlation of detected edges added with frequency correlations to the decision tree to detect changes [16]. There is no algorithm based on considering DN of an image pixel as a set of independent observations. The three color channels values, R, G and B, is the base of this research paper. The proposed change detection technique in this research paper is not based on any of the previous techniques. The change detection technique is based on an investigating of correlation between two data sets of color channels' values of each pixel in the input image of the study area and the conjugate one in the other registered image of the same study area. The implementation of the research algorithm for data processing, testing and validating the proposed change detection technique is executed through MATLAB environment using real data which are two high resolution satellite images captured from IKONOS satellite sensor without knowledge about the circumstances during the process of capturing images.

2. The Proposed Methodology

The objective of the proposed technique is to investigate the change detection based on applying statistical analysis on color channels of RGB image. The first step of the proposed algorithm is to separate the RGB image to its preliminary components, red color channel, green color channel and blue color channel to extract color signature of each pixel in the RGB image. The correlation coefficient between each pixel in the first image and the conjugate one in the other input image is calculated. The statistical analysis is applied on the correlation coefficient results to identify the number and locations of pixels with respect to their degree of correlation. Image of change detection is produced to show the positions of pixels of changed features in the area of study. 'figure 1', shows the schematic diagram of the work flow of the proposed technique.

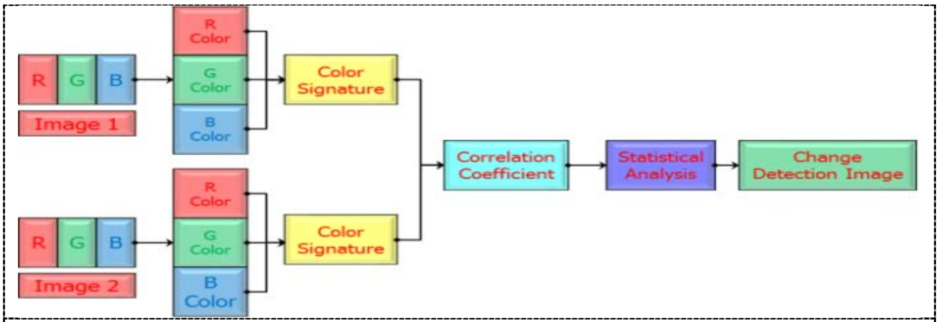

Figure 1. Work Flow of Research Algorithm.

2.1. Correlation Among Color Signatures Of Pixels

The color signature of a pixel is represented as a set of independent observations of R, G and B color channels as shown 'as in equation (1)'.

$$\mathrm{Colorsig} = [\mathrm{R.G.B}] \quad (1)$$

where:

Colorsig = color signature of pixel
R, G, B = color channels of the pixel

The correlation coefficient between any two sets of random observations can be determined by using the mathematical model that is represented 'as in equation (2)' [17-20].

$$C_{f1f2} = \frac{\sigma_{f1f2}}{\sigma_{f1} * \sigma_{f2}} \quad (2)$$

where:

C_{f1f2} = correlation coefficient between two sets f1 and f2
σ_{f1f2} = covariance of two sets f1 and f2
σ_{f1} = standard deviation of set f1
σ_{f2} = standard deviation of set f2

3. Area Of Study

The available real data for the area of study are two images that are captured in different times. 'figure 2', shows the first Image of the study area that is captured at 12/02/2004. 'figure 3', shows the second Image for the same area of study that is captured at 19/9/2006. There is no data about the capturing environment for each image. Examples of some differences are appeared between two images by visual inspection as shown.

Figure 2. First Image.

Figure 3. Second Image.

4. Experimental Results

Correlation coefficient represents the degree of correlation between each two pixels of same coordinates in the two images. The image pixels can be classified into five classes, strong correlation, high correlation, medium correlation, weak correlation and very weak correlation. (table 1, shows the relation between pixel classes and the calculated correlation coefficients).

Table 1. Relation between Classes and Correlation Coefficients.

Pixel Class	Correlation Coefficient
Strong Correlation	(91 – 100) %
High Correlation	(76 – 90) %
Medium Correlation	(51 – 75) %
Weak Correlation	(31 – 50) %

The proposed change detection technique is applied on the available real data sets. The color signature of each pixel is extracted and the correlation between each two conjugate pixels in the two images with same coordinates is calculated. Changes can be detected from classified image for all pixels that give correlation coefficients not equals to 1. The required application controls the threshold values that indicate the degree of sensitivity for identifying pixels that can be taken in consideration as changed pixels. (table 2, shows the relations among the thresholding values and different degrees of sensitivity). ‘figure 4’, shows the image classification based on pixel correlations.

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Table 2. Relations among Degree of Sensitivity and Thresholding Values.

Degree of Sensitivity	Thresholding Value
1st Degree	30 %
2nd Degree	50 %
3rd Degree	75 %
4th Degree	90 %

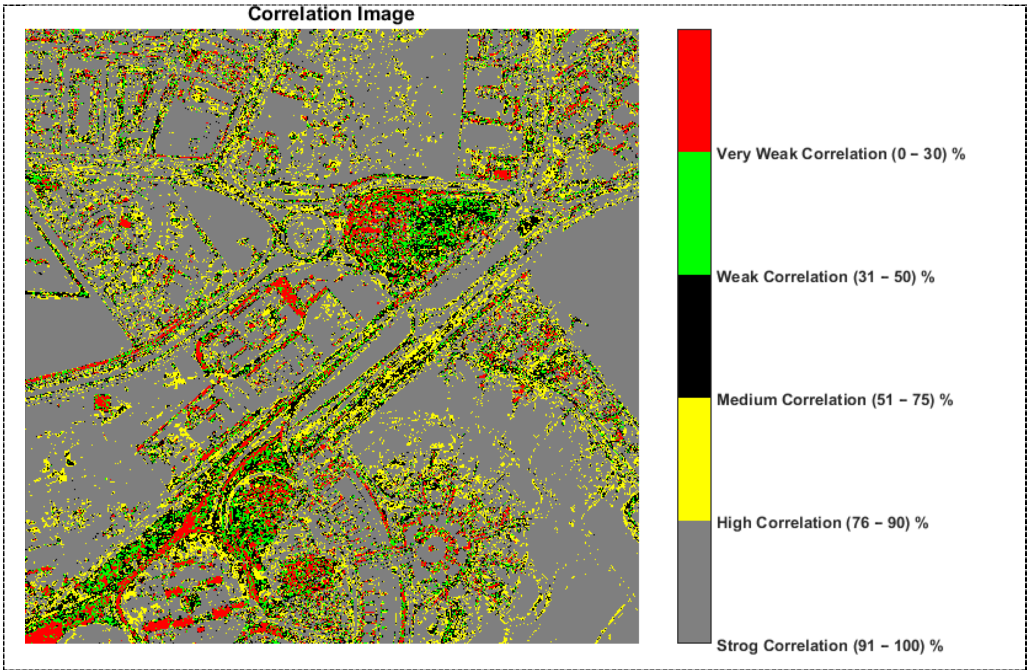

Figure 4. Classified image based on pixel correlation.

The target of this paper is to assess the efficiency of the proposed technique for change detection that will be suitable for many applications. The proposed change detection is applied for different degrees of sensitivity. The change detection results are represented on an image that shows the locations of pixels that are affected by changing on their color signatures. The image of changes contains only two colors, red and green. Red color represents the pixels of no changes, while the green color represents the pixels that have changes. (table 3, lists the number of detected pixels and its percentage of changes from the image of the study area in all degrees of sensitivity). 'figure 5', 'figure 7', 'figure 9', 'figure 11', shows the Images of Change at different degree of sensitivity. 'figure 6', 'figure 8', 'figure 10', 'figure 12', shows the detected features from images of change at different degree of sensitivity.

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Table 3. Number of Detected Pixels.

Degree of Sensitivity	Number of Detected Pixels	Percentage from Area
1st Degree	57680	5.768 %
2nd Degree	114167	11.4167 %
3rd Degree	223417	22.3417 %
4th Degree	370000	37.00 %

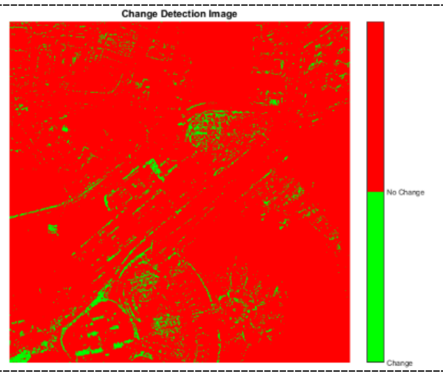

Figure 5. Image of Changes in First Degree of Sensitivity.

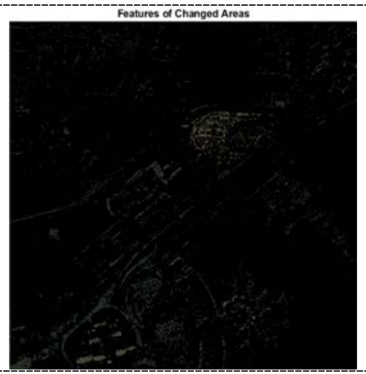

Figure 6. RGB Image for Detected Features in Area of Study in First Degree of Sensitivity.

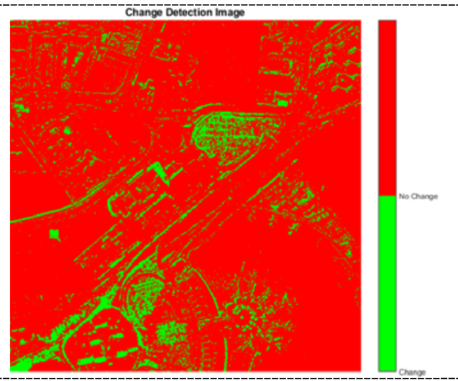

Figure 7. Image of Changes in Second Degree of Sensitivity.

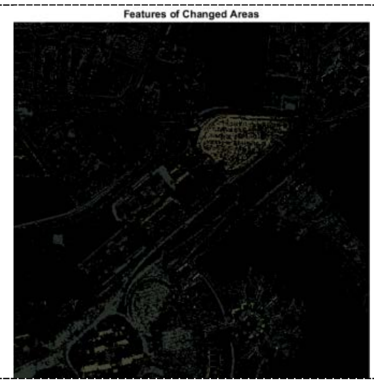

Figure 8. RGB Image for Detected Features in Area of Study in Second Degree of Sensitivity.

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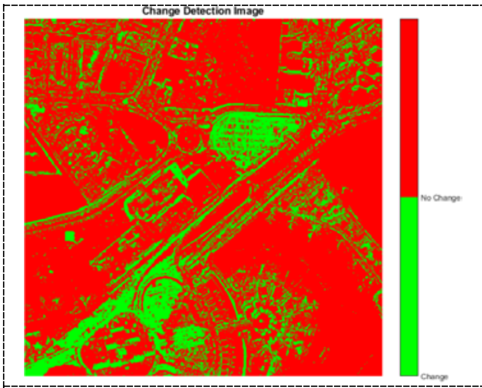

Figure 9. Image of Changes in Third Degree of Sensitivity.

Figure 10. RGB Image for Detected Features in Area of Study in Third Degree of Sensitivity.

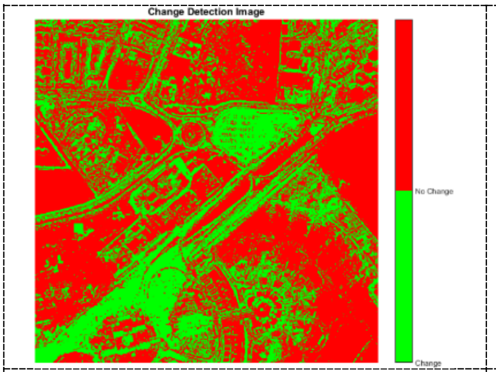

Figure 11. Image of Changes in Fourth Degree of Sensitivity.

Figure 12. RGB Image for Detected Features in Area of Study in Fourth Degree of Sensitivity.

All color channels were affected by same environment at the same time which can be mathematically represented as the set of color signature of each pixel multiplied by a constant. This condition will not affect the value of correlation coefficient. Then, the proposed change detection technique can detect changes between two images with accurate results without need of environment, brightness or contrast information. Shows the changes between two images by selecting any points and show the spectral changes that happened. 'figure 13', show the pixel coordinate for selecting point that belongs the First Image. 'figure 14', show the pixel coordinate for selecting point that belongs the Second Image.

'figure 15', show the spectral plot at point (494, 467) in the First Image. 'figure 16', show the spectral plot at point (494, 467) in the Second Image.

Figure 13. Pixel Coordinate at point (494, 467) for First Image.

Figure 14. Pixel Coordinate at point (494, 467) for Second Image.

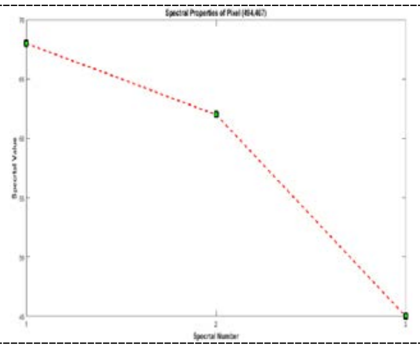

Figure 15. Spectral plot at point (494, 467) for First Image.

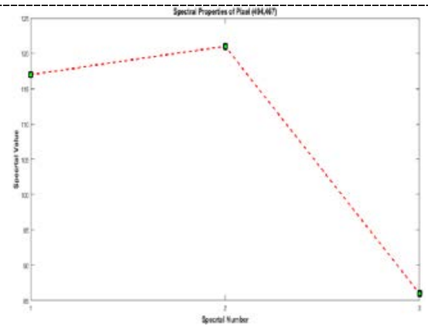

Figure 16. Spectral plot at point (494, 467) for Second Image.

5. Conclusion

RGB images may be captured in different environments and their contrast is commonly different. Color signature of image pixel is considered as a suitable representation for change detection from RGB image. The correlation coefficients are used to detect locations of changed pixels and then identifying the features in the input images. Correlation coefficients are used to define different degrees of change detection sensitivity based on specific application, targets, required mission or accuracy of required measurements. The degrees of sensitivity can be considered as a base of establishing risk management system that can be used for detecting and monitoring the effects of environmental hazards as floods and earthquakes. The investigated change detection technique is automated, unsupervised and fast. Thus, the proposed change detection technique can be used as a real time.

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