Multi-Modal Medical Image Fusion

M. Shanthi and V.R.S. Mani

Abstract--- *A multi-modal medical image fusion method is developed in the Intensity-hue-saturation transform domain. The IHST can efficiently capture both the spatial feature information and the functional information contents. Visual and statistical analyses demonstrate that the fusion quality can be significantly improved over that of five typical methods in terms of entropy and mutual - information, edge information, standard deviation, peak signal to noise and structural similarity.*

Index Terms--- *Image Fusion, Multi-Modal Fusion, Intensity-Hue-Saturation Transform, Fuzzy Logic*

I. INTRODUCTION

A Technique that integrate complementary information from multiple image sensor data such that the new images are more suitable for processing tasks. One possible solution for this is image fusion. The images used in image fusion should already be registered. The objective of image fusion is to combine information from multiple images of the same scene. The result of image fusion is a single image which is more suitable for further image processing tasks.

In this paper, a generic image fusion framework based on multi scale decomposition is studied. This framework provides freedom to choose different multiscale decomposition methods and different fusion rules. Different image fusion approaches are investigated based on this framework. Some evaluation measures are suggested and applied to compare the performance of these fusion schemes mis-registration is a major source of error in image fusion.

1.1 Multi-Scale Decomposition Method

In recent years, many researchers recognized that multiscale transforms are very useful for analyzing the information content of images for the purpose of fusion. More recently, wavelet theory has emerged as a well developed yet rapidly expanding mathematical foundation for a class of multiscale representations. At the same time, some sophisticated image fusion approaches based on multiscale representations began to emerge and receive increased attention. Most of these approaches were based on combining the multiscale decompositions (MSDs) of the source images. The basic idea is to perform a multiscale transform (MST) on each source image, then construct a composite multiscale representation from these. The fused image is obtained by taking an inverse multiscale transform (IMST).

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II. RELATED WORK

Nowadays, multi-scale decomposition (MSD)-based medical image fusion methods have been widely used because of their advantages over the other fusion techniques. some of the MSD based fusion schemes are,, Wavelet transform, Curvelet transform, Contourlet transform, Non-subsampled Contourlet transform (NSCT).

2.1 Wavelet Transform

This transform concentrates on representing the image in multi scales and it is appropriate to represent linear edges. Wavelets decompose images into only three directional high pass sub bands, namely, vertical, horizontal and diagonal, capturing only limited directional information. According to the theory of wavelets, the support of one wavelet is a square. When wavelet is used to represent the multi-dimensional features, such as contours, non-zero coefficients increase exponentially and cannot be neglected for their large amplitude, demonstrating the directional sensitivity is lost. Therefore, wavelet cannot be considered as the true sparse representation. Wavelet analysis is capable of revealing aspects of data that other signal analysis techniques miss, aspects like trends, breakdown points, discontinuities in higher derivatives, and self-similarity. wavelet analysis can often compress or de-noise a signal without appreciable degradation.

2.2 Curvelet Transform

Curvelet transform for curved object image fusion would result in a better fusion efficiency. To overcome the missing directional selectivity of conventional two-dimensional (2-D) discrete wavelet transforms (DWTs), a multiresolution geometric analysis (MGA), named curvelet transform was proposed. The curvelet transform has evolved as a tool for the representation of curved shapes in graphical applications. Then, it was extended to the fields of edge detection and image denoising.

2.3 Contourlet Transform

Contourlet has shown many advantages over the conventional image representation methods. Contour let is a_true‘‘2-D sparse representation for2-D signals like images. The overall result of contourlet transform is a sparse image expansion expressed by contour segments, so it can capture 2-D geometrical structures in visual information much more effectively than traditional multi resolution analysis methods. Contour let-based fusion algorithm provides an effective way to enable more accurate analysis of multimodality images. It is implemented by the pyramidal directional filter bank (PDFB) which decomposes images into directional sub bands at multiple scales.

2.4 Non-Subsampled Contour Let Transform

The contour let transform (CT) is one of the state-of-the-art multi scale analysis techniques. Aside from the true two-dimensional (2D) filtering for the image expansion, the flexible directional filtering makes it possible to capture the intrinsic geometrical structure of the image. By allowing the redundancy, the shift-invariance which means less sensitivity to the image shift can be achieved in the NSCT. The multi scale property of the NSCT is achieved by the non sub- sampled pyramid (NSP), which employs the non sub sampled filters (NSFs) to split the frequency plane into a low-frequency sub band and several annular high-frequency sub bands. Meanwhile, the multi- directional property is obtained by the non sub sampled directional filters (NSDFs) which further integrate high-frequency coefficients into wedge- shaped directional sub bands.

III. PROPOSED WORK

Image fusion techniques can be classified into three categories depending on the stage at which fusion takes place; it is often divided into three levels, namely: pixel level, feature level and decision level of representation. The pixel image fusion techniques can be grouped into several types depending on the tools or the processing methods for image fusion procedure. It is grouped into three classes: Color related techniques, statistical methods, arithmetic/numerical, and combined approaches. Multi-modal medical image fusion, an easy access for physicians to understand the lesion by reading images of different modalities, has been emerging as a new and promising research area due to the increasing demands in clinical applications. For the quality of the fused outcome is determined by the amount of the information captured from the source images. Visual and statistical analyses demonstrate that the fusion quality can be significantly improved over that of five typical methods in terms of entropy and mutual information, edge information, standard deviation, peak signal to noise and structural similarity. Besides, color distortion can be suppressed to a great extent, providing a better visual sense. Initially, the intensity-hue-saturation transform was applied for MRI and CT images. From this result the intensity component alone taken for further processes. Finally for getting the fused image the fuzzy logic concept was used here. The fused image will be having the more information than that of the two input images.

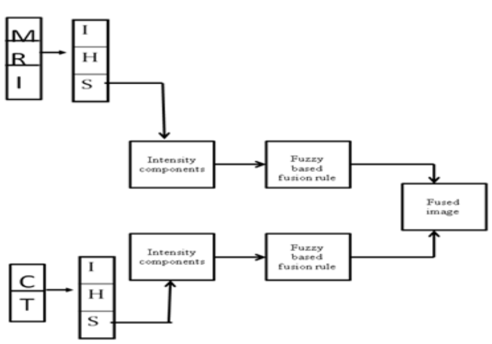

Figure1: Block Diagram for Image Fusion

3.1 Intensity-Hue-Saturation Transform

IHS fusion methods are selected for comparison because they are the most widely used in commercial image processing systems. The IHS technique is one of the most commonly used fusion techniques for sharpening. It has become a standard procedure in image analysis for color enhancement, feature enhancement, improvement of spatial resolution and the fusion of disparate data sets. In the IHS space, spectral information is mostly reflected on the hue and the saturation. From the visual system, one can conclude

that the intensity change has little effect on the spectral information and is easy to deal with. For the fusion of the high-resolution and multispectral remote sensing images, the goal is ensuring the spectral information and adding the detail information of high spatial resolution, therefore, the fusion is even more adequate for treatment in IHS space image processing systems. Among the existing ways to represent color on electronic display devices, the Red-Green-Blue [RGB] model and the Intensity- Hue-Saturation model are widely applied. The RGB model is applied for producing three-channel color composites on color monitors or other devices. The MS model defines the color mathematically, using cylindrical or spherical coordinates. In the RGB model, the coordinates range between 0 and 1 on each axis. In the MS the coordinates range for the hue component between 0 and 360 degrees while, for the intensity and saturation components, between 0 and 1. The IHS sharpening technique is one of the most commonly used techniques for sharpening. Different transformations have been developed to transfer a color image from the RGB space to the IHS space. IHS

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3.2 Fuzzy Logic

Fuzzy logic is an extension of Boolean logic Therefore, fuzzy approaches are mainly used when there is uncertainty and no mathematical relations are easily available. One of the major advantages of fuzzy logic over other existing fusion methods is that it permits the user to define the encoding directly by using linguistic labels as rules.

3.3 Steps Involved in Fuzzy Logic Based Image Fusion

The fuzzy sets and fuzzy membership functions are required for system implementation was carried out considering that the input image and the output image obtained after defuzzification are both 8-bit quantized; this way, their gray levels are always between 0 and 255. The original image in the gray level plane is subjected to fuzzification and the modification of membership functions is carried out in the membership plane. The result is the output image obtained after the defuzzification process. Steps involved here are

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- Read first image in variable I1 and find its size (rows: rl, columns: c1).
- Read second image in variable I2 and find its size (rows:r2, columns: c2).
- Variables I1 and I2 are images in matrix form where each pixel value is in the range from 0-255.
- Compare rows and columns of both input images. If the two images are not of the same size, select the portion, which are of same size Make a fis (Fuzzy) file, which has two input images.
- Decide number and type of membership functions for both the input images by tuning the membership functions.
- Make rules for input images, which resolve the two antecedents to a single number from 0 to 255 and display the fused image.

IV. Results and Discussions

There are many typical applications for image fusion. Hereby I have used it for medical images. The output for INTENSITY-HUE-SATURATION transform were displayed, and finally the fused image also displayed with more information.

Figure 1

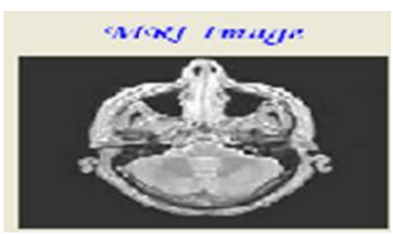

Figure 2: Source Images

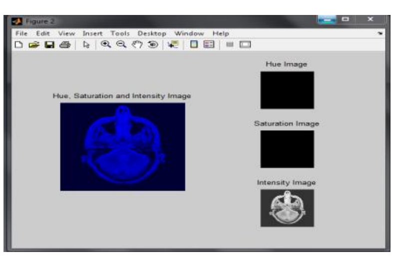

Figure 3: HIS Transform for MRI Image

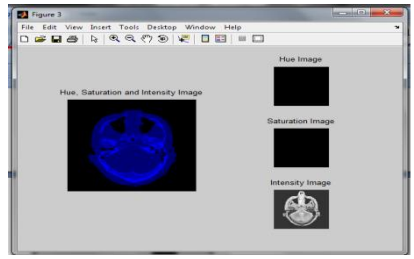

Figure 4: HIS Transform for CT Image

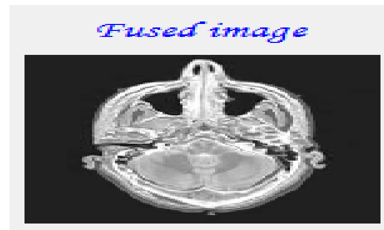

Figure 5: Fused Image

Table1: Comparison Table

Image Type	Entropy Value
MRI Image	4.7762
CT Image	4.4730
Fused Image	4.9510

V. Conclusion and Future Work

In this paper, a new medical image fusion method is proposed in the IHS domain. The IHS can efficiently capture both the spatial feature information and the functional information contents from different directions in the image. Although the proposed algorithm has shown basically good performance in our experiments, there is still much work to do.

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