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Optimized Wavelet Based Medical Image Fusion for Broken Bones

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ABSTRACT: The image fusion scheme presented in this research, the wavelet transforms of the input images are appropriately combined the new image is obtained by taking the inverse wavelet transform of the fused wavelet coefficients. The idea is to improve the image content by fusing images like computer tomography (CT) and magnetic resonance imaging (MRI) images, so as to provide more information to the doctor and clinical treatment planning system. Research aims to demonstrate the application of wavelet transformation to multi-modality medical image fusion. This work covers the selection of wavelet function, the use of wavelet based fusion algorithms on medical image fusion of CT and PET implementation of fusion rules and the fusion image quality evaluation. In the proposed scheme, the segments are detected in enhancing low contrasted medical images. This was done by accurately detecting the positions of the edges through finding bone edges. Applying morphological filter using flat structuring elements then sharpened the detected edges. By utilizing the detected edges, the system was capable to effectively segmenting the bones with fine details while retaining image integrity.

KEYWORDS: Wavelet, Computer Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET)

I. INTRODUCTION

Imaging has undergone certain developments with the advancement of science and technology. The reason why an image can be digitized is to be transformed into computer memory storable or other forms media storage such as CD-ROM or hard disk. Digital image is a representation of a double-dimensional image as a limited set of digital values known as pixels or picture elements. The digitization procedure can be conducted through a scanner or video camera. Once an image is digitized, it can be done using different image processing operations. Digital image processing lays emphasis on two main tasks namely amelioration of pictorial information for the purposes of human interpretation and processing of data image for storage, representation, and transmission for independent machine perception.

Image Fusion: Image fusion is the process by which input images are fused in order to increase the quality. The input images must be the images of the same scene with different quality measures. The quality of the output image will be better than any of the input images. The main methods of the image fusion involve simple image fusion, pyramid based image fusion and wavelet based image fusion. Image fusion methods can be used in areas of medical imaging, remote sensing, entertainment etc.

Advantages of Image Fusion

- Improve reliability (by redundant information).
- Improve capability (by complementary information).

Objective

- CT scans and PET scans contain details regarding soft and hard tissues. For medical diagnosis, CT provides the better information on denser tissue with less distortion, while PET offers better information on soft tissue

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with more distortion .For Medical applications, these CT and PET images needs to be fused with high efficiency for diagnosis purpose. Hence medical image fusion has been very important.

II. LITERATURE REVIEW

Computerized Tomography

Computerized tomography (CT) is a medical imaging technique that has made a prominent impact on medical diagnosis and assessments. This is a popular modality used in multi-modal medical image fusion [6]. Similar to MR images, the CT images are used in a vast range of medical applications under practical clinical conditions. Computerized assessment using CT images has been one of the early attempts towards modern medical imaging.

Positron Emission Tomography

Positron emission tomography, widely known as PET imaging or a PET scan, is a useful type of nuclear medicine imaging. Here, we discuss some application areas where PET is a prime modality considered in the data fusion. Similar to CT and MRI, a major application of PET is in radiology studies for brain diagnosis and treatment [17].

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.

III. RESEARCH METHODOLOGY

Proposed System

Wavelets are finite duration oscillatory functions with zero average value. They have finite energy and hence are suited for analysis of transient signal. Wavelets can be described by using two functions namely the scaling function f(t) or father wavelet and the wavelet function ψ(t) or mother wavelet. A number of basis functions can be used as the mother wavelet for Wavelet Transformation. The mother wavelet through translation and scaling produces various wavelet families which are used in the transformation.

Image Pre-processing: Pre-processing step involves inverting image colours. Inverting image colours means flipping the values of each colour in an image. Flipping values requires reading the pixels of a bitmap and writing back new RGB values the simplest way is to use GDI+ to access pixels and invert the image.

Edge Detection

Mean: The average intensity of a region is defined as the mean of the pixel intensities within that region. The mean μ_z of the intensities over M pixels within a region K is given by Equation

$$\mu_z = \frac{1}{M}\sum_{i=1}^{M} x_i$$

Mean

Edge Detection RGB Colour Histograms

Input: Image of variable size

Output: Edge regions

1. RGB is applied on an image and approximation band is considered.
2. Histogram Based methods is applied to obtain initial parameters like mean, variance and mixing parameter
3. Shaping parameter P is determined

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4. Expectation and Maximization algorithm is used to get updated final parameters.
5. PDF of Generalized Gaussian distribution is determined
6. Segmentation is obtained using Maximum-Likelihood estimation.

Tetrolet Forming Algorithm

Input: Image a = (a[i, j])N−1 i,j=0 with N = 2J , J $ N.
Output: Segmented Image.

1. Divide the image into 4 × 4 blocks. Divide the low-pass image ar−1 into blocks Q(i,j) of size 4 × 4, i, j = 0, . . . , N 4r − 1.
2. Find the sparsest tetrolet representation in each block.

$$E = -\sum_{i=1}^{n} p(x_i)\ \log_2(p(x_i))$$

3. Rearrange the low- and high-pass coefficients of each block into a 2 × 2 block.
4. Store the tetrolet coefficients (high-pass part).
5. Apply step 1 to 4 to the low-pass image.

Feature Extraction

In this research feature extraction is carried out for the phalanges bone of the hand. Segmented image is loaded on to the croping surface for croping the phalanges bones from the segmented full image. Cropping refers to the removal of the outer parts of an image to improve framing, accentuate subject matter or change aspect ratio. System.Bitmap class is used to crop the image in to user desired bones. Cropping canvas is provided using that user able to select the bone, selected area is cropped once clicks the confirm button.

Cropped images are loaded on the three different picture boxes for feature extraction process. On each bone we process the area, perimeter, diagonal for proximal, middle, distal bones separately.

First we find the height and width of the proximal, middle and distal bone separately. Using the height and width area, perimeter, diagonal is calculated using the below formulas:

Formula Used:
Area = length x breadth
Perimeter = (2 x length) + (2 x breadth)

Diagonal :

$$Diagonal = \sqrt{w^2 + h^2}$$

where:
w is the width of the outer
h is the height of the outer

Image Fusion

Cancer Bone is determined using image fusion, this project creates an trained ct and pet scan images which records the each bone extracted feature details including the processed image height, weight, area of bone separately for proximal, middle, distal. Training set is updated on each bone feature extraction.

IV. RESULTS AND DISCUSSION

The experimental results are shown in Table 1. It can be observed that the proposed method achieved noticeably better alignment performance over the MI and LINEAR methods in all test cases. Examples of the fused images achieved using the three methods are shown in Figure 4.1. The proposed algorithm outperformed the other two methods due to the fact that the intensity mappings of the PET and CT scans are significantly different. The two intensity-based methods (MI and LINEAR) are unable to find a good correspondence. However, the proposed algorithm relies on the significant structural characteristics that are mostly present and consistent between the PET scans and the CT scans so the proposed algorithm is able to find a good correspondence. The experimental results demonstrate the effectiveness of the proposed algorithm for fusing PET images with CT images.

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An example of a misalignment using the proposed method is shown in Figure 4.1. In this particular case, the randomly selected region of interest for alignment was a region that did not exhibit significant structural characteristics in one of the two modalities. In the absence of significant structural characteristics, the proposed algorithm has difficulty finding a suitable alignment. It should be noted that if a human expert were given this particular alignment task, a suitable alignment would be difficult to find between the two medical images in the region of interest. To help reduce misalignments, the entire image should be used for alignment since full medical images often exhibit significant structural characteristics that may not be present in a particular region of interest.

4.1 Performance Metrics to Evaluate Image Fusion Techniques

The image fusion process should preserve all valid and useful information from the input images, so also it should not introduce undesired artifacts. Various metrics are used in order to evaluate the performance of Image Fusion techniques[4]. They are as follows:

4.1.1. Entropy

Entropy measures the information quantity contained in an image [7] [11]. Higher entropy value of the fused image indicates presence of more information and improvement in fused image. If L is the total of grey levels and p = {p0, p1,.....,pL-1} is the probability distribution of each level, Entropy is defined as,

$$\text{Entropy} = -\sum_{i} P_i \operatorname{Log}_2 P_i$$

4.1.2. Mean Square Error (MSE)

The MSE between image X, and an approximation, Y, is the squared norm of the difference divided by the number of elements in the image. If i and j are pixel row column indices, M and N are the number of rows and columns. MSE is defined by,

$$x_{\mathrm{rms}} = \sqrt{\frac{1}{n}\left(x_1^2 + x_2^2 + \cdots + x_n^2\right)}.$$

4.1.3. Peak Signal to Noise Ratio (PSNR)

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of the signal. It is defined by,

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

PAN image and the essential spectral information of the Fused image, we introduce CT based, PET based combined with fusion schemes as shown in Table1.

Band	CT Scan resolution	PET Scan Spatial resolution
Gray Scale	0.45-0.90 µm	1 µm
Blue	0.445-0.516 µm	4 µm
Green	0.506-0.595 µm	4 µm
Red	0.632-0.698 µm	4 µm
Near IR	0.757-0.853 µm	4 µm

Table 1: Image Spectra Information

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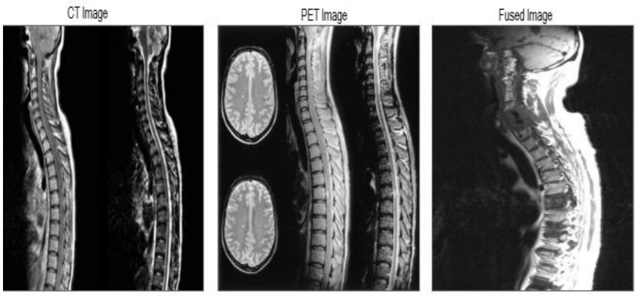

Fig 4.1. Image Fusion with CT and PET Scan Result

The PET is a functional image displaying the spinal cord activity, but without anatomical information. The CT, having higher spatial resolution than the PET, provides anatomical information but without functional activity.

Method	MS3 (0.445-0.516 µm)		MS2 (0.506-0.595 µm)		MS1 (0.632-0.698 µm)	
	CT	PET	CT	PET	CT	PET
Wavelet	43987.13	209.73	45672.59	213.71	33824.55	183.91
PCA	1366.13	36.96	5790.80	76.09	7193.81	84.81

Table 2: Experimental Results with various Image Spectra Levels

This system result of image fusion between CT and PET Scan is shown in Fig 4.1 Since the spatial resolution of the PET image is 1/2 of that of the MRI image, we use the DWT multifocus image fusion scheme (Fig 4.2) with WA fusion rule. The weights of WA in this experiment are deterministic, 0.4 and 0.6, respectively.

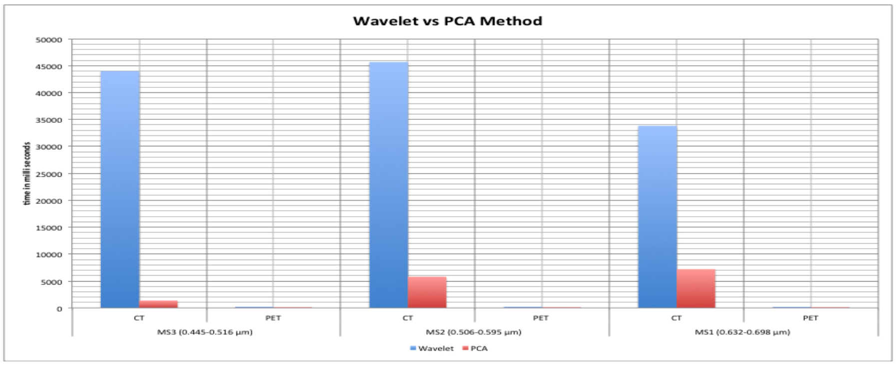

Figure 4.2. Wavelet vs PCA method

Image fusion activity-level measurement methods as shown in the above table. The PCA method which proposed by R.Desale, S.Verma [17] is worse than Wavelet because it requires good region segmentation, thus for some applications it is ineffective.

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V. SUMMARY AND CONCLUSION

CONCLUSION

The maximum fusion rule performs better as it achieved better fusion of CT and PET scan images. Using this method we have fused spinal cord image. The images used here are gray scale CT and PET images. This method gives encouraging results among all the fusion (like PET, SPECT, X-ray etc.,) with their true color nature may also be fused using the same method.

This research introduced new enhancement image fusion for digital medical images. In the proposed scheme, the segments are detected in enhancing low contrasted medical images. This was done by accurately detecting the positions of the edges through finding bone edges. Applying morphological filter using flat structuring elements then sharpened the detected edges. By utilizing the detected edges, the system was capable to effectively segmenting the bones with fine details while retaining image integrity.

The visual examples shown have demonstrated that the proposed method was significantly better than R. Desale, S. Verma [17] PCA based method and other systems for medical image edge detecting and image fusion.

FUTURE ENHANCEMENT

The system had much scope in the future. System will be developed in a new graphical model for learning the salient patterns in images that are simultaneously predictive of class and annotations. In the process, system derived the multi-class setting of supervised topic models and studied its performance for computer vision problems. System is improved to work beyond medical images with real-world image data, the future model is on par with state-of-the-art image annotation methods and outperforms current state-of-the-art image fusions methods.

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BIOGRAPHY

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