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Region-Based Image Fusion Using Complex Wavelets

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Abstract: *Image fusion using discrete complex wavelets is used to improve signal to noise ratio and good quality and shift invariant. This technique can be used for fusion of complementary information images as well as multi model image fusion. The proposed algorithm is very simple, easy to implement and could be used for real time applications. A Novel region- based method increase flexibility. A dual tree complex Wavelet transforms (DT-CWT) is used to segment the features of input images, to produce region map. Characteristics of each region are calculated and a region based approach is used to fuse the images, region-by-region , in the Wavelet domain .This method gives results comparable to pixel based fusion methods , but despite an increase in complexity.*

Key words: *Discrete complex wavelet, Dual tree complex wavelet transform(DT-CWT),Image Fusion, Pixel-Based Fusion, Region-Based Fusion*

I. Introduction

Image fusion means the combining of two images into a single image that has the maximum information content without producing details that are non-existent in the given images. Image Fusion is a mechanism to improve the quality of information from a set of images. .Use of the Simple primitive technique will not recover good fused image in terms of performance parameter like peak signal to noise ratio (PSNR), Normalized correlation (NC), and Men square error (MSE). With rapid advancements in technology, it is now possible to obtain information from multi source images to produce a high quality fused image with spatial and spectral information. There are a number of potential advantages of integrating the data from multiple sensors. These include

- A group of sensors can collect information of a scene more quickly than a single sensor.
- Complementary information from different sensors allows features in a scene to be perceived that would not be possible from individual sensors.

Image fusion can be performed at four levels are : signal, pixel, feature, and symbolic level. At pixel level , images are combined by considering individual pixel . for achieving feature level fusion ,region based method is used. This has more intelligent fusion rules by considering actual fusion rules rather than individual pixel. Wavelet transform techniques have advantage over Fourier transform technique for analyzing small duration signals. There are several wavelet Transform techniques for better quality we go for DT-CWT for region merging process for better Quality and performance. Wavelet uses multi sensor information for fusion. Pixel-based fusion is briefly discussed in Sec. 2. Sec. 3 gives an overview of our region fusion scheme.sec.4 gives discussion about wavelet theory. The remainder of the paper is organized with results listed in sec.5 and Discussion and the conclusion in Sec. 6.

II. Pixel-Based Fusion

It forms fused image by combing individual pixels by considering different fusion rules. This includes MAX, MIN,AVG methods and complex multi resolution pyramids and wavelet methods. In this method apply MR transform to each image and combine transformed image coefficients using above fusion rules and for reconstructing again apply inverse transform. But it has some disadvantages such as decreased directionality , and signal-to-noise ratio. It is more complex technique.

Pixel-based rules: the information fusion is performed in a pixel-by-pixel basis either in the transform or spatial domain. Each pixel (*x; y*) of the *T* input images is combined with various rules to form the corresponding pixel(*x; y*) in the "fused" image IT. Several basic transform-domain schemes were proposed such as:

Fusion by averaging: fuse by averaging the corresponding coefficients in each image ("mean" rule).

$$\mathcal{T}\{I_f(x,y)\}) = \frac{1}{T}\sum_{i=1}^{T}\mathcal{T}\{I_i(x,y)\} \quad (1)$$

Fusion by absolute maximum: fuse by selecting the greatest in absolute value of the corresponding coefficients in each image ("max-abs" rule)

$$\mathcal{T}\{I_f(x,y)\}) = \operatorname{sgn}(\mathcal{T}\{I_i(x,y)\}) \max_i |\mathcal{T}\{I_i(x,y)\}| \quad (2)$$

Fusion by de noising (hard/soft thresholding): perform simultaneous fusion and de noising by thresholding the transform's coefficients (sparse code shrinkage).

High/low fusion: this combining the "high-frequency" parts of some images with the "low-frequency" parts of some other images.

III. Region-Based Fusion

These schemes group image pixels to form contiguous regions, e.g. objects and impose different fusion rules to each image region. In Li et al created a binary decision map to choose between the coefficients using a majority filter, measuring activity in small patches around each pixel. Piella proposed several activity level measures, such as the absolute value, the median or the contrast to neighbors. Consequently, she proposed a region-based scheme using a local correlation measurement to perform fusion of each region. There are many applications with region base image fusion techniques over pixel-based these include fusion scheme are interested in features within the image, not in the actual pixels. Therefore, it seems reasonable to incorporate feature information into the fusion process. There are a number of advantages of region-based image fusion those include mainly:

- Processing semantic regions rather than at individual pixels or arbitrary regions can help overcome some of the problems with pixel-fusion methods such as sensitivity to noise, blurring effects and miss-registration.
- Fusion rules are based on combining groups of pixels which form the regions of an image. Thus, more useful tests for choosing the regions of a fused image, based on various properties of a region, can be implemented.
- Regions with certain properties can be either accentuated or attenuated in the fused image depending on a variety of the region's characteristics;
- The feature information extracted from the input images, could be used to aid the registration of the images.
- Region video fusion schemes could use motion estimation to track the fused features, allowing the majority of frames to be quickly predicted from some fully fused frames.

A number of region-based fusion schemes have been proposed, These initially transform pre-registered images using an MR transform. Regions representing image features are then extracted from the transform coefficients. A grey-level clustering using a generalized pyramid linking method is used for segmentation. The regions are then fused based on a simple region property such as average activity. These methods do not take full advantage of the wealth of information that can be calculated for each region.

The novel region-based fusion scheme proposed in this paper is shown in Fig-A. Initially, the *N* registered images *I*1*; I*2*; : : : ; IN* are transformed using *w* the DT-CWT.

$$[D_n, A_n] = \omega(I_n) \quad (3)$$

This gives a set of detail coefficients $D_{n,k(\theta,l)}$ for each image *In*, consisting of a group of six different subbands, μ, at each level of decomposition, *l*. *An* is the approximation of the image at the highest level. A combination of intensity information, *In* and textural information, *Dn*, is used to segment the images, either jointly or separately, with the segmentation algorithm *Á*, giving the segmentation maps: *S*1*; S*2*; : : : ; SN*; or a list of all the *Tn* regions for each image: *R*1*;R*2*; : : : ;RN*; where *Rn = {rn;*1*; rn;*2*; : : : ; rn;Tn}*, n belongs to N. The map is down sampled by 2 to give a decimated segmentation map of the image at each level of the transform. When down sampling, priority is always given to a pixel from the smaller of the two regions.

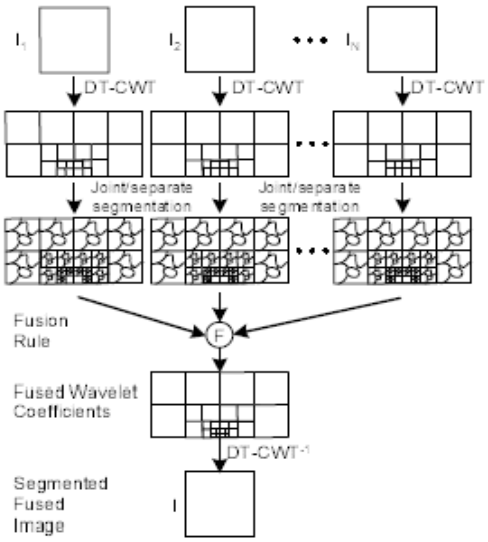

Fig-A: Region-Based Image Fusion Scheme Using the DT-CWT.

IV. Wavelet Theory

A 'wavelet' is a small wave which has its energy concentrated in time. It has an oscillating wave like characteristic but also has the ability to allow simultaneous time and frequency analysis wavelets are of limited duration, irregular and may be asymmetric. Waves are used as deterministic basis functions in Fourier analysis for the expansion of functions (signals), which are time invariant, or stationary. The important characteristic of wavelets is that they can serve as deterministic or non-deterministic basis for generation and analysis of the most natural signals to provide better time-frequency representation, which is not possible with waves using conventional Fourier analysis Wavelet theory is closely related to filter bank theory. The need of simultaneous representation and localization of both time and frequency for non-stationary signals (e.g. music, speech, images) led toward the evolution of wavelet transform from the popular Fourier transform.

There are two types of theoretical aspects of wavelet transforms given as:

- Continuous Wavelet Transform (CoWT)
- Discrete Wavelet Transform (DWT)

The wavelet based image fusion technique is briefly shown in the fig-B.

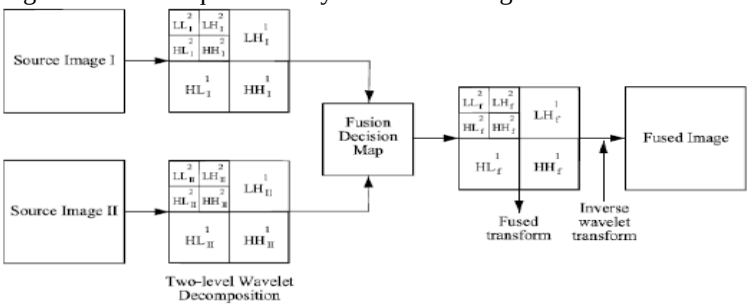

Fig-B: Wavelet based image fusion.

V. Results

The Fig-C shows the The two images to be fused are generated from the ground truth image using blurring. The aircraft in top half of the image is out of focus and the second aircraft is in focus. It is reverse in second image i.e. both images are contain complementary information. The fused image using region based algorithm is shown in Fig-D. It shows that the fused image contains all information coming from the complementary source images.

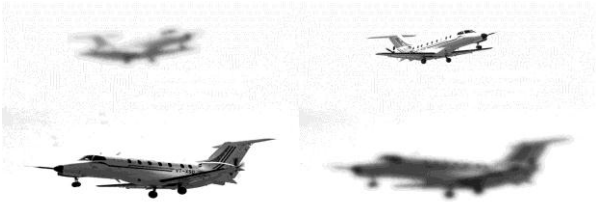

Fig-C: Images to be fused.

Fig-D:Fused image.

The Fig-E shows that the out of focus color images to be fused. And the Fig-F shows the fused image.

Fig-E: Images to be fused.

Fig-F:Fused image.

These results were obtained with a Mat lab implementation of the algorithm as part of an image fusion toolbox

VI. Conclusion

A Region based image fusion algorithm has been presented and evaluated. and is compared with well known image fusion technique by wavelets. It is concluded that the region-based image fusion perform almost similar to pixel-based image fusion but having small difference in wavelet algorithms. It is computationally very simple and it could be well suited for real time applications. The region-based algorithm has a number of advantages over the pixel-based fusion algorithm.

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