MULTIMODALITY MEDICAL IMAGE FUSION USING IMPROVED
CONTOURLET TRANSFORMATION WITH LOG GABOR FILTERS

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ABSTRACT

Image fusion is the latest concept in Digital image processing. It is a process of combination of two images to produce single image that provide more information. In order to diagnose the disease in medical field, image fusion is one of the best concept that is highly used. Multimodality medical image fusion is an advance technology that is used by doctors to diagnose the particular disease. Most important consideration in image fusion: images to be fused should be registered images i.e. multiple images have same alignment. Main issue in multimodality medical image fusion is how to fuse two or more images of different modalities, so that we get more clear and accurate information. In this paper, we proposed improved contourlet transformation technique with modifying DFBs using log gabor filters will not only provide good quality of images but also localizes an image more accurately and minimizes the DC component(noise in image).

Keywords: CNT, DFBs, Log Gabor Filter, Multimodalities, Medical images fusion.

I. INTRODUCTION

An image fusion can be defined as a process of combining two or more images in one single image without any loss of information. Main objective of image fusion is to merge the complementary and redundant information from different images into one fused images which results in more accurate and clear information. This information can be used for different purposes like human visual and machine perceptions, diagnosis, analysis. Basically there are two image fusion systems. First, Single sensor image fusion system in which we use one sensor that capture multiple images and then fusion them into one image. Imaging sensor has limited capability and does not work in bad environment like clicking an image in fog and rain. Second,
Multisensor image fusion system in which we use multiple sensor devices mainly we use infrared cameras which has capability to work in bad environmental conditions. There are three basic levels of image fusion. Pixel level image fusion is at lowest level and contains detailed information. Feature level we simply extract features of different images that are to be fused and then fuse that features to get new image and at last decision level which consist of compact data. Decision level fusion is effective for complicated systems with multiple true or false decisions but not suitable for general applications. All decision and control are decided according to the result of decision level image fusion [1].

1. **Multimodality Medical Image Fusion**

Medical images are used by doctors to get information about the patient body and to detect any disease. There are several types of diagnostic tools available to capture an image of patient’s body. Different types of medical images like X rays which is used to detect broken bones. CT (computer tomography) provide us structure of bones in patient body. These images are used to provide us detail information regarding body parts. MRI is used to get information about soft tissues, organs in human body. It does not use X rays and radiations that harm to our body. Ultrasound is a safe and less harmful image processing, in which high frequency sound waves are used. PET that stands for positron emission tomography. Medical imaging is an important term in field of research, diagnosis and treatment. Multimodality medical image fusion is a process to merge images that are captured by different modalities such as CT, MRI and PET and which results in more useful information for diagnosis or doctors regarding patient’s body. Various fusion techniques has attracted more researchers in this domain to assist the physicians in fusing and retrieving information from different modalities such as CT, MRI, PET, SPECT and so on[4].

2. **Image Fusion Techniques**

Image fusion techniques can be categories into two domains: spatial domain and frequency domain. In spatial domain we covert an image in the form of matrix and then process it. In frequency domain images are represented in form of signal or sub bands. Here in this paper, we are working in transform domain. Further there are three main types which are discussed below:

2.1 **Laplacian Method**

In this method, input image is decomposed in form of pyramids. Decomposed image is represented into two pyramids: First, Smoothing pyramid contains the average pixel values. Second, Difference pyramid contains the pixel differences that are edges. This pyramid is also known as multi resolution edge representation of the input image [6]. The basic idea behind this is to perform a pyramid decomposition on each source image, then integrate all these decompositions to form a composite representation, and finally reconstruct the fused image by performing an inverse pyramid transform.

2.2 **Wavelet Transformation**

Wavelet transform has been greatly used successfully in many areas, such as texture analysis, data compression, feature detection, and image fusion [5]. Wavelet transformation is basically used to decompose an input image into sub bands. We can apply this transformation in both spatial and frequency domain. But it is always preferred to apply wavelet in frequency
domain in which images are decomposed into frequency sub bands. Multi resolution analysis is done in wavelet transform.

![Wavelet Decomposition](image)

**Fig. 1 Wavelet Decomposition**

In this given figure, 1,2 denote decomposition levels. H denotes High Frequency Bands. L denotes Low Frequency Bands.

### 2.3 Contourlet Transformation

Contourlet transformation is based on pyramid method. It is recently developed transformations used to decompose an image. This method implemented in two stages, first stage is transformation and second stage sub band Decomposition [4]. Image is decomposed into different scale by laplacian pyramids and then DFBs are applied to each decomposed images. An image gets divided into low pass and high passes sub bands. Filtering of these bands is done by directional filter banks (DFBs). This is a part of a multi-dimensional signal processing theory called as Multi scale Geometric Analysis (MGA) Tools [4].

### 3. LOG GABOR FILTER

The “Gabor Filter Bank” is a popular technique used to determine a feature domain for representing an image [3]. The main limitation of Gabor filter is that, it was designed for a bandwidth maximum of 1 octave. So, Field introduced Log Gabor Filter to overcome this limitation. This filter is used for localizing the spatial and frequency information of an image. A Log Gabor Filter has no DC component and can be constructed with any arbitrary bandwidth. Two important characteristics of Log-Gabor filter, First, the Log-Gabor filter function always has zero DC components which not only improve the contrast ridges but also edges of images. Second, the Log Gabor filter function has an extended tail at the high frequency end which allows it to encode images [3]. Log Gabor Filter use logarithmic transformation which eliminates the DC component allocated in medium and high pass filters. We use Fourier transformation in log Gabor filter. This transformation decomposes an image into sin and cosine component. Major applications of FT (Fourier transformation) are image compression, image analysis and image filtering.

\[
G(\rho,0,p,k) = \exp\left(-1/2(\rho p_0/\sigma_0)^2\right)\exp\left(-1/2(0-\theta_{k,p}/\sigma_0)^2\right)
\]
Log Gabor filters consist of complex-filtering arrangement in p orientations and k scales, whose expression in the Log-polar Fourier domain is given in above equation. In this, (ρ, θ) are the log-polar coordinates and (σ_ρ, σ_θ) are the angular and radial bandwidths (common for all the filters). p and k represent the orientation and scale selection respectively.

II. PROPOSED SCHEME

In this paper, we proposed an efficient fusion technique based on contourlet transformation, in which basic assumption is, medical images which are going to fused should be registered to assure that corresponding pixels of images are aligned or similar. Algorithm is given below:
STEP 1: Select two images
STEP 2: Apply multi scale decomposition and Directional Filter Banks over registered images.
STEP 3: Apply multi scale decomposition with Log Gabor filters (modified DFBs) for both images.
STEP 4: Merge the frequencies.
STEP 5: Resultant single fused image.
STEP 6: Calculate PSNR and Standard Deviation for fused image.

III. EXPERIMENTAL RESULTS

![GUI for Medical Image Fusion](image)

Fig. 2 GUI for Medical Image Fusion
Fig. 3 Fusion of medical images using contourlet transformation

Fig. 4 Fusion of medical images using improved contourlet transformation
IV. RESULTS AND CALCULATIONS

After the experiments performed on registered Images in MATLAB, we have realized that above factors determine the quality of fused image. Our technique is better than those of other techniques of image fusion, because this technique provides high quality of information. The quality of image is measured by three factors which are given below:

PSNR computes Peak Signal to Noise Ratio, in decibels, between two images. This ratio is used to provide the quality measurement between two resultant fused images. Efficiency of particular technique is calculated by calculating PSNR value. Higher the PSNR more will be the quality.

\[
\text{PSNR} = 10 \log_{10} \frac{255^2}{\text{MSE}}
\]

Where MSE is calculated as:

\[
\text{MSE} = \sum_{i,j} \frac{(\text{OI}(i,j) - \text{DI}(i,j))^2}{M \times N}
\]

Where OI is fused image with contourlet transformation, DI is fused image with improved contourlet transformation, M*N is number of pixels. More the value of MSE lower the value of PSNR.

SD (Standard deviation) is used to measure the contrast in fused image. An image with high contrast would have high Standard deviation value.

\[
\text{STD} = \sqrt{\frac{1}{MN} \sum_{m=1}^{M} \sum_{n=1}^{N} (F(m,n) - \text{MEAN})^2}
\]

Where M*N denotes the size of an image and f(m,n) indicates the gray-value of the pixel of image f at position(m,n) and

\[
\text{MEAN} = \frac{1}{MN} \sum_{m=1}^{M} \sum_{n=1}^{N} |F(m,n)|
\]  

Table1. Calculation of PSNR, Standard deviation and Quality index values by applying contourlet and improved contourlet transformation.

<table>
<thead>
<tr>
<th>S. NO.</th>
<th>Technique</th>
<th>PSNR</th>
<th>Standard Deviation</th>
<th>Quality Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contourlet transformation</td>
<td>29.6515</td>
<td>55.367</td>
<td>71.6595</td>
</tr>
<tr>
<td>2</td>
<td>Improved Contourlet transformatio n</td>
<td>34.2325</td>
<td>78.9019</td>
<td>111.1285</td>
</tr>
</tbody>
</table>
V. CONCLUSION

Our proposed scheme is applied on medical image fusion. There are number of techniques have been proposed for image fusion; like wavelet transformation, laplacian pyramid method, contourlet transformation, curvelet transformation. The proposed fusion technique is evaluated on the multimodality medical images to fuse them with better quality so that there is no loss of information. And can be send to doctors without any loss of information with better quality. From series of experiments we have concluded that our proposed technique is yielding higher PSNR value then other techniques mentioned above.

REFERENCES

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