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SAR IMAGES CHANGE DETECTION BASED ON ADWT TECHNIQUE USING MFO ALGORITHM

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ABSTRACT- In this article a novel technique is introducing for performing the image fusion. As it is very familiar that more image information could be brought up by using image fusion process. Filter coefficients have been chosen in the DWT (Discrete Wavelet Transform) filter bank to perform DWT through optimization algorithm. The process of selecting filter coefficients through optimization process is known as ADWT (Adaptive Discrete Wavelet Transform). In this regard, satellite images with active sensor have been employed where these images are captured at same geo location but at different timings. Consequently, by satisfying the orthonormal properties filter coefficients have been chosen through Math-Flame Optimization (MFO) Algorithm. After performing the image fusion based on DWT by using optimized filter coefficients, the resultant image has been segmented with FCM-Clustering technique. Segmented image compared with the ground truth image. In this process input images are merged based on Particle Swarm Optimization (PSO) algorithm, Math-Flame Optimization (MFO) and Ant Lion Optimization Algorithm (ALO). Finally, the effectiveness of the proposed method is measured in terms of sensitivity, precision, selectivity, FDR and Accuracy.

Key words: ADWT, DWT, PSO, ALO, MFO, MSE and PSNR

I. INTRODUCTION

Synthetic Aperture Radar (SAR) is most versatile sensor for Earth monitoring based on remote sensing applications. It generates the images of objects irrespective of atmospheric conditions so that earth surface can be monitored in any weather conditions. Image fusion is the process to extract much information from two or more images. In this regard, DWT has been selected to perform image fusion by optimally selecting the filter coefficients through the optimization algorithms. The process of selecting optimum selection of filter coefficients is called as Adaptive Discrete Wavelet Transform (ADWT) [1-4] and the constrain is satisfaction of orthonormal properties of the filter coefficients. In this process, two SAR images have been taken and performed image fusion through 2D-ADWT process. The original will be reconstructed from the Inverse Discrete Wavelet Transform (IDWT) [5-8]. FCM clustering has been employed to perform segmentation. The performance of proposed 2D- ADWT (through MFO Algorithm) is compared with other optimization algorithms such as Particle Swarm Optimization (PSO) algorithm and Ant Lion Optimization Algorithm (ALO). In the last segmented image and ground truth images are compared, the performance of proposed method is measured and compared with other optimization algorithms.

II. RESEARCH METHODOLOGY

Generally, SAR sensor suffers with the speckle noise due to effect of target area, target location and atmospheric conditions at the target. Noise could be reduced by using image fusion based on DWT but information might be lost in the process. Meanwhile, by optimizing the filter coefficients in DWT process noise could be reduced. Consequently, optimization algorithms have been employed to select optimal filter coefficients.

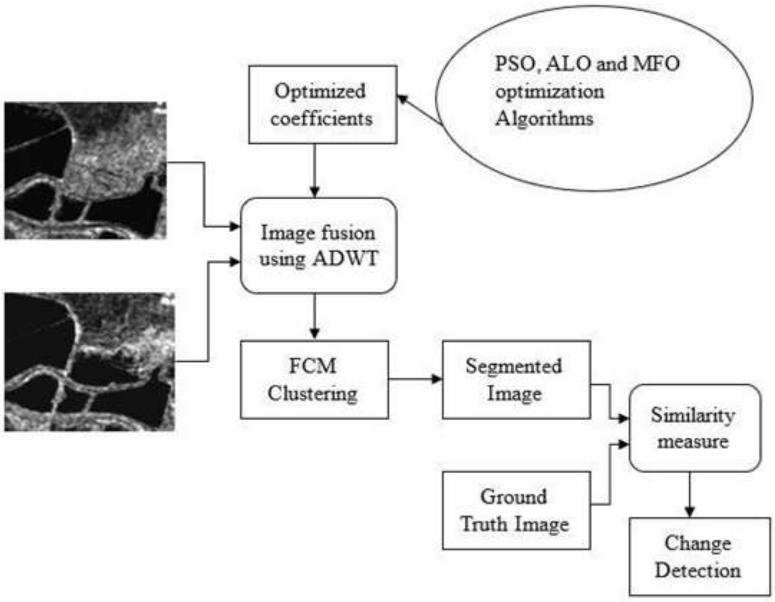


Fig.1. Block diagram of Proposed Model

Fig.1. shows the proposing model of this research article, in this regard two SAR images have been applied to 2D-ADWT

III. SYNTHETIC APERTURE RADAR (SAR):

SAR is one of the sensors which are employed in remote sensing applications for monitoring the Earth remotely. SAR is known as active sensor due to its self-illumination and it can generate the images of the Earth surface [11-15] irrespective of the atmospheric conditions. The basic phenomenon in generating the images using SAR sensors is capturing the reflected signal from the target and processing it to generate images. From the principal radiation mechanism of the EM (Electro Magnetic) wave when the EM wave hit the target with certain frequency and amplitude, the amplitude of the reflected signal will be affected owing to properties of that object or target. Mainly the amplitude of the signal will be deviated from its original amplitude based on the dielectric constant, shape and location of that object [16-22]. SAR polarimetry uses a scattering matrix (R) to identify the scattering behaviour of objects after an interaction with electromagnetic wave. Matrix R represented by eq (1)

$$\text{scattering matrix} = R = \begin{bmatrix} R_{HH} & R_{HV} \\ R_{VH} & R_{VV} \end{bmatrix} \quad (1)$$

where

R_{HH} represents transmitted signal in horizontal direction and received in horizontal direction

R_{HV} represents transmitted signal in horizontal direction and received in vertical direction

R_{VH} represents transmitted signal in vertical direction and received in horizontal direction

R_{VV} represents transmitted signal in vertical direction and received in vertical direction

The Pauli colour coding is applied for the captured signals and assigning of primary colours to the reflected signals is expresses in eq (2).

$$R = |HH - VV|, \quad G = 2|HV|, \quad B = |HH + VV| \qquad (2)$$

IV. IMAGE FUSION

Image fusion is the strategy of merging the required information of two or more source images into a last intertwined image [9-10]. Resultant image would be much effective and point by point when compared to any of the input images. By the strategy image fusion, the incredible information from each of the given image is melded. Basically, four types of image fusion technique have been opted by many researchers those are given as follows

a) Multi-view Image Fusion

This frame of image fusion incorporate combination of two or more source images that are takes at the same time which have that same methodology but distinctive source images are to be taken from different places or completely different foundation conditions.

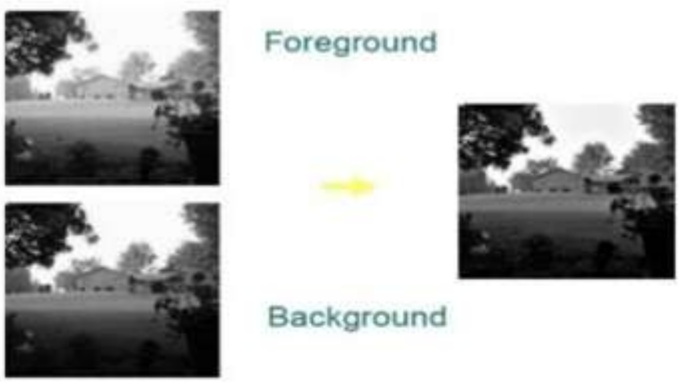


Fig.1. Representation of Multi-view Image Fusion

b) Multimodal Fusion

This type of fusion uses two or more images that includes different modalities and the object. Mostly this kind of fusion uses in Bio-Medical applications such as MRI, CT scan.

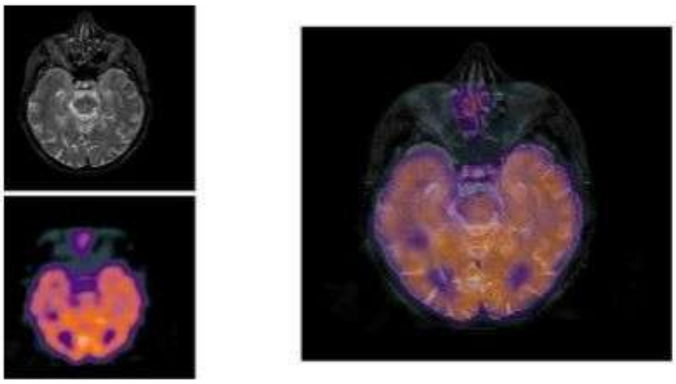


Fig.2. Representation of Multimodal Fusion

c) Multi-temporal Fusion:

This type of fusion uses two or more images that captures the same object at different timings. Mostly this kind of fusion uses in remote sensing applications such as SAR image processing.

Fig.3. Representation of Multi-temporal Fusion

d) Multi-focus Fusion: this type of fusion will be performed by two or more source images where each source image is divided into areas such that every pixel is in focus at least in any one of the source images.

V. PROPOSED ADWT WITH MFO OPTIMIZATION ALGORITHM:

5.1 Adaptive Discrete Wavelet Transform (DWT)

It is well known fact that the maximum content could be extracted from two or more images by using image fusion process. This fusion process could be performed using DWT (Discrete wavelet transform). Where DWT represents the image in terms of both time domain and frequency domain. Some information might be lost in DWT process and this could be due to quantization, encoding and in the conversion process (ADC OR DAC). In this process choosing of filter coefficients in an adaptive manner is called as Adaptive Discrete wavelet Transform [1-5]. Fig.4. illustrates the process of performing single level 2D-ADWT with optimization algorithms.

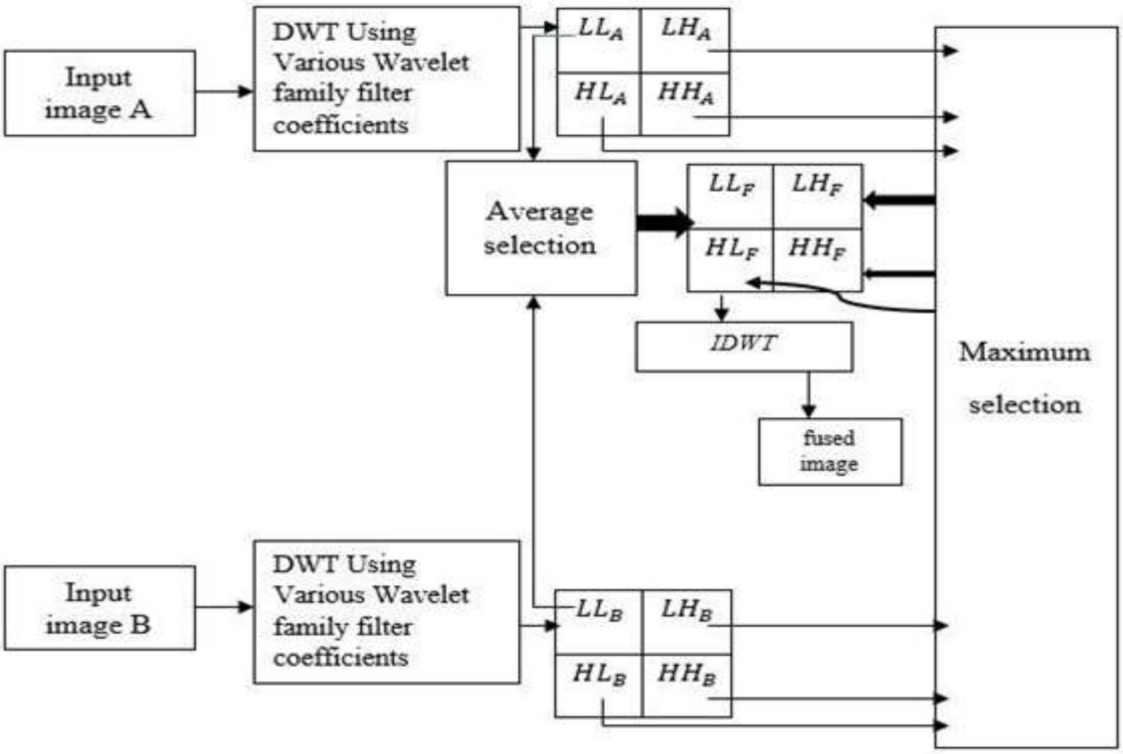


Fig.4. 2D-ADWT architecture with optimized filter coefficients

As illustrated in fig.4 two input images are fused based on DWT where filters are chosen optimally through optimization algorithms such as PSO, ALO and MFO optimization algorithms. Generally, the outcome images of image fusion consist of approximation content, vertical information, horizontal information and diagonal information. Consequently, the output image is average of approximation images, maximum selection of vertical, horizontal and diagonal images.

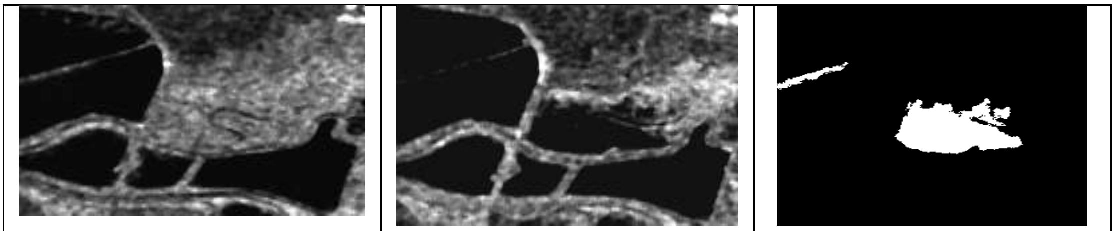
VI. RESULTS AND DISCUSSIONS

Two images have been tested to verify the proposed algorithm and these images have been capture in 2003 by ERS-2 at the area of San Francisco Bay in United States OF America.

6.1 Technical Information of data images capture by ERS-2

- Instrument: Synthetic Aperture Radar (SAR)
- Dates of Acquisition: Red: 3 November 2002, Green: 10 August 2003, Blue: 16 May 2004
- Frame: 747
- Orbit numbers: 39410, 43418, 47426
- Instrument features: 25-meter resolution, precision radar image
- Coordinates:

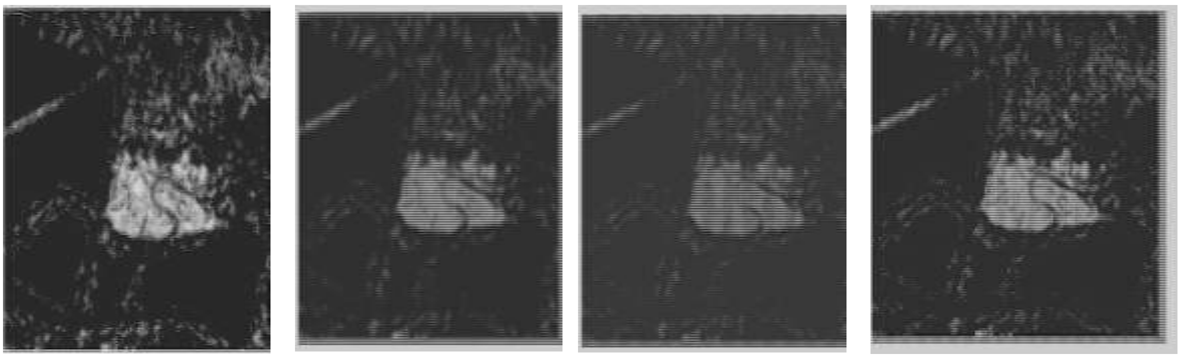
NE Lat/Long: N 38.11 / W 121.41 NW Lat/Long: N 38.00 / W 122.46



a. Pre image	b. After image	c. Ground truth image

Fig.5. Data images a) pre-image b) after image c) ground truth image

As illustrated in fig.5. it shows the pre image and after image, after image represents the image acquired in San Francisco Bay after irrigation. Fig.5.a shows the image before irrigation takes place and fig.b. shows the image after irrigation takes place and fig.c. shows the ground truth image which represents the corresponding changes in the pre image.



(a) (b) (c) (d)

Fig.6. Fused Images a) ADWT b) ADWT_PSO c) ADWT_ALO d) ADWT_MFO

Fig.6. represents the output images of ADWT with optimization algorithms (PSO, ALO and MFO).

(a) (b) (c) (d)

Fig.7. (a) FCM_DWT (b) FCM_ADWTPSO (c) FCM_ADWTALO (d) FCM_ADWTMFO

Fig.7. Represents the segmented images of the fusion images. These images are clustered images of fusion images of DWT, ADWT with PSO optimization algorithm, ADWT with ALO optimization algorithm and ADWT with MFO algorithm respectively. These images are compared with ground truth image and performance is measured and the corresponding results have been shown in Table1.

Measure	FCM_DWT	Using ADWT		
		FCM_PSO	FCM_ALO	FCM_MFO
F1-score	0.0517	0.0033	0.0038	0.0484
accuracy	0.9496	0.9507	0.9549	0.9660
sensitivity	0.0240	0.0029	0.0133	0.0373
specificity	0.9632	0.9625	0.9632	0.9641
precision	0.0656	0.0079	0.0126	0.0648
FPR	0.0068	0.0075	0.0068	0.0059
FNR	0.9560	0.9951	0.9897	0.9527
FDR	0.9932	0.9925	0.9932	0.9941
NPV	0.9144	0.9921	0.9874	0.9352
MCC	0.0581	0.0060	0.0113	0.0547

Table 1. Performance Analysis of proposed algorithm with existing algorithms

To validate the proposed technique three types of optimization algorithms have been employed for ADWT and Daubechies2 wavelet coefficients have been used to perform normal DWT process. As illustrated in table 1 the proposed technique FCM_MFO has better accuracy of 1.11 % ,1.53% and 1.64% over FCM_ALO, FCM_PSO and FCM_DWT. In terms of sensitivity the proposed FCM_PSO has proven betterment of 2.4%, 3.4% and 1.3% over FCM_ALO, FCM_PSO and FCM_DWT. FCM_MFO is given better result in terms of specificity of 0.09%, 0.16% and 0.09% over FCM_ALO, FCM_PSO and FCM_DWT.

VII. CONCLUSION

Generally, image fusion could be used to merge two images and to extract the required information from two images. This image fusion would be performed by DWT process but some essential information might be lost in this process. The accuracy percentage might be reduced due to loss in information. In this regard ADWT technique has been employed to increase the accuracy of change detection process. As discussed in previous sections various optimization algorithms could be used for selecting the DWT filter coefficients. Depending upon the optimization algorithm the accuracy might be changed therefore selection of optimization algorithm is also having much significance in ADWT. Finally, FCM_MFO has given better results over normal DWT, FCM_PSO and FCM_ALO.

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