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# Review on Different Aspects of Image Fusion for Medical Imaging

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**Abstract:** ***Image fusion can be broadly defined as the process of combing multiple input images into a single image without the introduction of distortion or loss of information. The resulting image contains more information as compared to individual images. Fusion is an important technique in many fields such as remote sensing, robotics and medical applications. This paper discusses different techniques and aspects of the image fusion for medical imaging.***

**Keywords:** Image Fusion, Wavelet, Medical Imaging, Medical image modalities.

## 1. Introduction

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. The purpose of image fusion is to combine information from several different source images to one image which becomes reliable and much easier to be understood by people [1]. The objective of image fusion is to combine complementary as well as redundant information from multiple images to create a fused output image. Hence, the new image generated contains a more accurate description of the scene than any of the individual sources image and is more suitable for human visual and machine perception or further image processing and analysis tasks. Although an increasing number of high-resolution images are available along with sensor technology development, image fusion is still a popular method to illustrate the image data for obtaining a more suitable image for a variety of applications that are visual interpretation as well as digital classification [2]. In case of medical image fusion motive is to combine the multiple images such as MRI,CT,PET etc into a single image which contains more information and useful for the purpose of diagnosis. As there are various modalities used for medical image fusion and each image provides different information for example-the CT image gives information of dense structures like bones whereas MR image gives information about soft tissues. Hence the single image cannot satisfy sufficient clinical requirements. Thus there is a huge need to fuse image like MRI and CT and many more. Figure 1 shows the process of obtaining a fused image. The two images Image 1 and Image 2 of same or different modalities are taken and by applying the various fusion methods final fused image is obtained which is more informative than each single image.

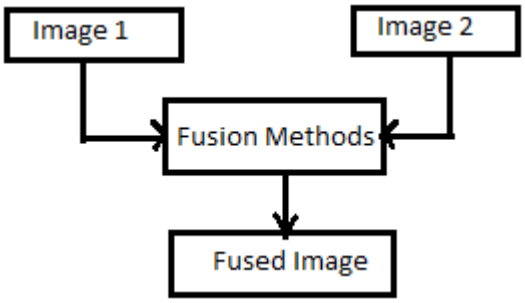


**Figure 1:** Image Fusion Process

## 2. Methods of Image Fusion

Some of the image fusion methods are:

### 2.1 Spatial Domain Fusion

**a. Average method**

The simpler way of image fusion is taking the average of the two images pixel by pixel. This type of method works well when the images which are to be fused are from a same type of sensor and contains the additive noise [3].

**Advantages**

It is very simple method and quite easy to understand and implement.

**Disadvantages**

It causes undesirable side effect that is reduced contrast. Also By the use of this method some noise is introduced into the fused image which reduces the final image quality [12].

**b. Brovey Transform**

Brovey transform (BT) is a commonly used fusion method for remote sensing images. It preserves the relative spectral contribution of each pixel but replaces the overall brightness with high-resolution panchromatic image [4].

**Advantages**

It is a simple method to merge the data from different sensors. This method is simple and fast method. Also it provides high spatial quality fused images [12].

**Disadvantages**
It produces spectral distortion.

**c. Intensity Hue Saturation**
The Intensity Hue Saturation fusion method is also very popular fusion method for remote sensing images. The IHS method uses three low-resolution multispectral images in different bands and transforms them into the IHS space. The intensity component of IHS space is replaced by the high-resolution panchromatic image and transformed back into an original RGB space with the previous H as well as S components [4].
**Advantages**
This method gives good visual effects and also shows better results when remote sensing images are to be fused.
**Disadvantages**
This method produces colour distortion.

### 2.2 Transform domain fusion

**a. Pyramid Method**
Image pyramid be described as the collection of low or band-pass copies of original image in which both the band limit as well as sample density are reduced in regular steps. The main strategy of image fusion based on pyramid method is the use of feature selection rule for constructing the fused pyramid representation from the pyramid representation of the original images. By taking inverse pyramid transform the composite image is obtained [5].
**Advantages**
It shows better performance in spatial as well as spectral quality of the fused image as compared to the some other spatial methods.
**Disadvantages**
It causes the blocking effects. During the fusion it causes undesired edges [12].
In recent years pyramid-based fusion schemes have been introduced. These are:-Ratio of low-pass pyramid and Contrast pyramid, Laplacian pyramid, Morphological pyramid Gradient pyramid [5].

**b. Wavelet based method**
The most common form of transform image fusion is wavelet transform fusion. In common with all transform domain fusion techniques the transformed images are combined in the transform domain using a defined fusion rule then transformed back to the spatial domain to give the resulting fused image.
**Advantages**
The wavelet transform is a more compact representation than the image pyramid. Images generated by wavelet image fusion have better signal to noise ratio than images generated by pyramid image fusion.

## 3. Various Modalities Used in Image Fusion

### 3.1 Magnetic Resonance Imaging

The MRI, which stands for "magnetic resonance imaging" plays an important role in non-invasive diagnosis of brain tumors and is one of the most widely, used image modality in the medical studies. The advantage of MRI is that it is very safe because it does not involve any exposure to radiation. MRI gives information about central nervous system (the brain and spinal cord), strokes, and other abnormalities in organs and soft tissues of the body. The use of image fusion in a multi-modal imaging environment, enabling reconstruction and prediction of the missing information from MRI. MRI imaging is widely used in fusion with CT imaging to get the more detail information [6].

### 3.2 Computerized Tomography

CT, which stands for "Computerized tomography" is a medical imaging technique provide excellent information about anatomical features and tissue density, allowing for the detection of tumors. Similar to MR images, the CT images are used in a vast range of medical applications. CT imaging is used for broken bones, injury etc [6].

### 3.3 Positron Emission Tomography

Positron emission tomography known as PET imaging is a nuclear medicine imaging technique. Similar to CT and MRI, a major application of PET is for brain diagnosis and treatment. The resolution limits of PET image are one of the main challenges. Hence there is increased interest in using fusion techniques to improve the imaging quality. Therefore there is a use of PET data in combination with some of the existing modalities using the image fusion techniques [6].
Along with these modalities there are several other modalities used in medical image fusion such as Single-Photon Emission Computed Tomography, Infrared, Microwave and Microscopic imaging.

## 4. Different Reviews for Fusion

Cao et. al. proposed a method in their paper title "*A Remote Sensing Image Fusion Method Based on PCA Transform and wavelet packet transform".* In this paper, a Remote-sensing image fusion method based on PCAT and WPT was studied. Firstly, multi-spectral image was transformed with PCAT, then, we can find three major components. Then the first principal component of the multi-spectral image and the panchromatic image were merged with WPT-based fusion method and the prior was replaced with the merged data. Lastly, the new multi-spectral image is obtained by inverse PCAT. Then compare the new method with PCAT-based fusion method, IHST-based one, and WT-based one. The new method performance was better. Proposed method not only preserves spectral information of original multi-spectral image, but also enhances spatial detail information of fused image [7].

Zeng et. al. presented a review on some recent image fusion algorithms and techniques in their paper titled "*Review of Image Fusion Algorithms for Unconstrained Outdoor Scenes*". They typically commented on the pixel-level algorithms that were released in past five years. The fusion algorithms were estimated with experimental quantitative evaluation techniques.A new practical example for image fusion was provided [8].

Pancham Shukla et. al. introduced a architecture with a hybrid algorithm which applies pixel based maximum selection rule

to low frequency approximations and filter mask based fusion to high frequency details of wavelet decomposition in their paper titled "*Novel Architecture for Wavelet based Image Fusion".* The main feature of the hybrid architecture was it is the combination of advantages of pixel and region based fusion in a single image which enhances the edges and structural details [9].

Nemir Al-Azzawi et. al. introduced a "Medical Image Fusion Scheme Using Complex Contourlet Transform based on PCA" The main feature is making an efficient method for the fusion of medical images using different modalities that enhances the original images and combines the complementary information of the different modalities. The contourlet transform had been mainly employed as a fusion technique for images obtained from equal or either from different modalities. The disadvantage of directional information of dual-tree complex wavelet (DT-CWT) was rectified in dual-tree complex contourlet transform (DT-CCT) by using directional filter banks (DFB) into the DT-CWT. The images produced by DT-CCT have improved contours and textures; also the property of shift invariance is retained. For improving the fused image quality, they propose a new method for fusion based on principle component analysis (PCA) which depends on frequency component of DT-CCT coefficients. For low frequency components, PCA method was adopted and for high frequency components, the main features were taken up based on local energy. The final fused image is obtained by directly applying inverse dual tree complex contourlet transform (IDT-CCT) to the fused low as well as high frequency components. The experimental results proved that proposed method produces fixed image with vast features on multimodality [10].

P.Natarajan at. el. proposed a technique for the "Fusion of MRI and CT Brain images using Histogram Equalization". They proposed the histogram equalization method which was useful in images with backgrounds and foregrounds that are both bright or both dark. Also, the method gives better views of the functional and structural parts in MRI as well as in CT images. The noise from images was removed by using adaptive filtering, the system was evaluated and the exact output will be produced. The fusion algorithm of both the foreground images and the background images was studied. Here, the foreground image was Magnetic Resonance Imaging and background image was Computed Tomography image [11].

## 5. Conclusion

Earlier proposed methods suffer from the noise, artifacts and spectral degradation. The average method leads to the undesirable side effects such as reduced contrast. Pyramid methods used for image fusion suffers from blocking artifacts and creates undesired edges, So these different methods shows various advantages as well as disadvantages and provides various results depending on the method to be used.

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