

Medical Image Fusion of PET and MRI Images

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Abstract— Medical image fusion is a process of gathering relevant data information from two or more images, the important information from the images sources is taken which results in having better or more reliable medical image. The Paper present medical image fusion in transform domain by using NSST (Non-Sampled Shearlet Transform). The Entropy for the decomposed bands of NSST based on the PCNN. The new fusion rule gave better fused image. Entropy is used to assess the performance of the proposed algorithm. The two images (MRI, PET) are used for the fusion by using NSST by using the proposed algorithm the decomposed band which contains higher information is present in the fused image. Finally, both the image is fused based on the NSST and PCNN of the system.

I. INTRODUCTION

With the developments in the medical imaging equipment's, which can have different modalities of imagining techniques like X-ray which is used to display the bones, Computed Tomography (CT) which can be used to display the hard tissues, Magnetic Resonance Tomography (MRI) which can display the soft tissues, Positron Emission Tomography which can display the physiology and pathology contents. By using medical image fusion, the information present in the fused image is better than the original source image, so the diagnosis will be easy and also the image fusion is used in different applications like space research, defence, remote sensing etc. By using the transform domain, images are transferred from time domain to frequency domain. Wavelet Transform are the multi-resolution image decomposition tool that provides different types of channels representing of image features by using different frequency sub-bands. When the decomposition on the image is performed the detailed and approximation coefficients are separated. The DWT and SWT will first convert the image from spatial domain into transform domain. This domain conveys the sharpness and edges. DWT is proven to be efficient in 1-D singularity, which gives better spectral contents. It is a shifted variant, so DWT transform require down sampling. The draw back with the DWT is limited directionalities. The DWT is not time invariant transform, the way to get back [5] the invariance is by using un-decimated DWT that is called SWT. Many researchers have developed different algorithms performed on the transforms like average and maximum. The proposed algorithm edge and energy gave better results than the average and maximum method. In the edge and energy method the higher edges information and the higher energy of the decomposed bands are used for the fusion which gives better performance than the average and maximum method.

1.1 DWT

The wavelet transform quantifies the matching of the signal with wavelets [1]. If the values of the signal match with the wavelet value, then the greater values of the transform are obtained. If the values of the signal do not match with the signal lesser values of the transform is obtained. It is used to detect the regional characteristics of the image. The DWT decomposes the image into bands by using decimation. The 2-D transform is obtained by using two 1-D transforms. The source or input images is firstly filtered along the rows and then decimated by two then the filtering of the input or source image by columns. The decomposition of the input image gives the following sub-bands. The size of the sub-bands is half of the original signal. To get this scaling is implemented. DWT is a multi-resolution transform. LL band is almost like a spatial image. Higher bands represent various frequencies. The decomposition and reconstruction of the image is done by using 'db2'. The 2-D wavelet is given as:

$$\varphi_{\phi}(j, u, v) = \frac{1}{\sqrt{N \times N}} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x, y) \phi_{j,u,v}(x, y) \quad (1)$$

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where as scaling function is

$$\phi_{j,u,v}(x, y) = 2^j \phi(2^j x - u, 2^j y - v)$$

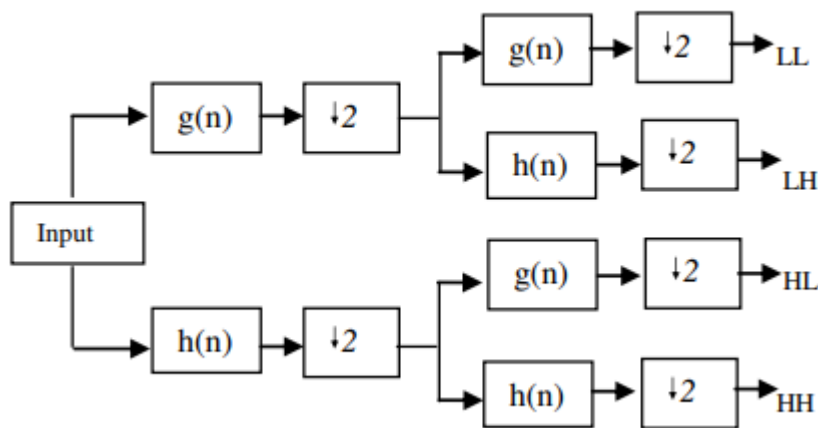


FIGURE 1: DWT Decomposition

1.2 SWT

The SWT is called as un-decimated DWT, it does by up sampling the signal instead of down sampling by adding zeros in between the filter coefficients [5]. The algorithm in which the zeros are added in between the filter coefficients is called as ‘trous’ which means with holes. In SWT the decomposed image will give sub-bands with one approximation coefficients and three detailed coefficients of the images. The size of the sub-bands will be same as the size of the original or input image. The approximation coefficients of images from the undecimated algorithm are therefore represented as the levels in a parallelepiped [6], with the spatial resolution of the image becoming coarser at every higher level so the size of the sub-band remains the same the 2D-SWT is on the idea without using the decimation. It applies the Discrete wavelet transform but without the down sampling during the decomposition and applies up-sampling during the reconstruction by using inverse transform. To be précised, it applies transform at every point of the image and saves the detailed coefficient and uses low frequency information at every level [5].

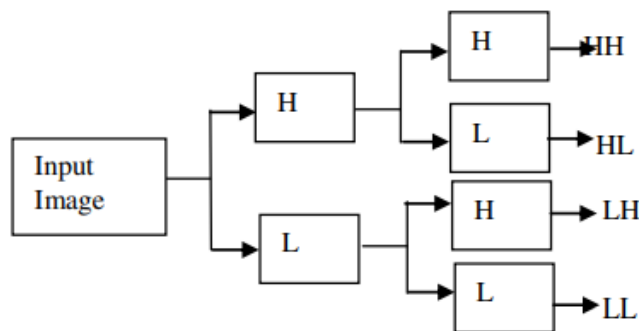


FIGURE 2: SWT Decomposition

1.3 Proposed NSST and Pcnm

1.3.1 NSST

Shearlets offer a unique combination of very remarkable features: they have a simple and well-understood mathematical structure derived from the theory of affine systems, they provide optimally sparse representations, in a precise sense, for a large class of images and other multidimensional data where wavelets are suboptimal and the directionality is controlled by shear matrices rather than rotations. This last property, in particular, enables a unified framework for continuum and discrete setting since shear transformations preserve the rectangular lattice and is an advantage in deriving faithful digital implementations. The shearlet decomposition has been successfully employed in many problems from applied mathematics and signal processing, including decomposition of operators, inverse problems, edge detection , image separation , and image restoration. NSST is the shift-invariant version of shearlet transform, which can capture 2-D geometrical structure much more effectively than that traditional multi-scale transforms, When the NSST is introduced into the image fusion field, more

information for fusion can be obtained and the impacts of miss-registration on the fused results can also be reduced effectively. Moreover, the computational complexity of NSST is lower than that of the NSCT. A non-sub-sampled shearlet transforms is the very good technique for the image fusion provide a high-quality spectral content, Hence NSST has stronger selectivity of anisotropic direction, higher computational efficiency, and provides additional information about the geometry of the set of singularities such as edges and other discontinuities compared to NSCT. Therefore, NSST is more applicable in various applications of image fusion.

1.3.2 PCNN:

Pulse-coupled networks or pulse-coupled neural networks (PCNNs) are neural models proposed by modelling a cat's visual cortex, and developed for high-performance of image processing. Over the past decade, PCNNs have been used in a variety of image processing applications, including are image segmentation, feature generation, face extraction, motion detection, region growing, and noise reduction. A PCNN is a two-dimensional neural network. Each neuron in the network corresponds to one pixel in an input image, receiving its corresponding pixel's color information (e.g. intensity) as an external stimulus. Each neuron also connects with its neighbouring neurons, receiving local stimuli from them. The external and local stimuli are combined in an internal activation system, which accumulates the stimuli until it exceeds a dynamic threshold, resulting in a pulse output. Through iterative computation, PCNN neurons produce temporal series of pulse outputs. The temporal series of pulse outputs contain information of input images and can be used for various image processing applications, such as image segmentation and feature generation. Compared with conventional image processing means, PCNNs have several significant merits, including robustness against noise, independence of geometric variations in input patterns, capability of bridging minor intensity variations in input patterns, etc.

1.3.3 Proposed Algorithm

For performing the fusion rules firstly, we need two different input images, here I considered the MRI, PET images of the same source. The pre-processing for the input images has been done by making the size of all the input images to be same i.e., 256*256.

Step-1: - Applying transform to the input images which decomposes the input image to sub-bands namely Low pass and Band pass Band

Step-2: -Applying proposed fusion rule that is calculating the entropy information of the low level subband and calculating the energy for the other sub-bands. In the proposed algorithm based on the neural network is calculated by using the PCNN.

Step-3: Finally, the image will be fused based on the MRI and PET images.

II. LITERATURE REVIEW

Multimodal Medical Image Fusion using NSCT and DWT Fusion Frame Work

K. Koteswararao, K. Swamy – 2019

Image fusion is the process, which gathers significant details from two or more images. In the image fusion important information is selected from multiple images. Implementation of fusion of images is carried out either in spatial or in transforms domains. In this work, fusion is done in both domains to get better performance. Energy of decomposed bands of NSCT is used to select important bands in NSCT based image fusion. Energy of decomposed bands of DWT is used to select important bands in DWT based image fusion. Fused images of NSCT and DWT are further fused by using spatial domain technique. In spatial fusion ESOP values are taken into consideration to perform fusion. Experiments are done on several medical images .Experiments show that, the proposed method is giving perceptually meaningful fused images. Image metrics like entropy, edge-based similarity measure and quality of mutual information have been used for the assessment of performance of the work. In this research work, two medical images (CT, MRI), after pre-processing, will be merged according to the wavelet and NSCT transformations using energy fusion techniques to generate two independent fusion images that will be merged again using spatial domain to get the desired output. In this way the large amount of comprehensive information can be presented in the merged image, all the comprehensive information obtained from the two medical images appears in the final output. The experimental outcomes on different CT and MRI images are analyzed qualitatively and quantitatively. Image fusion has been implemented in the various applications like remote sensing, space research, defence, medical imaging etc. The performance parameters show remarkable improvements. Collapse.

A Review of Quality Metrics for Fused Image

Author: Jagalingam Pa, ArkalVittal Hegde - 2020

Image fusion is the process of combining high spatial resolution panchromatic (PAN) image and rich multispectral (MS) image into a single image. The fused single image obtained is known to be spatially and spectrally enhanced compared to the raw input images. In recent years, many image fusion techniques such as principal component analysis, intensity hue saturation, Brovey transforms and multi-scale transforms, etc., have been proposed to fuse the PAN and MS images effectively. However, it is important to assess the quality of the fused image before using it for various applications of remote sensing. In order to evaluate the quality of the fused image, many researchers have proposed different quality metrics in terms of both qualitative and quantitative analyses. Qualitative analysis determines the performance of the fused image by visual comparison between the fused image and raw input images. On the other hand, quantitative analysis determines the performance of the fused image by two variants such as with reference image and without reference image. When the reference image is available, the performance of fused image is evaluated using the metrics such as root mean square error, mean bias, mutual information, etc. When the reference image is not available the performance of fused image is evaluated using the metrics such as standard deviation, entropy, etc. The paper reviews the various quality metrics available in the literature, for assessing the quality of fused image.

Medical Image Fusion using NSCT

K. VeeraSwamyI, B. Ashwanth - 2020

Image fusion is a process of extracting needed or important useful information from two or more images and fusing into a single or one image. This process results to a better image which contains more detailed information compared to the source or input images. General fusion techniques are not considering the edge and energy information which is very important information in the image. The fusion techniques using average and maximum rule techniques fail to fuse important edge information present in the source images. Further, energy available in the source images is also not considered. Hence, quality of the fused image is affected. To address these problems, edge and energy-based technique is explored. In this paper we are comparing the average and maximum fusion rule and Edge and Energy fusion rule for NSCT (Non-Sub-sampled Contourlet Transform) and comparing this transform with DWT and SWT. We are using the PET (Positron Emission Tomography) and MRI (Magnetic Resonance Imaging) images as the source images. The performance is assessed using metrics called Entropy.

Image Fusion using NSCT Theory and Wavelet Transform for Medical Diagnosis

Anju P J, Dr.D.Loganathan - 2016

Image fusion is the process of combining relevant information from two or more images to produce a single fused image. Medical image fusion is mainly a multi modal image fusion where images from different modes such as Computed Tomography (CT), Magnetic Resonance Image (MRI), and Positron Emission Tomography (PET) etc. are fused for diagnosis purpose. The classification of image fusion is wide and vibrant. Some of the popular medical image fusion methods are discussed and comparative study is made. A new method for medical image fusion which combines Nonsubsampled Contour let Transform (NSCT) and wavelet transform is proposed.

Intelligent Multimodal Medical Image Fusion with Deep Guided Filtering

B. Rajalingam, Fadi Al-Turjman, R. Santhoshkumar&M. Rajesh- 2020

Medical image fusion is a synthesis of visual information present in any number of medical imaging inputs into a single fused image without any distortion or loss of detail. It enhances image quality by retaining specific features to improve the clinical applicability of medical imaging for treatment and evaluation of medical conditions. A big challenge in the processing of medical images is to incorporate the pathological features of the complement into one image. The fused image presents various challenges, such as existence of fusion artifacts, hardness of the base, comparison of medical image input, and computational cost. The techniques of hybrid multimodal medical image fusion (HMMIF) have been designed for pathologic studies, such as neurocysticercosis, degenerative and neoplastic diseases. Two domain algorithms based on HMMIF techniques have been developed in this research for various medical image fusion applications for MRI-SPECT, MRI-PET, and MRI-CT. NSCT is initially used in the proposed method to decompose the input images which give components of low and high frequency. The average fusion rule applies to NSCT components with low frequency. The

NSCT high frequency components are fused by the law of full fusion. NSCTs high frequency is handled with directed image filtration scheme. The fused picture is obtained by taking inverse transformations from all frequency bands with the coefficients obtained from them. The methods suggested are contrasted with traditional approaches in the state of the art. Experimentation proves that the methods suggested are superior in terms of both qualitative and quantitative assessment. The fused images using proposed algorithms provide information useful for visualizing and understanding the diseases to the best of both sources' modality.

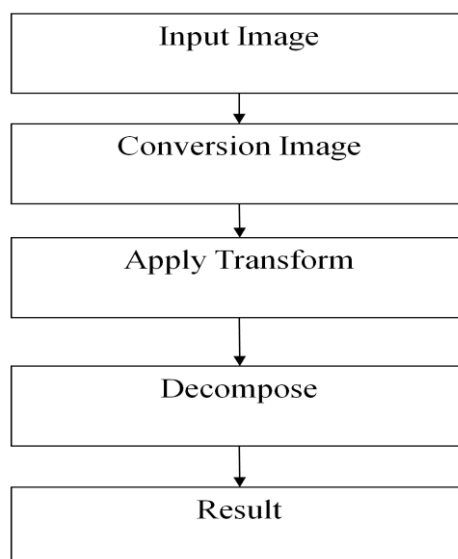
Problem Statement

- In our existing method, the Paper present medical image fusion in transform domain by using DWT (Discrete Wavelet Transform) and SWT (Stationary Wavelet Transform).
- The edge and energy rule for the decomposed bands of DWT, SWT based image fusion are performed.
- The new fusion rule gave less performance to obtain the fused image.
- Entropy is used to assess the performance of the existing method of the system.
- The two images (MRI, PET) are used for the fusion by using DWT, SWT by using the image processing.
- But, in our existing method the fusion not come in accurate results.

Disadvantages

- Fusion not in proper way
- Inefficiency
- Less performance

III. METHODOLOGY



3.1 Input Image

Input Image is based on the two types of image will be obtained. First image will be taken the MRI image then the second image will be taken Pet scans images. Both type of the image is taken to process it. A function of MRI scan image to useful for imaging the brain, the spine, the soft tissue of joints, and the inside of bones. Also called magnetic resonance imaging, NMRI, and nuclear magnetic resonance imaging. MRI can be used to detect brain tumours, traumatic brain injury, developmental anomalies, multiple sclerosis, stroke, dementia, infection, and the causes of headache. Magnetic resonance imaging (MRI) scans produce detailed images of the organs and tissues in the body. A positron emission tomography (PET) scan is an imaging test that allows your doctor to check for diseases in your body. The scan uses a special dye containing radioactive tracers. These tracers are either swallowed, inhaled, or injected into a vein in your arm depending on what part of

the body is being examined. Certain organs and tissues then absorb the tracer. When detected by a PET scanner, the tracers help your doctor to see how well your organs and tissues are working. The tracer will collect in areas of higher chemical activity, which is helpful because certain tissues of the body, and certain diseases, have a higher level of chemical activity. These areas of disease will show up as bright spots on the PET scan. The PET scan can measure blood flow, oxygen use, how your body uses sugar, and much more.

3.2 Conversion Image

Here, the conversion part takes place the grey scale conversion of the image. To implement the algorithm to the input image, first to convert the gray scale image.

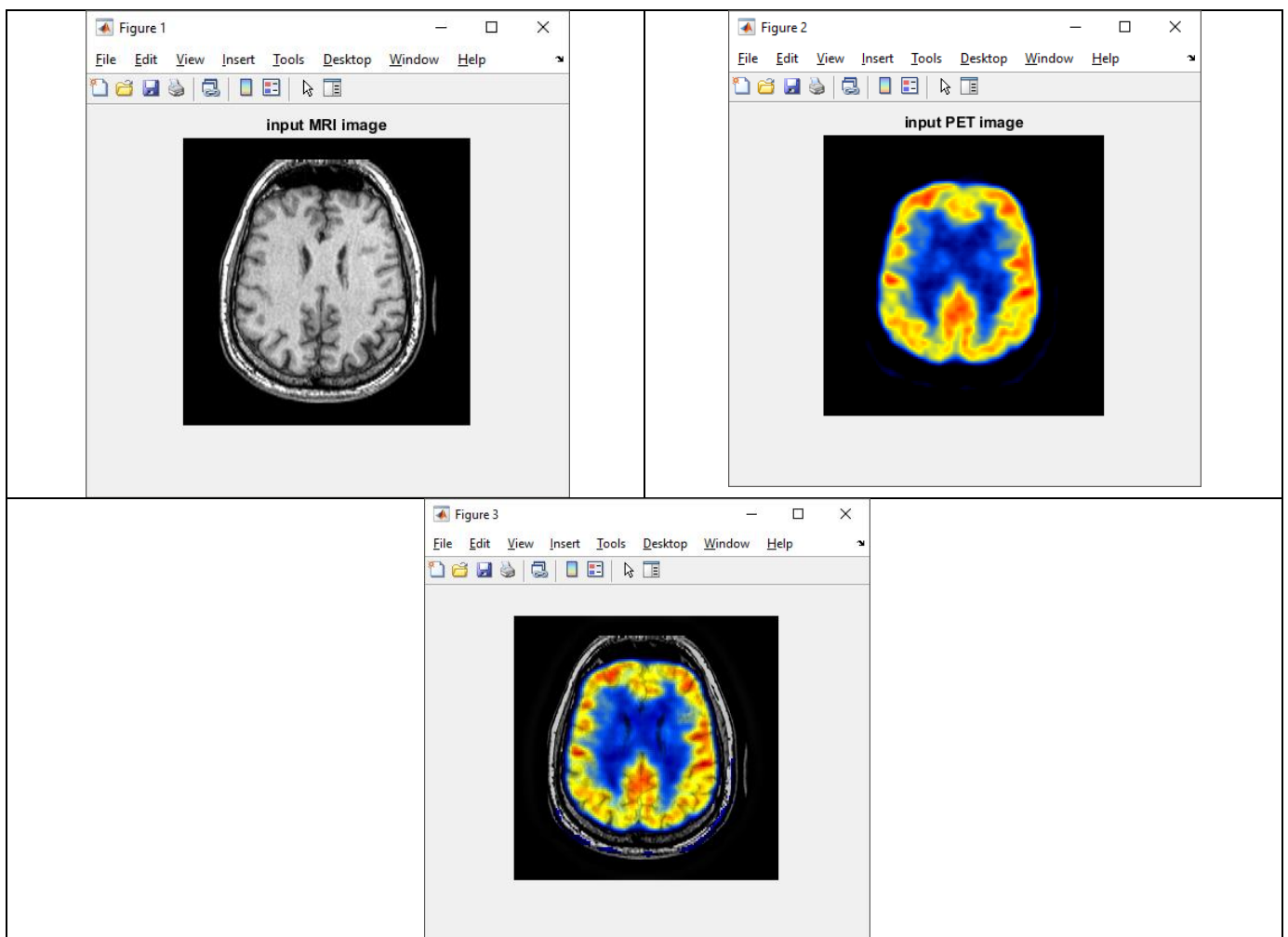
3.3 Apply Transform

After, complete the conversion techniques, next to apply the transform based on the NSST. A NSST is one type of technique is used in the Image Processing Toolbox. Also it have very good technique for the image fusion provide a high quality spectral content, Hence NSST has stronger selectivity of anisotropic direction, higher computational efficiency. A non-sub-sampled shearlet transform (NSST) is found to be best algorithm for image fusion.

3.4 Decompose

After, to apply the transform then to decompose the image into some level based on the Pixel range of the system. Here, the 5 times to decompose the image based on the input requirement. Decompose image obtained the some band based upon the low pass and band pass of the system. Next, to calculate the entropy based on the mean, median and gradient value. Finally, the entire image will be reconstructed based on the input requirement. The Results will be shown the Fused image of the system.

IV. IMPLEMENTATION



V. CONCLUSION

Image fusion using PCNN and NSST is implemented in transform domain. LL Higher bands band selection is based on input of two images. Entropy is obtained the parameter of mean and median and gradient of the image based on the pixel. This method can be extended by decomposing into several levels. Experiments are performed NSST and PCNN. The results, shown the better performance, when compared to the other techniques.

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