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MULTIMODAL IMAGE FUSION BY USING NON-SUBSAMPLED CONTOURLET TRANSFORM

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Abstract - *Medical image fusion is the process of combining two different modality images into single image. This resultant image is helpful in medical field for efficient disease diagnoses, retrieval of images, undergo surgery treatment, tumor identification etc. This single image features cannot be obtained from the single modality medical images and it can be resolved by image fusion.*

In this project a new hybrid algorithm will be developed based on non-sub sampled contourlet transform for directive contrast based multimodal medical Image Fusion.

By using proposed techniques, Magnetic Resonance Image (MRI) and Positron-emission tomography (PET) images will be fused and it will be compared with existing techniques using quantitative and qualitative measures.

The validation of the algorithms will be done by using quantitative measures such as Entropy (EN), Normalized Correlation Coefficient (NCC) and Structural Similarity Index (SSIM).

Key Words: **MRI, PET, NCC, Entropy, NSCT**

1. INTRODUCTION:

The word image is also used in the broader sense of any two-dimensional figure such as a map, a graph, a pie chart, or an abstract painting, carving, rendered automatically by printing or computer graphics technology, or developed by a combination of methods, especially in a pseudo-photograph. An image is a rectangular grid of pixels. It has a definite height and a definite width counted in pixels. Each pixel is square and has a fixed size on a given display.

However different computer monitors may use different sized pixels. The pixels that constitute an image or ordered as a grid (columns and rows); each pixel consists of numbers representing magnitude of brightness and color.

Fig. 1. Color representation of a pixel

2. IMAGE PROCESSING:

Digital image processing is the process that uses the computer algorithms to perform processing on digital images. It has many advantages over image processing. Digital images are usually obtained by converting continuous signals to digital format. They are viewed using diverse display media including digital printers, computer monitors and so on. The frequency with which information is transmitted, stored, processed and displayed in the digital visual format is increasing rapidly.

The objective of this chapter is to give an idea of image processing by examining some of the principal areas in which it is applied. The principal approaches discussed in this chapter include digital image representation, overview of the tasks contained in an image processing system and reconstruction of an image using the magnitude and phase information of the Fourier Transformed image. Description of the image statistics such as average brightness, standard deviation, Signal to Noise ratio (SNR), Mean Square Error (MSE) etc., used in image processing are also discussed.

2.1 MEDICAL IMAGING

Medical images are the images which represents body structures for diagnosis and treatment for patients. They capture definite body parts image which show hard structures like bones and soft tissues and also blood flow in the body. It is useful for identifying tumours, fractures in bones or skull.

Medical imaging technology has revolutionized health care over the past 30 years, allowing doctors to find disease earlier and improve patient outcomes. That's why the New England Journal of Medicine ranked imaging as one of the top medical developments of the past 1,000 years. From physicians and patients to professional organizations and peer-reviewed journals, those who have evaluated and experienced medical imaging know its immense benefits, both personally and empirically.

2.2 TYPES OF MEDICAL IMAGES

In medical imaging, a Diagnostic Radiographer/Medical Imaging Technologist is a key member of the health care team. They are responsible for producing high quality medical images that assist medical specialists and practitioners to describe, diagnose, monitor and treat a patient's injury or illness.
Here we majorly deal with images like.

- MRI- for soft tissues, organs
- PET- for blood vessels and tissues
- CT(X ray) - for structure of bones
- SPECT- for detection of blood flow in brain, can provide 3D information.

What does an MRI show?

Nearly every part of the body may be studied with MRI. MRI gives very detailed pictures of soft tissues like the brain. Air and hard bone do not give an MRI signal so these areas appear black. Bone marrow, spinal fluid, blood and soft tissues vary in intensity from black to white, depending on the amount of fat and water present in each tissue and the machine settings used for the scan. The radiologist compares the size and distributions of these bright and dark areas to determine whether a tissue is healthy.

Fig.2.1 MRI of the brain.

Positron Emission Tomography (PET):

A positron emission tomography (PET) scan is a type of nuclear imaging test that shows the metabolic activities (energy usage) of your brain. While X-ray, CT, and MRI scans look at the anatomy of your brain, a PET scan can give your doctor information about how your brain is working.

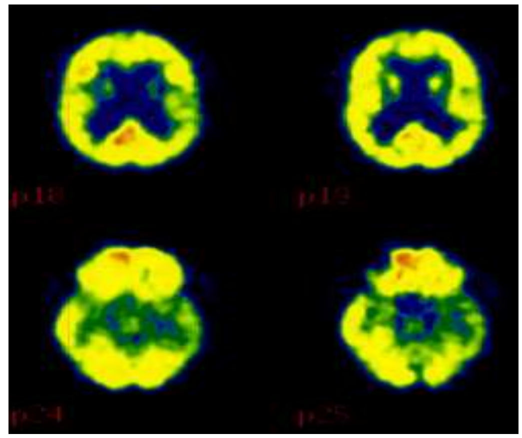

Fig 2.2: PET SCAN

3. MEDICAL IMAGE FUSION :

The term Image fusion is used when multiple images of a patient are registered and overlaid or merged to provide additional information. Fused images may be created from multiple images from the same imaging modality or by combining information from multiple modalities, such as magnetic resonance image (MRI), computed tomography (CT), positron emission tomography (PET), and single photon emission computed tomography (SPECT).

In radiology and radiation oncology, these images serve different purposes. For example, CT images are used more often to ascertain differences in tissue density while MRI images are typically used to diagnose brain tumours.For accurate diagnoses, radiologists must integrate information from multiple image formats. Fused, anatomically consistent images are especially beneficial in diagnosing and treating cancer. With the advent of these new technologies, radiation oncologists can take full advantage of intensity modulated radiation therapy (IMRT). Various modal images and their combinations using image fusion techniques.

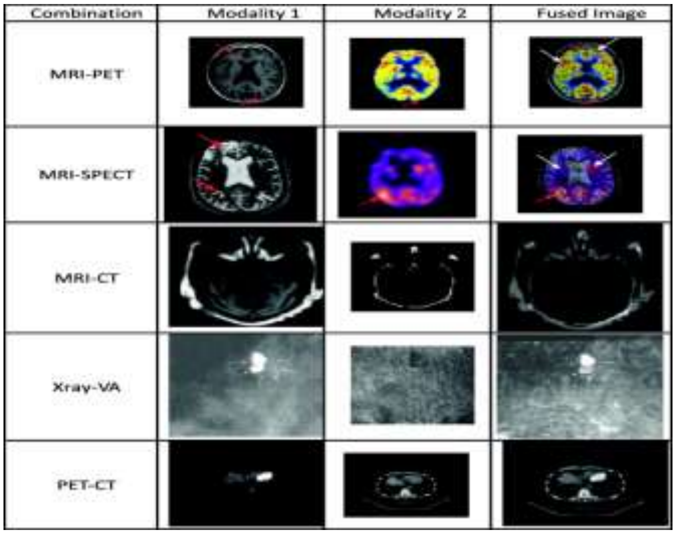

Fig. 3: various images and their fusion combinations

3.1 IMAGE FUSION USING NSCT

This paper is organized as follows:

- presents different medical image fusion techniques
- tables a comparative study of above described techniques,
- discuss the image fusion on Non-subsampled counter let transform(NSCT)
- describes the enhancement to existing system and performance comparison
- Conclude the paper.

3.2. MEDICAL IMAGE FUSION TECHNIQUES

3.2.1 Principal Component Analysis (PCA)

It is a simple non -parametric method for drawing out pertinent information from confusing data sets. PCA find application in multivariate data analysis. It is a vector space transform used to limit multi-dimensional data sets to lower dimensions for examinations.

The algorithm involves these steps:

(i) Generate column vectors from input image matrix.

(ii) Find covariance matrix for the two column vectors formed from above

(iii) Determine the Eigen vectors and Eigen values of covariance vector and then obtain the Eigen vector corresponding to larger Eigen values

(iv) Compute the normalized components from the Eigen vectors

(v) The fused image is the summation of two scaled matrices from above step .

3.2.2. The Framework for the model

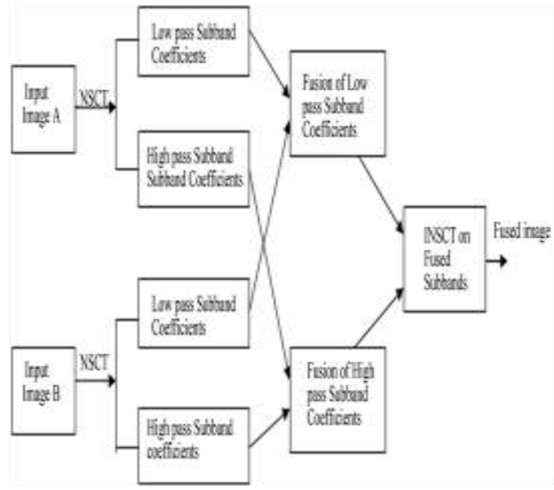

Fig.3.1: Frame work for the fusion model

4. COMPARISON OF VARIOUS FUSION TECHNIQUES:

Here we have made comparison of the medical image fusion methods discussed in above.

Table 4.1: Calculation Of Required Parameters Values For Performance Evaluation

Fusion method	Advantages	disadvantages
Principal Component Analysis (PCA)	Simple method, reduces the number of dimensions, without much loss of information.	Produce the spectral degradation
Wavelet Transform (WT)	Minimizes the spectral distortion, provide better signal to noise ratio	Final fused image has less spatial resolution.
Contrast pyramid	No chance for spatial Degradation	Performance depends on no. of decomposition levels
ShearletTransform (ST)	Multi-directionality, avoids noises in fused images efficiently.	Complex and high time complexity

Entropy:

Entropy of grayscale image

Syntax

E = entropy(I)

Description

E = entropy(I) returns E, a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as

-sum(p.*log2(p))

where p contains the histogram counts returned from imhist. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays.

It can be a multidimensional image. If I has more than two dimensions, the entropy function treats it as a multidimensional grayscale image and not as an RGB image.

Examples

I = imread('circuit.tif'); J = entropy(I)

4.1 Matlab as a tool for data analysis:

What about looking at data in Matlab? Usually, data comes in tables. For example, some observation as a function of time is observed, such as the average temperature as a function of a month.

This data will have two columns, one for the month and another for the value of a temperature. Or several replicates on an experiment where the average wait of some organisms was observed in environment with different food levels.

This data can be recorded as a table with the number of rows equal to the number of replicate experiments and the number of columns equal to the food levels tasted.

A mathematical term for the table is a matrix. Matlab deals with matrices very well. Let's create want in a matrix. Suppose we want to create a matrix of ones with 2 rows and 3 columns. To do this, type ones(2,3). The Matlab will return temp (i, l)=80*rand twelve times, where i is a number between 1 and 12.

To do this

In Matlab type:

For i=1:12,

Temp(i,l)=80*rand;

End

Now type temp.a row of 12 random numbers between 0 and 80 is obtained. Now, what has just happened? A for loop is made. "For loop" performs an operation several times.

As seen, it starts with the word for and ends with the word end. Let's translate the line of code to English: for i=1:12 means let i be 1, then 2, then 3, etc. until i=12 and perform the command temp(i,l)=80*rand; for each value of i. Note that there is a comma after 12 to signify that what follows is the command what is to be performed. End a command with a semicolon.

5. RESULTS AND DISCUSSIONS:

Showing MRI image using "imshow" instruction.

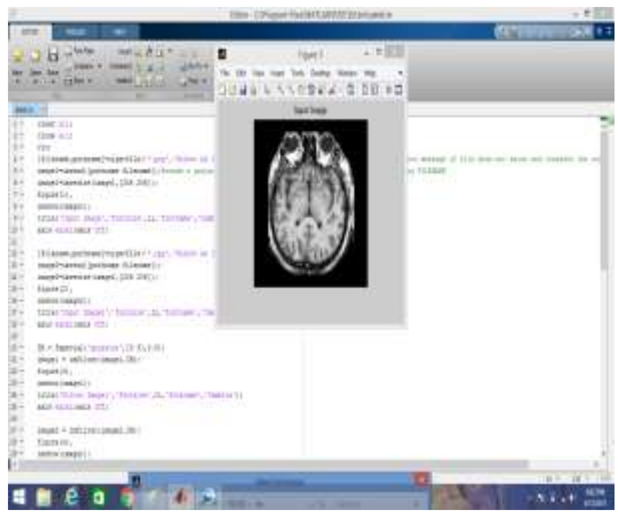

Fig 5.1 : MRI image

Displays PET image on the screen.

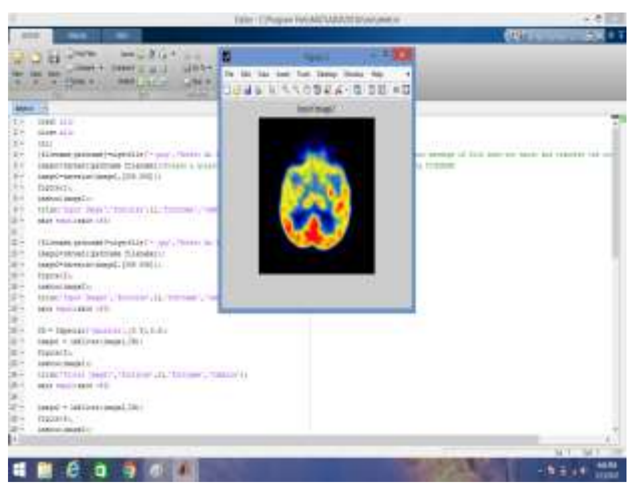

Fig 5.2: PET Image

Fusion of approximation is applied at this stage. The fused image using NSCT is displayed here.

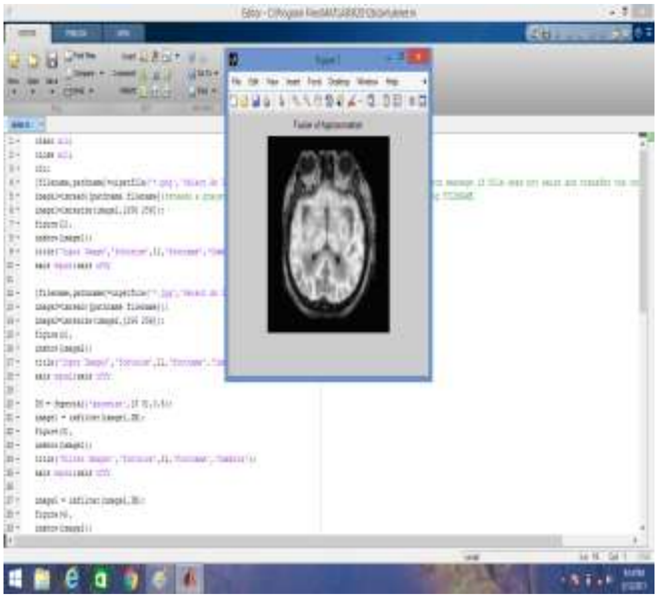

Fig 5.3 : The fused image

The outputs of image fusion techniques using NSCT method and wavelet method is shown below.

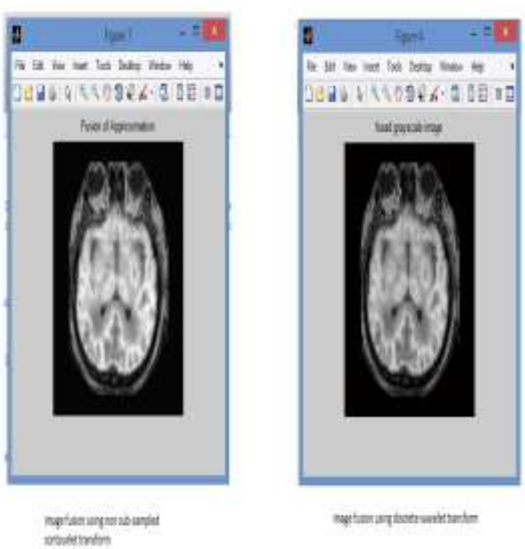

Fig 5.4: fused image using NSCT i

As per the results we have obtained the values of entropy like, for a dwt fused image, entropy(h)= 3.857 and for NSCT fused image entropy = 3.93. As entropy defines the 'business' of the image , low entropy images have little contrast but run on large pixels(poor quality with large size) and high entropy images have a high contrast and are easy/better to distinguish the color differences of structures. So due to high entropy of NSCT fused image, It helps doctors for clear vision for better identification of tissues for diagnosis as compared to dwt fused image.

In the same way, we have calculated structure similarity index of both the NSCT and dwt based fusion output images with reference input MRI image.

Mean SSIM for dwt fused image is 0.7948 and for NSCT fused image is 0.0365, originally the value of SSIM must lies between -1 to +1, so we have obtained valid values for both methods, butmore the value of SSIM indicates less image quality degradation after image processing. But in NSCTcase, lower value of Structure similarity with MRI image may indicate better fusion between MRI and PET and color information of PET is more in the fused image compared to MRI information resulting in lower value of Mean SSIM.

5.1 APPLICATIONS AND USES OF IMAGE FUSION

- ✓ Fusion is basically used remote or satellite area for the proper view of satellite vision
- ✓ It must use in medical imaging where disease should analyses through imaging vision through spatial resolution and frequency perspectives.
- ✓ Image fusion used in military areas where all the perspectives used to detect the threats and other resolution work based performance.
- ✓ For machine vision it is effectively used to visualize the two states after the image conclude its perfect for the human vision.
- ✓ In robotics field fused images mostly used to analyze the frequency variations in the view of images.
- ✓ Image fusion is used in artificial neural networks in 3d where focal length varies according to wavelength transformation.

6. Conclusion:

In this project, a novel image fusion framework is proposed for multi-modal medical images, which is based on non-sub-sampled contourlet transform and directive contrast. For fusion, two different rules are used by which more information can be preserved in the fused image with improved quality. The low-frequency bands are fused by considering phase congruency whereas directive contrast is adopted as the fusion measurement for high-frequency bands. In our experiment, two PET and MR brain images are fused using conventional fusion algorithms and the proposed frame-work.

The visual and statistical comparisons like calculating the entropy, structure similarity index (SSIM) demonstrate that the proposed algorithm can enhance the details of the fused image, and can improve the visual effect with much less information distortion than its competitors (several existing methods like principal component analysis (PCA), wavelet transform and others). These statistical assessment findings agree with the visual assessment.

6.1 FUTURE SCOPE OF THE PROJECT:

- ✓ With this successful image fusion technique using NSCT, this can extend to a new invention.
- ✓ A machine which replaces all existing imaging scanners which has existing imaging mechanism along with fusion mechanism resulting in fused image output which is helpful for doctors to treat patients more effectively.

Expected model for new invention:

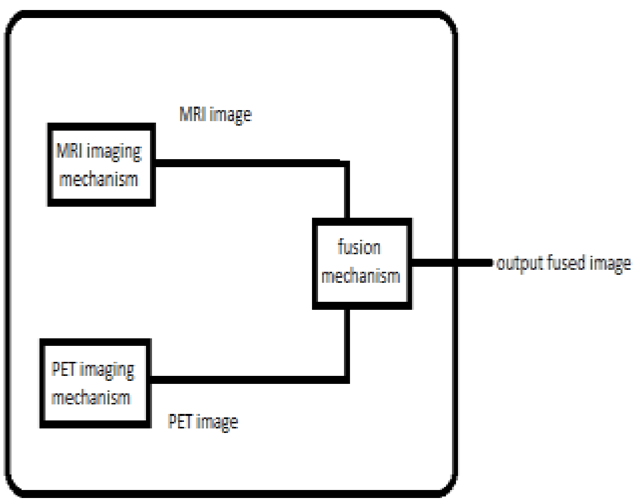

Fig 10: expected model

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