Review on Image Fusion and Its Techniques

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Abstract - **Image Fusion is one of the major research fields in image processing. Image Fusion is a process of combining the different information from a set of images, into a single image, where in the resultant fused image will be more informative and complete than any of the input images. Image fusion process can be defined as the integration of information from a number of registered images without the introduction of distortion. The objectives of this paper is to present an overview of imaging fusion and its different techniques. Image fusion techniques can improve the quality and increase the application of input images.**

Keywords - **Decision fusion, Feature fusion,Fusion Methods, Image Fusion, Pixel fusion.**

Abbreviations – Computed Tomography (CT), Positron Emission tomography (PET), Magnetic resonance Imaging (MRI)

INTRODUCTION

1.1 *Image fusion*

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 image [1]. Image Fusion is a Process to improve the quality of information from a set of images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics.

Medical image fusion is the process of registering and combining multiple images from single or multiple imaging modalities to improve the imaging quality and reduce randomness and redundancy in order to increase the clinical applicability of medical images (like CT Scan , X-ray , Diagnostic sonography , PET Scan , MRI etc.) for diagnosis of medical problems[2].

1.2 *Levels of Fusion*

Fusion process may be classified into three classes:
1) pixel fusion
2) feature fusion
3) decision fusion

Table 1 – Comparison of Fusion Levels

pixel-level fusion	Feature-level fusion	. Decision-level fusion
It is the lowest processing level which generates a fused image in which each pixel is determined from a set of pixels in each input image.	It is the medium level fusion and employs features(like edge, shape, angle, texture, lighting area and depth of focus area) extraction on the input data so that features from each source can be jointly employed.	It is the highest-level fusion. Input images are processed individually for information extraction.

FUSION TECHNIQUES

In the Image Fusion method the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images.
Image fusion method can be broadly classified into two groups:

1) **Spatial domain fusion method**
2) **Transform domain fusion method**

In *spatial domain* methods, we directly deal with the pixel value of an image. The pixel values are manipulated to achieve desired result.

In *frequency domain* methods the pixel value is first transferred in to domain methods by applying DCT and DFT based fusion methods and further image is enhanced by changing frequency component of an image [4].
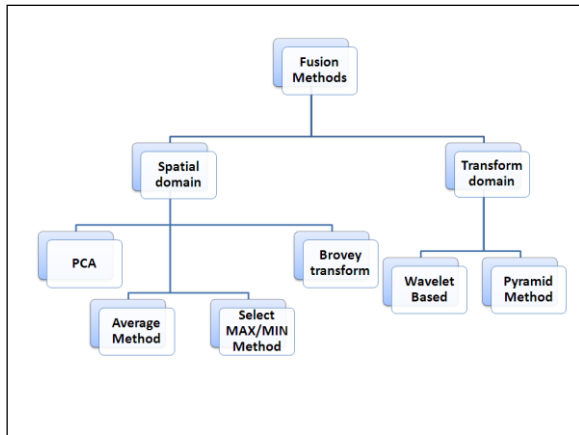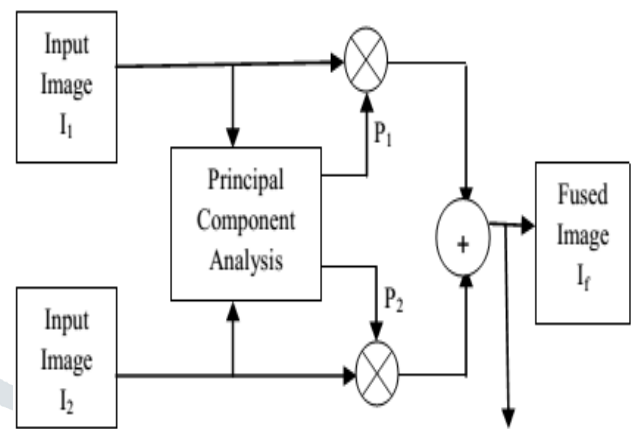

Fig.1.Fusion Methods

Fig.2.PCA Method of Fusion

1.1   Spatial Domain Methods

1.1.1   PCA (Principle Component analysis)

PCA is one of the linear mapping Techniques used in many application of image processing. It is known as a general statistical method that transforms correlated variables into uncorrelated variables. These new variables are getting as linear combination of the original variables.

In Principal Component Analysis (PCA), extracted components are equivalent to observed variables which are being analyzed.

Steps involved in image fusion using PCA transform are[6]:

Step1. Register two input images I1(x, y) and I2(x, y) .
Step2. Arrange both input images in two   column vectors and subtract their   empirical means. Dimension of resulting   vector is nx2, where n is the length of the   each image vector.
Step3. Calculate the co-variance matrix C.
Step4. Compute the Eigen vector   V   and   Eigen value   D   of C.
Step5. Consider first column of V which   corresponds to larger Eigen value to compute components P1and P2.   Component P1and P2 are calculated as:

$$p_1 = \frac{v_1}{\sum v}$$

$$p_2 = \frac{v_2}{\sum v}$$

Step6. Normalize the components P1and P2.
Step7. Fused image I_f(x, y)   is obtained by

$$I_f(x, y) = p_1 I_1(x, y) + p_2 I_2(x, y)$$

1.1.2   Average Method

Average Method working as averaging every corresponding pixel of input images to obtain final fused image.

1.1.3   Select Maximum / Minimum Method

In *Maximum Method*, the pixel with maximum intensity from the corresponding spatial locations from all the images to be fused is selected as the resultant pixel of the fused output image. The advantage of this method over averaging method is that there is no compromise made over the good information available in the input images. But the disadvantage is that it considers only the higher pixel intensity as the better information ignoring all other values.

Minimum Method similar to the select maximum method but with the difference, it considers only the pixel with lowest intensity value and ignores all other values. This method also has the disadvantage of either completely considering information or discarding it fully.

1.1.4   Brovey Method

This method is developed and supported by an American scientist. *Brovey method* is also known as color normalization transform because it contains a red-green-blue (RGB) color transform method. It is a simple method for combining data from different sensors. In this method combination of arithmetic operation are used[9].

1.2   Transform Domain Methods
1.2.1   Wavelet Based Method

The **Wavelet Transform** is a mathematical tool that can detect local features in a signal process. It also can be used to decompose two-dimensional (2D) signals such as 2D gray-scale image signals into different resolution levels for multi resolution analysis[8]. **Wavelet transform** has been greatly used in many areas, such as texture analysis, data compression, feature detection, and **image fusion**. In this section, we briefly review and analyse the wavelet-based image fusion technique.

Types of Wavelet Transforms:

1) **DWT**(Discrete Wavelet Transform)
2) **CWT**(Continuous Wavelet Transform)

Wavelet based techniques for fusion of 2D images is described here. In all wavelet based image fusion techniques the wavelet transforms W of the two registred input images I1(x,y) and I2(x,y) are computed and these transforms are combined using some kind of fusion rule Ø as show in below equation.

$$I(x,y) = W^{-1}\left(\emptyset\left(W\big(I_1(x,y)\big), W\big(I_2(x,y)\big)\right)\right)$$
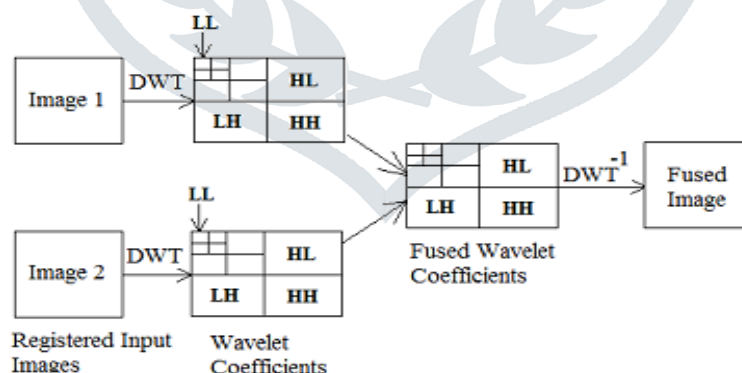

Fig.3.Block diagram of DWT[7]

It retains most of the advantages for image fusion as compare to other fusion methods. Wavelet Transform is the most common form of transform image fusion is wavelet transform fusion.

1.2.2   Pyramid Method

A generic **Image Pyramid** is a sequence of images where each image is constructed by low pass filtering and sub sampling from its predecessor.

Image Pyramids have been initially developed for multi resolution image analysis and as a model for the binocular fusion in human vision.

FUSION PARAMETERS

Fusion performance is measured on the basis of root mean square error (RMSE), peak signal to noise ratio (PSNR). These parameters can be calculated as:

1. **Root Mean Square Error (RMSE)**
   Root Mean Square Error (RMSE) between the fused image and original image provides error as a percentage of mean intensity of the original error.
2. **Peak Signal to Noise Ratio (PSNR)**
   PSNR is defined as ratio between the maximum possible power of a signal and power corresponding to noise the fidelity of its representation.
3. **Mutual Information (MI):**
   Mutual information of two random variables is a quantity that measures the mutual dependence of the two variables.

LITERATURE SURVEY

Image Fusion is used extensively in image processing systems. Various Image Fusion methods have been proposed in the literature to reduce blurring effects. Many of these methods are based on the post-processing idea. In other words,Image fusion enhances the quality of image by removing the noise and the blurriness of the image. Image fusion takesplace at three different levels i.e. pixel, feature and decision. Its methods can be broadly classified into two that isspecial domain fusion and transform domain fusion. Averaging, Brovery method, Principal Component Analysis(PCA), based methods are special domain methods. But special domain methods produce special distortion in the fused image .This problem can be solved by transform domain approach. The multi-resolution analysis has become a very useful tool for analyzing images.We analyze some Implimented Results With Parameter Measurements which is mentioned below

Table 2 – Parameter analysis of Different Methods

Input Images	Parameters	Techniques					
		Maximum	Averaging	PCA	Laplacian Pyramid	DWT	MIN-SUM-MOM
C1.jpg	PSNR	31.9243	33.6611	33.4303	33.6611	49.0438	93.2853
	SSIM	33.2678	20.4436	18.8690	20.4436	18.1178	31.1589
	SNR	0.9614	0.9222	0.9198	0.9222	0.9484	0.9667
	ENTROPY	0.2932	0.4485	0.4717	0.4485	0.5824	5.1286
M1.jpg	PSNR	32.4152	33.6611	33.9047	33.6611	49.0535	86.7532
	SSIM	58.2547	37.6462	41.3375	37.6462	31.5243	49.4951

CONCLUSION

In this paper two different modality images are fused using different Fusion Methods. The field of medical diagnostics and monitoring medical images have technological, scientific challenges.Thetechnological improvement in medical imaging technologies have resulted in improved image accuracies.

In this paper, We Present theory of fusion with different types and also given an idea how it is different in performance.When we perform a different fusion on medical images then we analyze that wavelet based method have better performance than other techniques.

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