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Image Enhancement Using Transform Domain Based Image Fusion Technique

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Abstract : *Image enhancement for the better quality of image is required in various image based application. One of the technique to enhance the image is image fusion. It is an effective way for optimum utilization of large volumes of images from multiple sources. It extracts complete information from source images into the result, without introducing any artifacts or inconsistencies. In this process, it combines relevant information from multiple source images into a single image which contains more accurate and all important information of input images. Image fusion is also helpful to reduce the overall uncertainty and redundant information from various sources. The main aim of transform domain based image fusion is image enhancement and image sharpening for the purpose of human visual perception and computer processing*
Keywords - *Image Registration, Image Fusion, Spatial Distortion , Transform Domain*

I. INTRODUCTION

Image fusion is one of the techniques which are used in image enhancement. The fusion of different images can reduce the uncertainty related to a single image to produces better quality image without distortion. Image fusion can also be defined as the integration of information from a number of registered images without the introduction of distortion. It provides an effective way of reducing this increasing volume of information while at the same time extracting all the useful information from the source images.

It is often not possible to get an image that contains all relevant objects in focus, and that's why image fusion come in focus and become so popular in image world. It enhances the quality of image by removing the noise and the blurriness of the image. The aim of image fusion, is to create new images that are more suitable for the purpose of human or machine perception, and for further image processing tasks. The fused image can be used in various applications like object detection, weapon detection, remote sensing, target recognition, microscopic imaging, analysis of images from satellite, battlefield monitoring, military applications, computer vision, robotic vision and medical image analysis.

i. Different Techniques used for Image Fusion

The important pre-processing steps for the fusion process are image registration & image sampling. Image registration is the process of transforming different sets of data into one coordinate system. Image Registration is the process of aligning two or more images of the same scene taken from different viewpoints, at different times, from different sensors. In order to be able to compare or integrate the data obtained from different measurements, image registration is necessary. Sampling corresponds to a discretization of the space. A continuous image f(x,y) is approximated by equally spaced samples arranged in the form of an N x M array where each element of the array is a discrete quantity. Sampling represents a mapping from one discrete set of points to another (smaller) set. [1, 9, 10, 12]

Image fusion typically begins with two or more registered images with different representations of the same scene. They may come from different viewing conditions, different sensors (multisensor), multimodal or multifocus. We can acquire a series of pictures with different focus settings and fuse them to produce an image with extended depth of field. [7,10]

There are important requirements for image fusion process such as -

- The fused image should preserve all relevant information from the input images.
- Image fusion should not introduce artifacts which can lead to wrong diagnosis.[6]

The actual fusion process can take place at different levels of information representation. Image fusion can be performed using different techniques which are classified on level base and domain base.

Level based technique used for image fusion :-
On level base, image fusion classified in 3 types as - .
- Pixel Level Image Fusion / Low Level Image Fusion
- Feature Level Image Fusion / Middle Level Image Fusion
- Decision Level or Knowledge Level Image Fusion / High Level Image Fusion

Domain based technique used for image fusion :-
On domain base, these methods can be broadly classified into two parts :-
- Special domain fusion and
- Transform domain fusion [1,2]

ii. Spatial Domain Fusion :-

Spatial domain technique directly deals with pixel value of input image. The pixel values are manipulated to achieve desired result. The spatial domain techniques fuse source images using local spatial features such as gradient, spatial frequency, and local standard derivation.

Averaging method, Brovery method, Principal Component Analysis (PCA), IHS (Intensity, Hue & Saturation) based methods, High Pass Filtering based technique are spatial domain methods.

Spatial domain image fusion methods are complicated, time consuming which are difficult to be performed on real-time images. It also produces spatial distortion in the fused image and have blurring problem. This problem can be solved by transform domain approach.[1,3,6, 9]

Transform Domain Fusion :-

In transform domain method, image is first transferred into frequency domain. In this, source images are projected onto localized bases which are usually designed to represent the sharpness and edges of an image. Therefore, the transformed coefficients (each corresponds to a transform basis) of an image are meaningful in detecting salient features. The transform domain methods provide a high quality spectral content. Wavelet based fusion methods fall under transform domain method such as wavelet transform, curvelet transform, contourlet transform and non-subsampled contourlet transform. [5,6,13]

II. TRANSFORM DOMAIN IMAGE FUSION METHODS :-

1. Laplacian Pyramid Fusion Method :-

The basic idea behind the Laplacian pyramid is to perform a pyramid decomposition on every source image, then integrate of these decompositions to make a composite representation and finally reconstruct the fused image by performing an inverse pyramid transform. The various steps used in Laplacian pyramid based fusion method are as follows:
1. The first step is to construct a pyramid for each source image.
2. Then the fusion is implemented at each level of the pyramid using a feature selection decision method.
3. The feature selection method selects the most significant pattern from the source image and copies it to the composite pyramid.
4. Finally, fused image is obtained by performing an inverse pyramid transform. [9]

2. Discrete Cosine Transform (DCT) :-

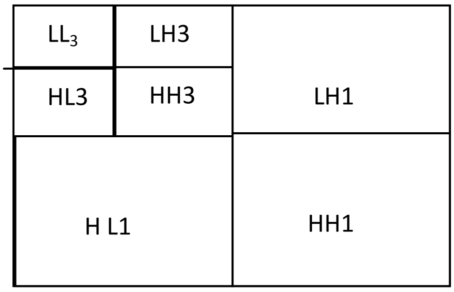
Spatial domain image fusion methods are complicated and time consuming which are difficult to be performed on real-time images. Also, fusion approaches which are applied in DCT are very adept when the source images are coded in Joint Photographic Experts Group (JPEG) format or when the fused image will be saved or transmitted in JPEG format [9]. To perform the JPEG coding, an image is first subdivided into blocks of 8x8 pixels. The Discrete Cosine Transform (DCT) is then performed on every block. This generates 64 coefficients which are then quantized to reduce their magnitude. The coefficients are then reordered into a one-dimensional array in a zigzag manner before further entropy encoding takes place. The compression is achieved in two stages the first is during quantization and the second during the entropy coding procedure. JPEG decoding is the reverse process of encoding [9]

III. WAVELET TRANSFORM :-

iii. Discrete Wavelet Transform (DWT) :-

Wavelet transforms are multi-resolution image decomposition tool that provide a variety of channels representing the image feature by different frequency sub-bands at multi-scale. It is a famous technique in analyzing signals. When decomposition is performed, the approximation and detail component can be separated 2-D Discrete Wavelet Transformation (DWT) converts the image from the spatial domain to frequency domain.

The image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be separated with four parts those are LL1, LH1, HL1 and HH1 as shown in fig. 1 [10]



Here,
1,2,3 – Decomposition Levels
H – High Frequency Bands
L – Low Frequency Bands

The wavelet transform decomposes the image into low-low, low-high, high-low and high-high spatial frequency bands at different scales. The LL band contains the approximation coefficients whereas the other bands contain directional information due to spatial orientation. LH band contains the horizontal detail coefficients. HL band contains the vertical detail coefficients. HH contains the diagonal detail coefficients and also contain the higher absolute values of wavelet coefficients correspond to salient features such as edges or lines. Figure shows Discrete Wavelet Transform (DWT) based image fusion. The wavelets-based approach performs the following tasks:-

1. It is a multi scale (multi resolution) approach well suited to manage the different image resolutions. It is Useful in a number of image processing applications including the image fusion.
2. The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information.
3. Such coefficients approaching from different images can be appropriately combined to obtain new coefficients so that the information in the original images is collected appropriately.
4. After the coefficients are merged then the final fused image is achieved by applying the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved.

General process of image fusion using DWT has following steps -
Step 1 - Implement Discrete Wavelet Transform on both the input image to create wavelet lower decomposition.
Step 2 - Fuse each decomposition level by using different fusion rule.
Step 3 - Carry Inverse Discrete Wavelet Transform on fused decomposed level, which means to reconstruct the image, while the image reconstructed is the fused image F.

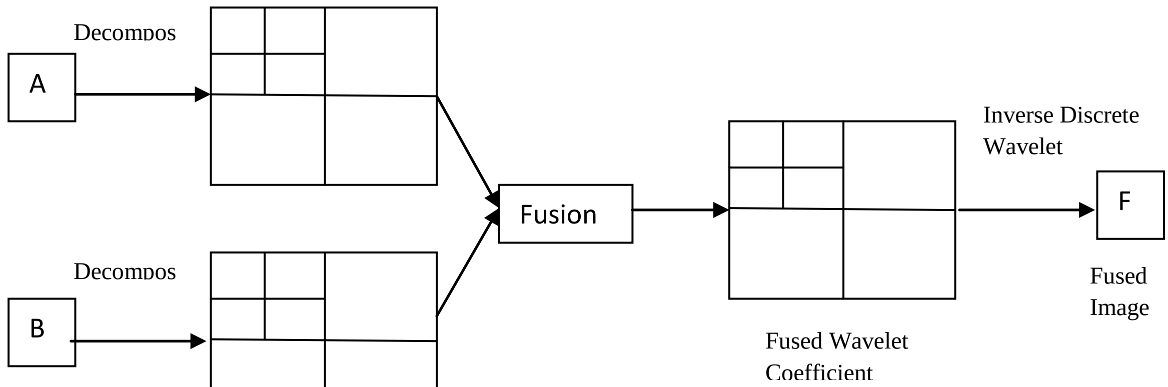


Fig. 2 :- Discrete Wavelet Transform (DWT) based Image Fusion

Discrete Wavelet Transform (DWT) based image fusion provides better signal to noise ratio and high quality spectral content.
But it has one disadvantage as in final fused image , it have a less spatial resolution. [9,10,11].

iv. Contourlet Transform :-

Contourlet transform is a multi-scale and multi-direction framework of discrete image.

The wavelet transform is good at isolating the discontinuities at object edges, but cannot detect the smoothness along the edges and it captures limited directional information. The contourlet transform effectively overcomes these disadvantages of wavelet. In this contourlet transform, the multiscale analysis and the multidirection analysis are separated in a serial way. Contourlet expansion of images consists of basis images oriented at various directions in multiple scales with flexible aspect ratio. In addition to retaining the multi-scale and time-frequency localization properties of wavelets, the contourlet transform offer high degree of directionality.

Contourlet transform adopts nonseparable basis functions, which makes it capable of capturing the geometrical smoothness of the contour along any possible direction. For image enhancement purpose we need to improve the visual quality of an image with minimal image distortion. Contourlet transform has better performance in representing the image with salient features such as edges, lines, curves and contours than wavelet transform because of its anisotropy and directionality. Therefore it is well-suited for multi-scale edge based image enhancement.

v. Nonsubsampled Contourlet Transform :-

The contourlet transform achieves better quality in terms of edges and contours. But,due to downsampling and upsampling, the contourlet transform is lack of shift-invariance and results in ringing artifacts which is required in image analysis applications, such as edge detection,

Contour characterization, image fusion and so on. Therefore, non-subsampled contourlet transform (NSCT) was proposed based on non-subsampled pyramid decomposition and non-subsampled filter bank (NSFB). In NSCT, the multiscale analysis and the multidirection analysis are also separated, but both of them are shift-invariant. First, nonsubsampled pyramid (NSP) is used to obtain a multiscale decomposition by using two-channel non-subsampled 2-D filter bands. Second, non-subsampled directional filter bank is used to split band pass sub-bands in each scale with different directions. Hence, the nonsubsampled contourlet transform offers better frequency characteristics than the original contourlet transform.[13]

IV. CONCLUSION

This paper reviews different transform domain based image fusions for image enhancement. Some spatial domain based image fusion techniques suffer from color artifacts, roughness of edges and problem of degradations of image. All these problems have overcome by transform domain based image fusions with improving clarity of the image. Transform domain based fusion techniques show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion.

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