Development of Method for Change Detection Based on Information Fusion for PALSAR-2 Data

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Abstract

This paper presents an approach for change detection which helps in detecting change information to achieve final change map. The different techniques are available to generate difference image but there is a need to explore a technique for threshold detection. Therefore, the work presented in this paper explored Expectation Maximization (EM) algorithm which is used for threshold selection for change detection map. Further, information fusion is performed in the approach to achieve resultant fused change map. The proposed algorithm is implemented on fully polarimetric PALSAR-2 data.

1. Introduction

Fully polarimetric SAR data is well known for providing its applications in various areas among which change detection is one of the major application. Change detection map itself has so many applications that include environment monitoring, land use and land cover change, and other environmental changes [1]. In the literature, several change detection techniques have been reported [2,3,4,5].

Various combinations of difference image method and thresholding methods exist but there is no existing optimal approach for all cases [6]. Difference image is rich in information and the selection of one of the difference image is a difficult task. Hence, information fusion is performed in the approach adopted in the paper. The main objective of image fusion is to extract more relevant information from individual images and thus leads to better interpretation of fused image. The methods exist in the literature [7,8,9,10] require ground truth information and manual threshold selection making the algorithm unsupervised. Therefore, in the present work, a simple method is employed for fusion of change information achieved by two different change detection methods. It is used to generate a fused change map having confidence for "change" and "no-change" pixels. The proposed approach mainly comprises of two steps. First, Expectation Maximization (EM) algorithm is used for automatically selecting threshold for change detection map after that information obtained from individual techniques is used to achieve final change detection map which gives confidence for "change" and "no-change" pixels.

This paper organizes as follows: Section 2 provides a brief description about the test site and data used in the study. Theoretical background and, development of proposed change detection have been discussed in Section 3. Section 4 consists of proposed approach. Implementation and discussion is given in Section 5. Final conclusion is given in Section 6.

2. Study Area and Data Used

The study was carried out in the Roorkee region in the state of Uttarakhand, India. The work has been performed on the PALSAR -2 L-band fully polarimetric data. Two data sets are used for work. The first data was acquired on 13th March, 2015 and second data was acquired on 25th march 2016.

3. Theoretical Background and Algorithm Development

3.1. Change Detection

As per definition given in the paper [1], “Change detection is the process of identifying the change and no-change pixels in the pair of satellite images of same scene acquired at two different times.” Simple mathematical operations are used to create the difference image. Threshold is then determined manually or automatically to get the change map from the difference image. Changes between the two input images are shown by setting the pixel of that particular area in change map to 1. All other remaining pixels are set to 0. Two change detection techniques are applied in this paper namely, image differencing and post-classification comparison. In Image Differencing, simple pixel based subtraction is performed on two multi-temporal images [11]. This method is quite simple, easy to implement and interpret, and straightforward. But, this method is not able to provide complete change information in terms of change matrix which limits the use of this type of change detection method. This technique requires some threshold criteria to identify the changed areas. Next, Post-Classification comparison deals with the comparison of two or more independent classified images of same scene acquired at different times. There is no need to apply thresholding technique to detect change and no-change pixels.

3.2. Proposed Adaptive Threshold Selection

The change detection method give the difference image as output but pixel value of difference image gives the quantity of change between input images. Therefore, there is a need to make threshold which helps in neglecting small pixel values as change pixels. This paper deals with the automatic selection of threshold for which Expectation maximization (EM) technique is used [2]. It estimates the parameter iteratively and does not require manual setting and empirical changes of parameters. This reduces the probability of human error and makes the approach fully automatic. It is the basic technique of automatic thresholding hence it is widely used. Another advantage of the technique is that it does not require any prior knowledge of input data. It overcomes the difficulty of manual assessment of vast area. EM algorithm can be used to select the threshold automatically for the difference image classification. This algorithm is based on Bayes rule. It assumes that the pixels are independent of one another and the difference image can be modeled using unimodal Gaussian curve.

3.3. Information Fusion

All change detection techniques have different outputs except some common changed pixels [12]. Information obtained from individual techniques is used to achieve final change detection map for “change” and "no-change" pixels. In this work, a simple fusion approach is applied for information fusion to obtain good results. It is used to generate a fused change map which gives confidence for “change” pixels.

4. Proposed Methodology

Figure 1 shows the architecture of proposed framework. For the development of algorithm, some pre-processing steps are performed on the data [13]. Change map is represented as “CM” in Figure 1. In the change map, created after EM algorithm application, changed pixels are represented by 1 and no-change pixels by 0. Then, these change maps are combined using fusion of information obtained from each individual change map which gives the final binary change map.

5. Results and Discussions

5.1. Implementation of algorithm on test image

The proposed methodology as discussed in Section 4 is implemented on PALSAR-2 data of date 13th march 2015 and 25th march 2016. The implementation steps are discussed in this section. The 1800×1800 size of image is used for experiment containing 3240000 pixels.

Step 1. After image pre-processing, difference images are calculated by image differencing and post-classification comparison techniques.

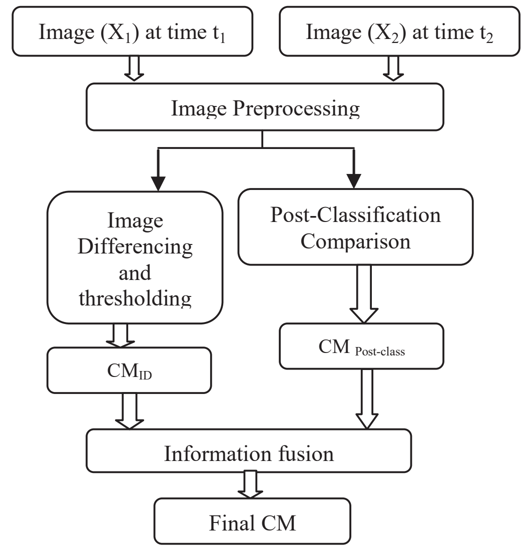

Figure 1. Architecture of proposed framework

Step 2. EM algorithm is applied on change map calculated from image differencing to estimate the threshold. All the values of difference image above the threshold value are assigned to change class and the values below the threshold are assigned to no-change class. In Post Classification Comparison, there is no need to apply threshold value, only subtract two classified images which shows the results of change and no change pixels[14].

Step 3. The percentage of no-change pixels and change pixels obtained from image differencing technique is 84.801% and 15.199% respectively. The resultant output image obtained by applying image differencing technique is shown in Figure 2.

Step 4. The percentage of no-change pixels and change pixels obtained from post-classification comparison technique is 68.91% and 31.09% respectively. The resultant output image obtained by applying image differencing technique is shown in Figure 3.

Step 5. Then after fusing, the resultant no-change pixels and change pixels are 84.91% and 15.08% respectively. The resultant output image obtained by applying information fusion is shown in Figure 4.

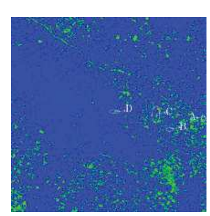

Figure 2. Output Image after applying Image Differencing

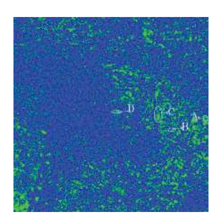

Figure 3. Output Image after applying Post-Classification

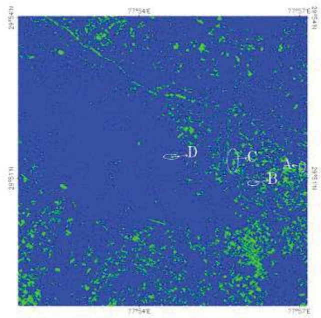

Figure 4. Resulting Output Image applying Information Fusion

The areas marked (areas A,B,C,and D) in the Figures 2, Figure 3, Figure 4 are the common areas which show change and no-change areas in all three images.

5.2. Validation of Algorithm

The validation has been performed on different regions of same data of date 13^{th} march 2015 and 25^{th} march 2016. The same steps are followed for validation as done in implementation step (section 5.1). The results are quite satisfactory.

6. Conclusion

In this work, an unsupervised approach for change detection has been proposed. The proposed approach creates the change map automatically with change and no-change pixels. The paper also presents an Information Fusion approach which is helpful in removing the difficulty of selection of one type of change detection technique. In this work, Expectation maximization technique has been used for automatic thresholding and information fusion is applied for data fusion. Final fused change map shows higher confidence in revealing the change and no-change pixels.

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8. References

1. A. Singh, "Review article digital change detection techniques using remotely-sensed data" International journal of remote sensing, 10(6), 1989, pp.989-1003.

2. L. Bruzzone, and D.F. Prieto, "Automatic analysis of the difference image for unsupervised change detection" IEEE Transactions on Geoscience and Remote sensing, 38(3), 2000, pp.1171-1182.

3. A.K. Helmy, and G.S. El-Taweel, "Neural network change detection model for satellite images using textural and spectral characteristics" American Journal of Engineering and Applied Sciences, 3(4) , 2010, pp.604-610.

4. B. Demir, F. Bovolo, and L. Bruzzone, " Detection of land-cover transitions in multitemporal remote sensing images with active-learning-based compound classification" IEEE Transactions on Geoscience and Remote Sensing, 50(5), 2012, pp.1930-1941.

5. H. Sahbi, "Interactive Satellite Image Change Detection With Context-Aware Canonical Correlation Analysis" IEEE Geoscience and Remote Sensing Letters, 14(5), 2017, pp.607-611.

6. D. Lu, P. Mausel, E. Brondizio, and E. Moran, "Change detection techniques" International journal of remote sensing, 25(12), 2004, pp.2365-2401.

7. T. Celik, "Change detection in satellite images using a genetic algorithm approach" IEEE Geoscience and Remote Sensing Letters, 7(2), 2010,pp.386-390.

8. T. Celik, and K.K. Ma, "Unsupervised change detection for satellite images using dual-tree complex wavelet transform" IEEE Transactions on Geoscience and Remote Sensing, 48(3), 2010, pp.1199-1210.

9. Z. Yetgin, "Unsupervised change detection of satellite images using local gradual descent" IEEE Transactions on Geoscience and Remote Sensing, 50(5), 2012, pp.1919-1929.

10. F. Bovolo, L. Bruzzone, and M. Marconcini, "A novel approach to unsupervised change detection based on a semisupervised SVM and a similarity measure" IEEE Transactions on Geoscience and Remote Sensing, 46(7), 2008, pp.2070-2082.

11. M. İlsever, and C. Ünsalan, "Pixel-based change detection methods. In Two-Dimensional Change Detection Methods",2012, (pp. 7-21). Springer London.

12. M. Hussain, D. Chen, A. Cheng, H. Wei, and D.Stanley, "Change detection from remotely sensed images: From pixel-based to object-based approaches" ISPRS Journal of Photogrammetry and Remote Sensing, 80, 2013, pp.91-106.

13. P. Mishra, D. Singh, and Y. Yamaguchi, “ Land cover classification of PALSAR images by knowledge based decision tree classifier and supervised classifiers based on SAR observables” Progress In Electromagnetics Research B,30,2011,pp- 47-70.

14. A.Jain, “SAR data analysis for land cover classification and soil moisture retrieval”, Ph.D. thesis , IIT Roorkee , 2017.