PIXEL & FEATURE LEVEL MULTIRESOLUTION IMAGE FUSION BASED ON FUZZY LOGIC

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Abstract: **The motivation behind fusing multi-resolution images is to create a single image with improved interpretability. In algorithm (based on pixel and feature level) presented in this paper, images are first segmented into regions with fuzzy clustering and are then fed into a fusion system, based on fuzzy "if-then" rules. Fuzzy clustering offers more flexibility over traditional strict clustering; thus allowing more robustness as compared to other segmentation techniques (e.g. K-means clustering algorithm). A recently proposed subjective image fusion quality evaluation measure known as IQI (Image Quality Index) [1] is used to measure the quality of the fused image. Results and conclusion outlined in this paper would help explain how well the proposed algorithm performs**.

Keywords: Image Fusion, Discrete Wavelet Frame Transform (DWFT), Fuzzy C-Mean Clustering, Discrete Wavelet Transform (DWT) and Image Quality Index (IQI).

I. INTRODUCTION

In the past few years multi-sensor systems have utilized data fusion to get the improved and enhanced versions of acquired data. This can be useful in some diagnostic and research situations. Image fusion is a process by which several registered images or some of their features are combined together in such a way that there is no loss of information and introduction of distortion [2]. Fused image produced is thus more suitable and enhanced for human / machine perception. Composite image improves image content and make it easier for detection, recognition and identification of targets and thus increase situational understanding.

Image fusion has a number of applications in remote sensing, multi-focus camera applications, medical imaging, concealed weapon detection and night-time security.

Image fusion is generally performed at three different levels of information representation; these are pixel level, feature level and decision level [2]. Fusing images at pixel level means to perform integration at a level where the pixels are least processed. Each pixel in the fused image is calculated from pixels in the source images by for-example averaging. Fusion at feature level first requires extraction of features from the source images (through e.g. segmentation); fusion then takes place based on features that match some selection criteria. At symbol level/decision level, the output from the initial object detection and classification using source images is then fed into the fusion algorithm. Every image fusion algorithm is performed at one of these three levels or some combination thereof. Our algorithm focuses on a framework which combines aspects of both pixel and feature level image fusion.

Looking in the literature, we find image fusion techniques which vary from simple pixel averaging to complex methods involving principal component analysis (PCA) [4], pyramid based image fusion [3] and wavelet transform (WT) fusion [5]. Lately methods involving wavelet based fusion have gained much popularity because wavelet transform provides directional information while the pyramid representation doesn't introduce any spatial orientation in the decomposition processes. Liu et al [7] proposed a method in which authors take discrete wavelet frame transform (DWFT) of images because of its shift invariant property which lacks in DWT (discrete wavelet transform). Images are then segmented into regions using k-means clustering algorithm and are fed into the fuzzy fusion system.

In this paper an image fusion algorithm based on fuzzy logic is introduced. The segmentation of images is done using fuzzy c-mean clustering algorithm instead of k-means clustering algorithm because fuzzy clustering not only preserves but also emphasizes the grey level present in the image.

The subsequent sections of this paper are organized as follows. Section 2 explains the components of algorithm proposed. Section 3 is about the proposed scheme of image fusion Section 4 explains IQI, an objective image fusion quality evaluation measure followed by results in Section 5 and conclusion.

II. INGREDIENTS OF PROPOSED SCHEME

The key constituents of our scheme are discrete wavelet frame and fuzzy c-mean clustering. Below we have discussed some of the prospects regarding these techniques.

A. Why DWFT?

The lack of translation invariance together with rotation invariance is the key drawback of DWT in feature extraction. Due to shift variance the fusion methods using DWT lead to unstable and flickering results. This can be overcome with DWFT by calculating and retaining wavelet coefficients at every possible translation of convolution filters or in other words the redundant transforms. More detail can be found in MATLAB wavelet toolbox, where it is called Discrete Stationary Transform (SWT).

T. Sobh (ed.), Innovations and Advanced Techniques in Computer and Information Sciences and Engineering, 129–132.

B. Fuzzy c-mean Clustering:

Fuzzy c-means is a technique for clustering which allows one data item to belong to more than one cluster, whereas in hard (k-means) clustering an entity belongs to one and only one cluster. For more information on k-means clustering you may visit [11].

In fuzzy c-mean clustering algorithm random membership values and cluster centers are assigned. The iterative process continues to calculate the new membership values and cluster centers according to the distance b/w entities and centers. This process comes to stop when a maximum number of iteration is reached or an objective function reaches a required threshold value [6].

III. Proposed Image Fusion Scheme

It is important to know for the readers that the set of images used in this algorithm are registered images. With registration we find correspondence between images. . It is necessary because only after it is ensured that spatial correspondence (information from different sensors can be guaranteed to come from identical points on inspected object) is established, fusion makes sense. More detail on image registration can be found in [8], [9].

A. Algorithm and Flowchart:

The general framework of the proposed algorithm can be shown with the help of a flowchart. Step # refers to the steps of the algorithm mentioned below.

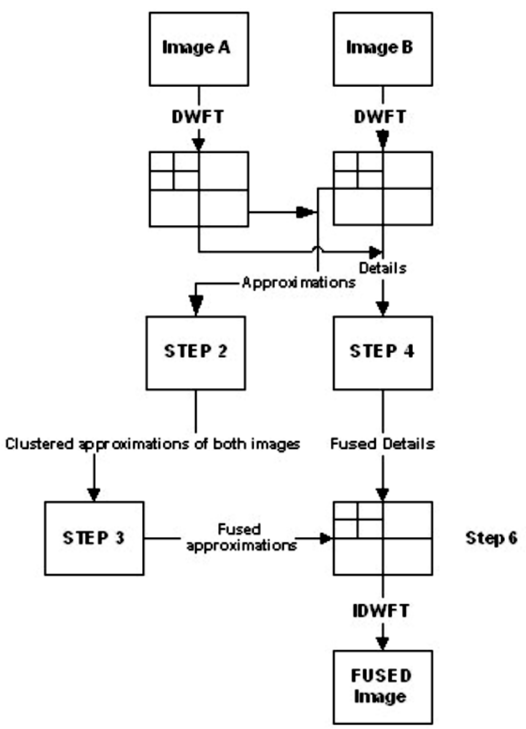

Fig. 1. Flowchart of the proposed scheme

1. Apply DWFT to two registered source images giving detail sub-bands and approximation sub-band.
2. Fuzzy c-mean clustering algorithm is used to segment the approximations into three regions, important region, sub-important region and background region, named on the basis of grey levels. Each pixel will have a degree of membership for the regions it belongs ranging between 0-1.
3. **Feature Level Fusion:-** Segmented approximations are fed into a fusion system based on fuzzy "if-then" rules, to get fused approximations. The membership functions, rules and de-fuzzification function details can be found in [7].
4. **Pixel Level Fusion:-** The details are fused by absolute maximum coefficient selection method.
5. Apply morphological filtering Zheng et al. [4] which use "fill" and "clean" operators to sweep isolated points.
6. With fused Approximations and fused details get fused wavelet frame coefficients map. Take Inverse Discrete Wavelet Frame Transform (IDWFT) and get fused image.

IV. Image Quality Index

Image Quality Index proposed by Piella et al [1] has been used as an objective image fusion quality evaluation measure. IQI is recently proposed, easy to calculate and is used quite often for image quality measurement. The expression of global image quality index is:-

$$Q_o(A,B) = \left(\frac{\delta_{AB}}{\delta_A \delta_B}\right)\left(\frac{2\overline{AB}}{(\overline{A}^2 + \overline{B}^2)}\right)\left(\frac{2\delta_A \delta_B}{\delta_A{}^2 + \delta_B{}^2}\right) \quad (1)$$

Where δ_A is variance of A, δ_{AB} is covariance of A and B and $\overline{A}$ is the mean of A. The value of $Q_o \in [0, 1]$, $Q_o = 1$ means A and B are completely identical.

We then compute λ, a local weight giving more importance to one of the two images. The more the value of λ the more weight is being given to that particular image. To compute the value of λ we have:-

$$\lambda = SF(A)/[SF(A) + SF(B)] \quad (2)$$

In (2) SF is the spatial frequency of image and it measures the overall activity level of the image [10].

$$Q_F = \lambda Q_o(A,F) + (1-\lambda) Q_o(B,F) \quad (3)$$

V. Results And Discussions

Three existing image fusion schemes are used for comparative analysis of our proposed scheme. These schemes are:-

A. DWT based image fusion:-

In this method, images are first decomposed using DWT. Approximation and detail sub-bands are fused by choosing maximum wavelet coefficients from both the DWT coefficients