



Image Fusion Technique using Fuzzy and Wavelet Analysis of Medical Image

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ABSTRACT

Image fusion has attracted a widespread attention attributable to applications in medical imaging, automotive and remote sensing. Image fusion deals with group action knowledge obtained from completely different sources of data for intelligent systems. Image fusion provides output as one image from a collection of input pictures obtained from completely different sources or techniques. {Different totally completely different completely different} approaches in image fusion offer different sort of results for various applications.. We tend to found this system terribly helpful in medical imaging and different areas, wherever quality of image is a lot of necessary than the \$64000 time application. The work is supplemented by algorithms, its simulation and analysis victimization entropy.

Keywords: Image Fusion; Medical Imaging; Wavelet; Entropy; DWT

INTRODUCTION

In recent years, multimodality medical image fusion has drawn lots of attention with the increasing rate at which multimodality medical images are available in many clinic application fields. Radiotherapy plan, for instance, often benefits from the complementary information in images of different modalities. Dose calculation is based on the Computed Tomography (CT) data,

while tumor outline is often better performed in the corresponding magnetic resonance (MR) image. For medical diagnosis, CT provides the better information on denser tissue with less distortion, while MRI offers better information on soft tissue with more distortion. With more available multimodality medical images in clinic application, the idea of encompassing different image information comes up very important, and medical image fusion has been emerging as a new and promising research area. The goal of image fusion is to obtain useful complementary information from multimodality images as much as possible. The simplest way to obtain a fused image from two or more medical images is to average them. Although mostly preserving the original meaning of the images, it is prone to reduce the contrast of the fused image. With the development of new imaging sensors arises the need of a meaningful combination of all employed imaging sources. The actual fusion process can take place at different levels of information representation; a generic categorization is to consider the different levels as, sorted in ascending order of abstraction: signal, pixel, feature and symbolic level. This site focuses on the so-called pixel level fusion process, where a composite image has to be built of several input images. To date, the result of pixel level image

fusion is considered primarily to be presented to the human observer, especially in image sequence fusion (where the input data consists of image sequences). In pixel level image fusion, some generic requirements can be imposed on the fusion result. The fusion process should preserve all relevant information of the input imagery in the composite image (pattern conservation) The fusion scheme should not introduce any artifacts or inconsistencies which would distract the human observer or following processing stages .The fusion process should be shift and rotational invariant, i.e. the fusion result should not depend on the location or orientation of an object the input imagery .In case of image sequence fusion arises the additional problem of temporal stability and consistency of the fused image sequence. The human visual system is primarily sensitive to moving light stimuli, so moving artifacts or time depended contrast changes introduced by the fusion process are highly distracting to the human observer. So, in case of image sequence fusion the two additional requirements apply.

Image Fusion: Image Fusion is the process of combining relevant information from two or more images into a single image. The fused image should have more complete information which is more useful for human or machine perception. The resulting image will be more informative than any of the input images. Medical fusion image is to combine functional image (CT) and anatomical image (MRI) together into one image.

Fuzzy Based Image Fusion: In the image fusion, the background, contour and edge of image are ambiguous concept without strict definition and distinction. However, fuzzy logic is adept at processing data which is dubious or has ambiguous mathematical relationship. For the image uncertainty, it uses the membership function to

describe the distribution and clustering of the pixel values, and provides rich fusion operators and decision rules for image fusion. Therefore, fuzzy logic makes the fused image cater to human sight and psychology, also makes the adaptability of fused image wide. Image fusion rules based on Fuzzy Logic use fuzzy inference to solve the uncertainty in the image fusion. Firstly, utilize fuzzy sets to describe the gray levels of the source images and establish fuzzy inference system (FIS). Secondly, carry out fuzzy inference according to the fuzzy rules and obtain the membership degree of each output pixel. Finally, calculate the output gray value through defuzzification and obtain the fused image. Select medical image CT and MRI as the input which have the same number of pixel points, and the fused image is the output, so we should establish a fuzzy inference system which includes two inputs and one output.

Fuzzy Rules

In this paper, with Mamdani-type inference whose fuzzy rules form is “IF-THEN,” make the following fuzzy rules:

CT\MRI	VL	L	M	H	VH
VL	VL	L	M	H	VH
L	L	L	M	H	VH
M	M	M	M	H	VH
H	H	H	H	H	VH
VH	VH	VH	VH	VH	VH

MIN-SUM-MOM algorithm: MIN-SUM-MOM algorithm was presented based on Mandeni - type FIS. In MIN-SUM-MOM algorithm, fuzzy implication operation utilized MIN algorithm; calculating the membership functions of total output fuzzy sets employed SUM algorithm; defuzzification operation used MOM algorithm. The difference between the algorithm MIN-SUM-MOM and MIN-MAX-Centroid was that they



utilized different fuzzy inference algorithm and defuzzification algorithm.

Based on MIN-SUM-MOM algorithm, establish a FIS which included two inputs, one output and seventeen fuzzy rules. If the gray level of input image CT is 17(VL) and the gray level of input image MRI is 217(H), when the input gray levels are 17(VL) and 217(H), fuzzy inference only employs the three fuzzy rules. In accordance with MIN-SUM-MOM algorithm in this paper, carry out the fuzzy inference according to the three fuzzy rules, and get the corresponding membership functions of output fuzzy set.

Algorithmic Implement:

Use FIS editor in the fuzzy logic toolbox to implement the following fusion algorithm. In the window of FIS editor, establish the membership function and adjust the inference rules intuitively.

Algorithm Process...

- Read first image in variable M1 and find its size (rows: z1, columns: s1).
- Read second image in variable M2 and find its size (rows: z2, columns: s2).
- Variables M1 and M2 are images in matrix form where each pixel value is in the range from 0-255. Use Gray C o I or map.
- 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.
- Convert the images in column form which has C= Z1*S1 entries. 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. Input images in antecedent are resolved to a degree of membership ranging 0 to 255.
- Make rules for input images, which resolve the two antecedents to a single number from 0 to 255.

- For num=1 to C in steps of one, apply fuzzification using the rules developed above on the corresponding pixel values of the input images which gives a fuzzy set represented by a membership function and results in output image in column format.
- Convert the column form to matrix form and display the fused image.

Image Fusion has become a topic of great interest to a variety of engineers working in different disciplines. The advantages of image fusion range from medicine or navigation to surveillance, fire control, and missile guidance to improve accuracy. Fuzzy approaches are used where there is uncertainty and no mathematical relations are easily available. The fuzzy logic technique for image fusion is now being widely used in Medical research applications so as to get a better image, as is evident from the results shown in topic 4 of this work. It is also being researched in navigation and automotive industries to enhance the vision of road so as to see a better image during a rainy or a foggy weather. Multi-spectral sensors are increasingly being employed in military applications. Just as in satellite imagery of the earth, multi-spectral data is required in order to extract the maximum amount of information from a scene. The military applications include automated target recognition, battlefield surveillance. Intelligent mobility. Etc. Images of mine fields generated using light of different wavelengths. And or at different time of the day are fused together to closely estimate the probability of a mine existence at a particular location

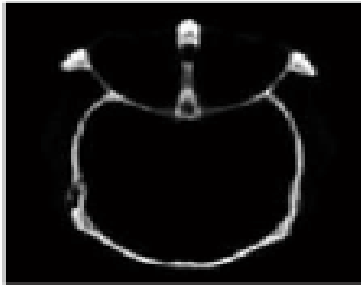


Fig. 1: (a) CT Scan Image

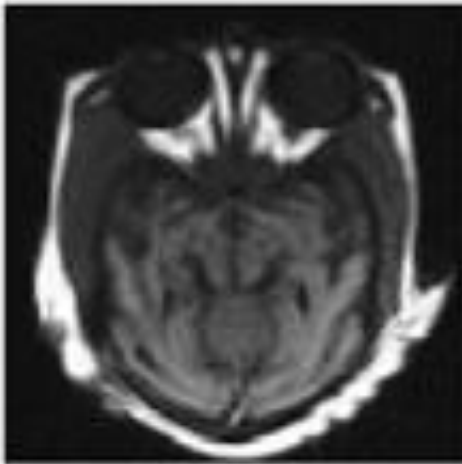


Fig. 1: (b) MRI Scan Image

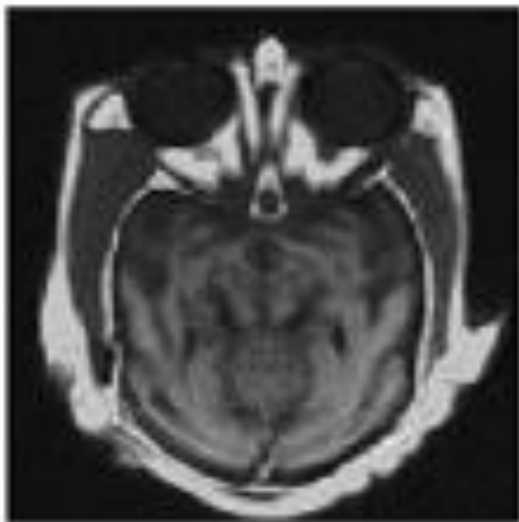
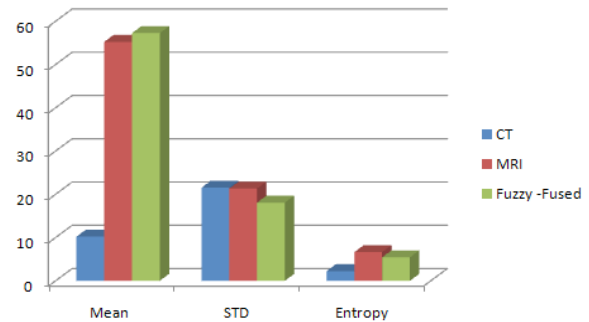


Fig. 1: (c) Fuzzy Rule based Fused Image

	Mean	STD	Entropy
CT	10.21	21.53	2.24
MRI	55.24	21.32	6.63
Fuzzy -Fused	57.26	18.08	5.43



Wavelet Process on Fuzzy Fused Image:

Wavelet Transform: Wavelet transform is the local transformation from time and frequency domain, with zoom and pan features similar to a mathematical microscope, can easily generate a variety of different resolution images, and has been widely used in image processing.

Wavelet Enhancement: There exist the imaging sensor noise, imaging light scattering and other factors in the image acquisition process, which may make the resolution and contrast of the obtained images that hide some important information decline. Therefore, in order to get a richer picture which contains a large amount of information, the original image enhancement must be processed before image fusion. The traditional image enhancement algorithm can amplify the noise of the image, while improving image contrast and enhancing image details. However the wavelet based enhancement algorithm can enhance the image details while suppressing the noises. The details of the features of different scales can be obtained through the wavelet transform, then gray-scale transformation function can be used to transform the different frequency sub image

separately in order to enhance the detailed features contained in different resolutions to some extent; while the low-frequency sub-image may be changed through gray-scale transformation function or MSR(Multiscale Retinex) accordingly. MSR uses the consistency of the human eye's color sense to process images and has good dynamic range compression performance for grayscale images.

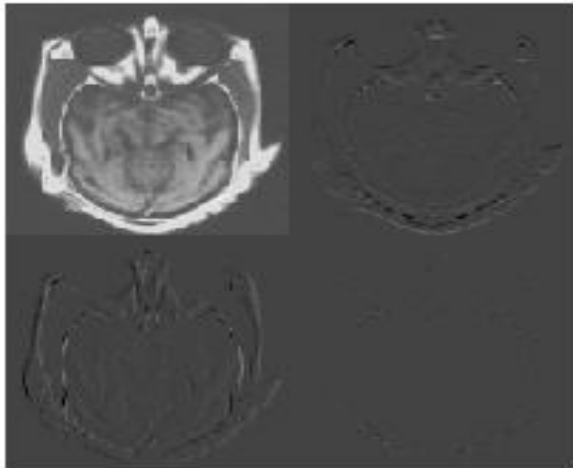


Fig. 2: Haar Wavelet Process on Fused Image

Here the low contrast input image is decomposed in two ways. One way is directly decomposed the input image by using Discrete Wavelet Transform (DWT). Here the image is separated into four frequency sub bands such as LL, LH, HL, and HH. In LL band the value is obtained by calculating the average of all parameters. In LH band the horizontal values are passed through low pass filter and vertical values are passed through high pass filter to get the average of all parameters. In HL band the horizontal values are passed through High Pass Filter and Vertical values are passed through Low Pass Filter to get the average value. In HH band the average value is obtained by using Diagonal Curvature. Image analysis, by contrast, produces information that is much smaller in

quantity but much more highly refined than an image, for example the position and orientation of an object. In many cases the output is just an accept/reject decision, the smallest quantity of information but perhaps the highest refinement. Output behavior and execution speed are generally difficult and sometimes impossible to characterize. To overcome this image Contrast enhancement Technique is mostly used increase the execution speed

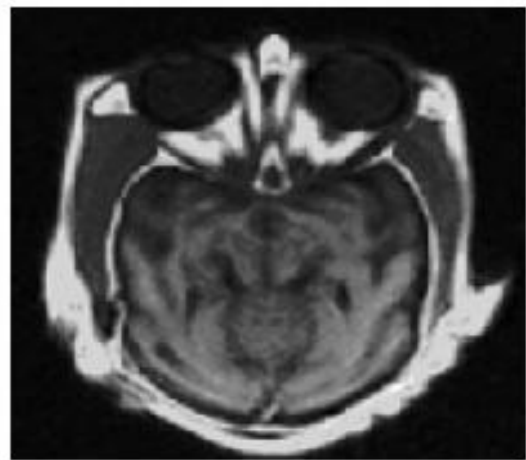
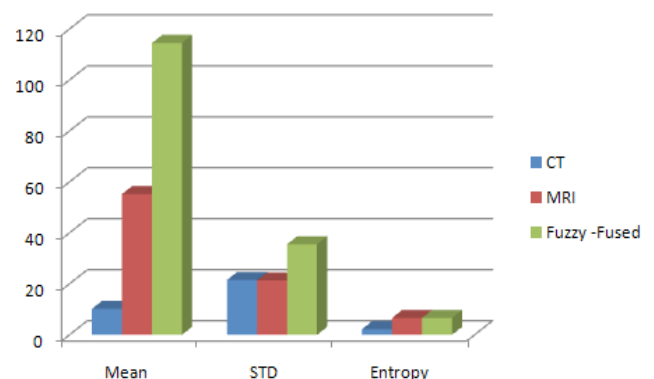


Fig. 3: LL Sub Band of Fused Image Output

	Mean	STD	Entropy
CT	10.21	21.53	2.24
MRI	55.24	21.32	6.63
Fuzzy -Fused	57.26	18.08	5.43



Result Analysis: It is almost impossible to demarcate some unique universally applicable quantitative performance measures for the fusion process. The texture of an image could be used as a guiding criterion for assessing its quality.

1. Mean: The mean was defined as

$$\text{mean} = \sum_{j=1}^n \sum_{i=1}^m M(i, j) / (m * n)$$

2. Standard Deviation: The STD can be calculated as

$$\text{Std} = \sqrt{\sum_{j=1}^n \sum_{i=1}^m [M(i, j) - \text{mean}]^2 / (m * n)}$$

Where $m * n$ (rows: m , columns: n) is the size of image M ; $M(i, j)$ is the gray value of a pixel-point.

3. Entropy: As we all know, information entropy, namely EN, is also a very important parameter for describing image information.

$$EN = - \sum_{i=1}^m p_i \ln p_i$$

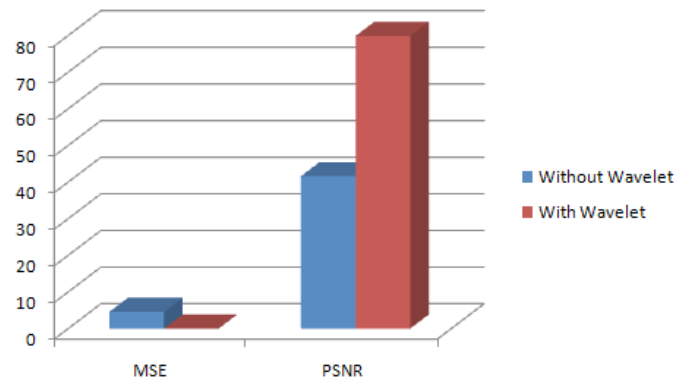
4. Mean Square Error: It is defined as the square of error between original image and the compress image. The distortion in the image can be measured using MSE.

$$\text{MSE} = \frac{\sum \sum [A(i, j) - B(i, j)]^2}{M * N}$$

Here, $A(i, j)$ = Original image. $B(i, j)$ = Fused image. $N * N$ = row and column of image intensity of pixel vales (255 255) image

5. Peak Signal to Noise Ratio: It is the ratio of the maximum signal to noise in the compress image
 $\text{PSNR} = 20 \log_{10} \{ (255 * 255) / (\text{MSE}) \}$

	MSE	PSNR
Without Wavelet	4.5413	41.559
With Wavelet	6.71E-04	79.8611



In this paper, MIN-SUM-MOM algorithm based on Mamdani type FIS was successfully used to fuse the medical images CT and MRI, and the fused results were given above. In comparison with the fused results of MIN-MAX-Centroid algorithm, the improved fused images were not only relatively clear from the visual perspective, but also more satisfactory from the qualitative evaluation. To sum up, the improved fused result was better. Therefore, MIN-SUM-MOM fusion algorithm was effective. From the algorithms themselves, MIN-MAX-Centroid algorithm used MIN-MAX algorithm to calculate the output membership functions, so the partial information of the original images was lost; while MIN-SUM-MOM algorithm used MIN-SUM algorithm, the information can be retained as much as possible. Therefore, the improved fused image contained more information, and MINSUMMOM fusion algorithm was reasonable. MIN-SUM-MOM fusion algorithm based on the simple fuzzy inference rules, we could get the fused results intuitively and quickly in the clinical environment, and instead of a strict classification, fuzzy clustering made it more adaptive and reasonable.

To validate the effective of the algorithm, the two images of the same scene taken at different times were tested, and the proposed algorithm was compared with the general clarity based algorithm without using of wavelet enhancement. As can be seen from attaching TABLE, the proposed algorithm based on wavelet enhancement, has larger values of the fusion image entropy, standard deviation than the general method without using of wavelet enhancement. Entropy and standard deviation is increasing, indicating that the integration based on wavelet enhancement can broaden the image intensity distribution, increase the amount of information, and dig the hidden information into the fused image to the maximal extent. Although the clarity of the wavelet enhanced fusion image is less than the image obtained without using of wavelet enhancement, but the wavelet enhanced fusion image has better overall result.

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