International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 5 Issue 8, August 2018

ISSN: 2394-4404

Medical Image Fusion Based On Quality Assessment Metrics

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***Abstract:** Medical image processing has developed as one of the critical factor in regular clinical applications, such as disease diagnosis and treatment planning. Owing to the technical limitations, the quality of medical images is usually unsatisfactory, degrading the accuracy of human interpretation and further medical image analysis, thereby requiring the quality of this image to be enhanced. One approach to enhance the image quality is by image fusion which improves the image quality by combining the corresponding information from multimodal image into single modified image. This paper explains about an algorithm which is developed to detect additional features using fusion techniques for diagnosing portion of brain damaged (Alzheimer)based on the radio imaging in an efficient way in medical applications, the input images taken are (MRI) Magnetic Resonance Imaging[1] and (PET) Positron Emission Tomography[2]. Different techniques are adopted using statistical values and component analysis and wavelet transform [3]. The algorithm is tested for different images, for comparison of existing methods-evaluation metrics are like SSIM, standard deviation and correlation coefficient are used [4].*

***Keywords:** Image Fusion, Principal component Analysis, Wavelet Transform, SSIM, Standard Deviation, Correlation Coefficient.*

I. INTRODUCTION

The term fusion means in general approach to extraction of information acquired in several domains to get a better image with high information than any of the input image .Medical Image fusion encompasses a broad range of techniques from image fusion and general information fusion to address medical issues reflected through images of human body, organs and cells. There is a growing interest and application of the imaging technologies in the area of medical diagnostics, analysis and histogram documentation. Since computer aided imaging techniques enable a quantitative assessment of the images under evaluation, it helps to improve the efficiency of the medical practitioners in arriving at an unbiased and objective decision in a short span of time.

The solution for whatever problems presented in the MRI and PET scan images is to fuse the both images with and individual component analysis and transformation of the both the images to get better performance.

II. THE PROPOSED IMAGE FUSION SYSTEM

The proposed system is described by flow chart. The next step is going to discus in blocks.

A. IMAGE ALIGNMENT – COLOR SPACES

In our work, we used two different images of brain those are MRI and PET scan images. The first step was to check whether the two input images are in same dimension and also same format. To address this problem, we used the image alignment method.

The next step was to separate the RGB component [5] from the input MRI image, and then convert the second input PET image into Gray scale image, i.e. RGB to Gray conversion will done on the input PET image. Why because if only the brightness information is needed, color images can transformed to gray scale images. As it is also noted in the JPEG compression scheme, the transformation is made by the following equation

$I_Y = 0.333F_r + 0.5F_{g} + 0.1666F_b$

Where r, g and b are the intensities of R, G and B component respectively and I_y is the intensity of equivalent gray image of RGB image.

B. IMAGE DESCRIPTION

In our work, we are using two types of images those MRI (Magnetic Resonance Imaging) and PET (Positron emission Tomography). Since MRI development in the 1970s and 1980s, MRI has proven to be a highly versatile imaging technique. MRI was originally called as NMRI (nuclear magnetic resonance imaging), and is a form of NMRI, through the use of 'nuclear' in the acronym was dropped to avoid negative associations with world. Certain atomic nuclei are able to absorb and emit radio frequency energy when placed in an external magnetic field.

The second input image was PET image. The positron emitting radioisotopes used are usually produced by a cyclotron, and chemicals are labelled with these radioactive atoms. The labelled compound, called a radiotracer, is injected into to the bloodstream and eventually makes its w ay to the brain through blood circulation. Detectors in the PET scanner detect the radioactivity as the compound charges in various regions of the brain. A computer uses data to collect from the detectors to create a multi – dimensional image that show the distribution of the radiotracer in the brain.

C. IMAGE FUSION – SYNTHESIS

Image fusion [6] is the process of collecting important information from two or more images and produces a better image with a high quality information and sufficient data in that. That single image is more informative than the input image and also it consists of all necessary things that present in the input images. The fused image should have more information; it is very useful for human visual system machine perception.

The principal component analysis is a vector space transform, often to reduce multidimensional data sets to lower dimension for analysis, in other words PCA transform the number of correlated variables into uncorrelated variables is called principal components. Where the use of PCA data size is compressed as well as dimensions are altered then there is no much loss of information at the image.

The wavelet transform has gained widespread acceptance in signal processing and image processing compression. Wavelet transform decomposes a signal into a set of basis functions. These basis are called wavelets. Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting. The 2D-DWT is nowadays established as a key operation in image processing. It is multi-resolution analysis and it decomposes images into wavelet coefficients. This characteristic is useful for images compression.

The histogram of a digital image is a distribution of its discrete intensity levels in the range [0, L-1]. The distribution is a discrete function h associating to each intensity: r_k the number of pixels with this intensity: n_k. Normalize histogram is a technique consisting into transforming the discrete distribution of intensities into a discrete distribution of probabilities. Histogram equalization is a method to process images in order to adjust the contrast of an image by modifying the intensity distribution of the histogram.

D. EVALUATION METRICS

- ✓ *SSIM:* The structural similarity index [7] is a method for predicting the perceived quality of digital television and cinematic picture, as well as other kinds of digital images and videos. SSIM is used for measuring similarity between two images. The SSIM is a measurement or prediction of image quality is based on an initial uncompressed or distortion- free image as reference.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad \text{----------} (2)$$

Where as

$$\mu_x = \frac{1}{T}\sum_{i=0}^{T} X_i \quad ,\mu_y = \frac{1}{T}\sum_{i=0}^{T} Y_i$$

$$\sigma_x^2 = \frac{1}{T-1}\sum_{i=1}^{T}(x_i - \bar{x})^2 \quad \sigma_y^2 = \frac{1}{T-1}\sum_{i=1}^{T}(y_i - \bar{y})^2$$

$$\sigma_{xy}^2 = \frac{1}{T-1}\sum_{i=1}^{T}(x_i - \bar{x})(y_i - \bar{y})$$

Where μ is the average of the image and Σ is the variance of the image.

- ✓ *STANDARD DEVIATION: Standard deviation* [8] measures the spread of the data about the mean value. It is useful in comparing sets of data which may have the same mean but a different range. Just like when working out the mean, the method is different if the data is given to you in groups. The formula for standard deviation is given by,

$$\sigma = \sqrt{\sum(x - \bar{x})^2} \quad \text{--------------------} (2)$$

Where σ = lower case sigma
Σ = capital sigma
$\bar{x}$ = X bar

- ✓ *CORRELATION COEFFICIENT:* The correlation coefficient [9] is a very helpful statistical formula that measures the strength between variables and relationships. In the field of statistics, this formula is often referred to as the Pearson R test. When conducting a statistical test between two variables, it is a good idea to conduct a Pearson correlation coefficient value to determine just how strong that relationship is between those two variables.

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}} \quad \text{--------------------4}$$

Where N = number of pairs of scores
Σxy = sum of the products of paired scores
Σx = sum of x scores
Σy = sum of y scores
Σx^2 = sum of squared x scores
Σy^2 = sum of squared y scores

III. ALGORITHM

STEP1: Input images are acquired (read) from a scanner.

STEP2: Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) images are indentified and resized to 256X256 pixels.

STEP3: The scanned PET images are in RGB format will be converted to Gray Scale format.

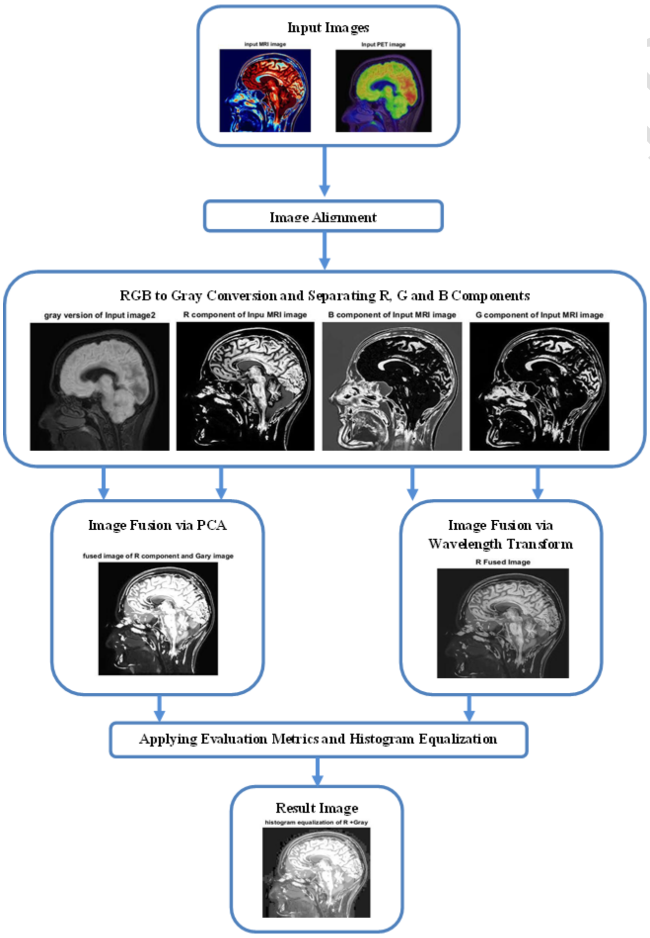
STEP4: Separating R, G and B parameters of MRI image.

STEP5: Different combinations of fusion will be applied to generate multiple fused images like MRI(R) + PET (Gray), MRI (G) + PET (Gray), MRI (B) + PET (Gray).

STEP6: A better image with high information is obtained.

STEP7: To test the performance of the algorithm, Entropy, Mean Value, Standard Deviation, Correlation Coefficient and Histogram are calculated.

FLOW CHART



IV. TABULAR COLUMN

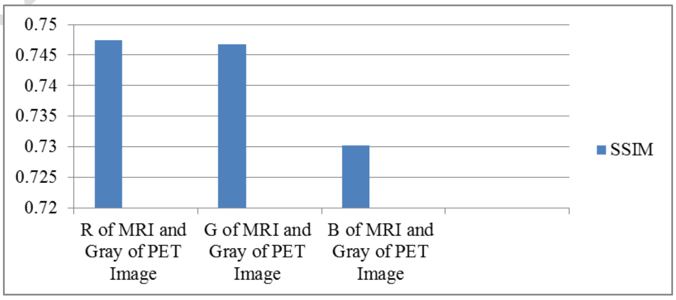
Image Type	SSIM	Standard Deviation (Va)	Correlation (R)
R of MRI and Gray of PET Image	0.7474	94.0912	0.9862
G of MRI and Gray of PET Image	0.7468	79.5502	0.9777
B of MRI and Gray of PET Image	0.7302	61.8712	0.9670

Table 1: Results of PCA Fused Images

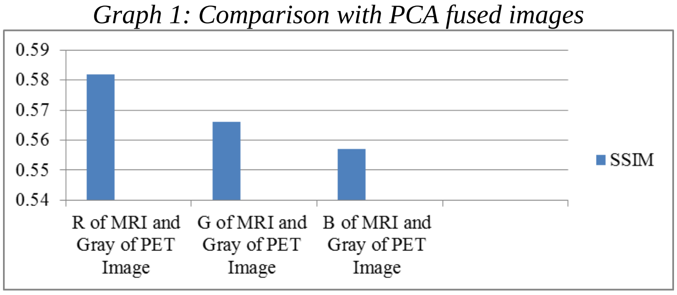
Image Type	SSIM	Standard Deviation (Va)	Correlation (R)
R of MRI and Gray of PET Image	0.5818	57.4796	0.9597
G of MRI and Gray of PET Image	0.5661	45.4485	0.9297
B of MRI and Gray of PET Image	0.557	36.5768	0.9043

Table 2: Results of Wavelet Fused Images

V. GRAPH



Graph 1: Comparison with PCA fused images



Graph 2: Comparison with Wavelet fused images

VI. EXPERIMENTAL IMAGES

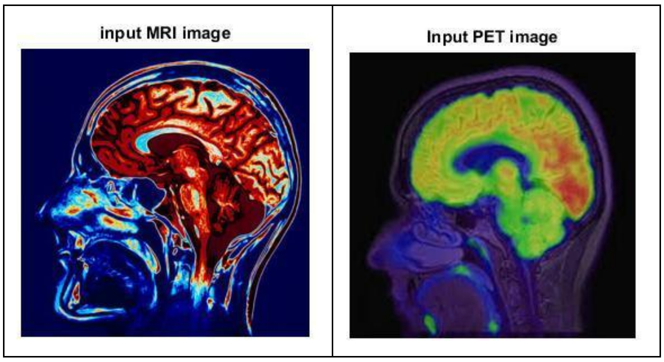


Figure 1: Input Images

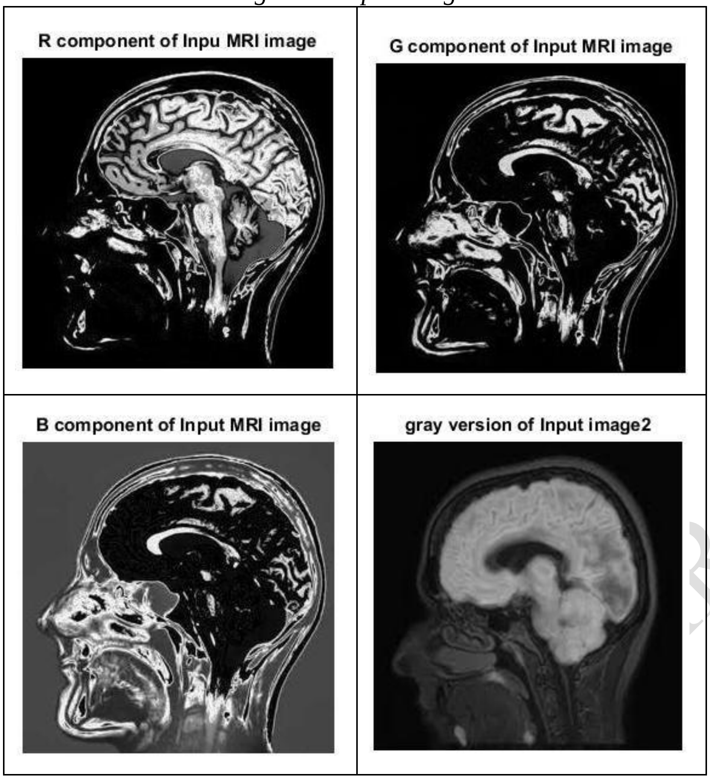
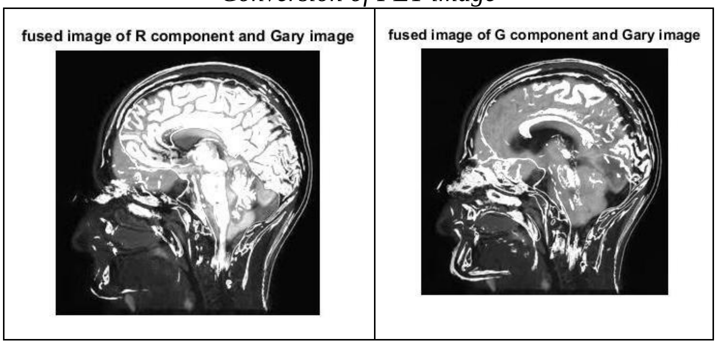


Figure 2: R, G and B component of MRI image and Gray Conversion of PET image



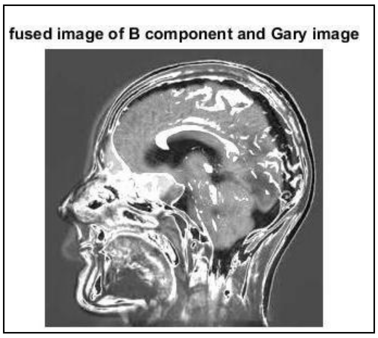


Figure 3: Image Fusion with PCA

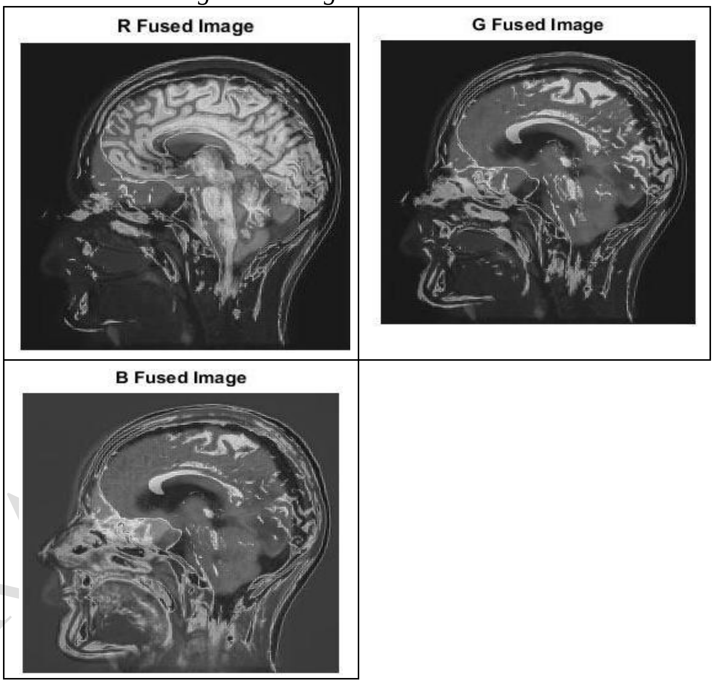


Figure 4: Image Fusion with Wavelet Transform

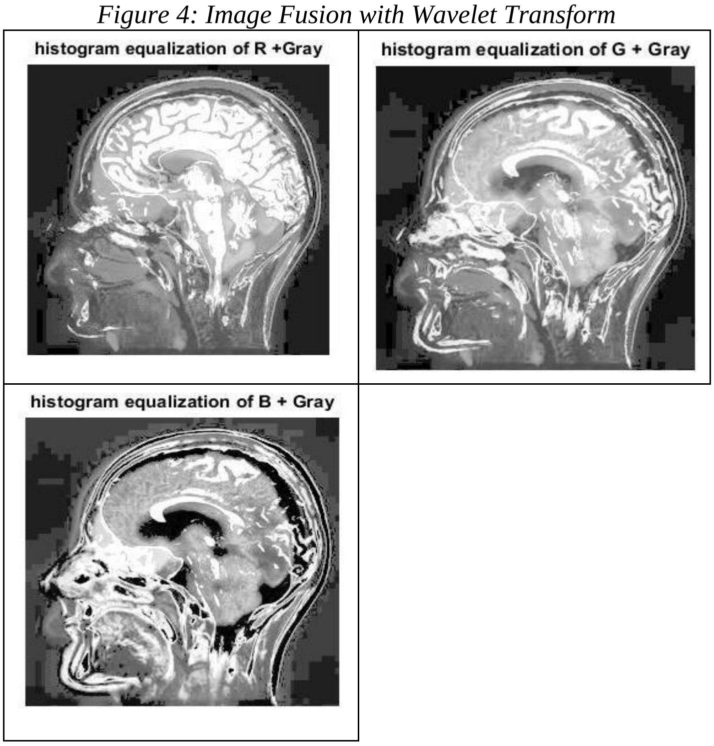


Figure 5: Histogram Equalization of PCA Fused Image

ISSN: 2394-4404

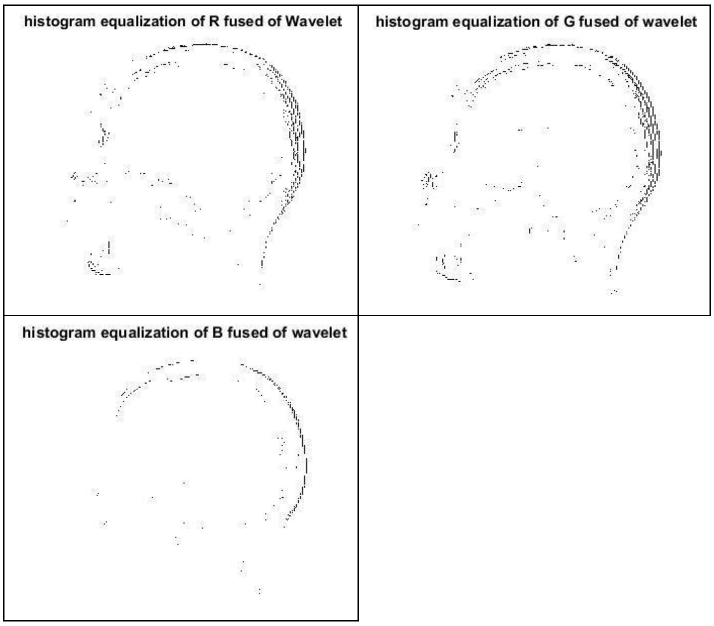


Figure 6: Histogram Equalization of Wavelet Fused Images

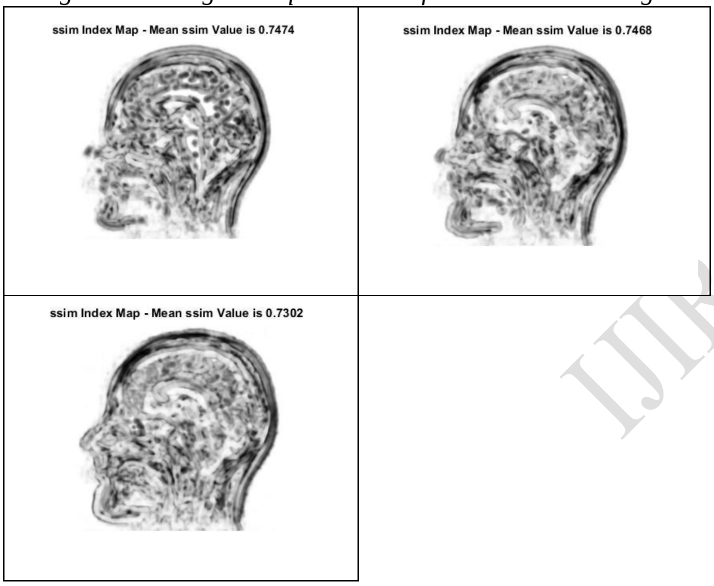


Figure 7: Result Comparison with SSIM for PCA Fused Images

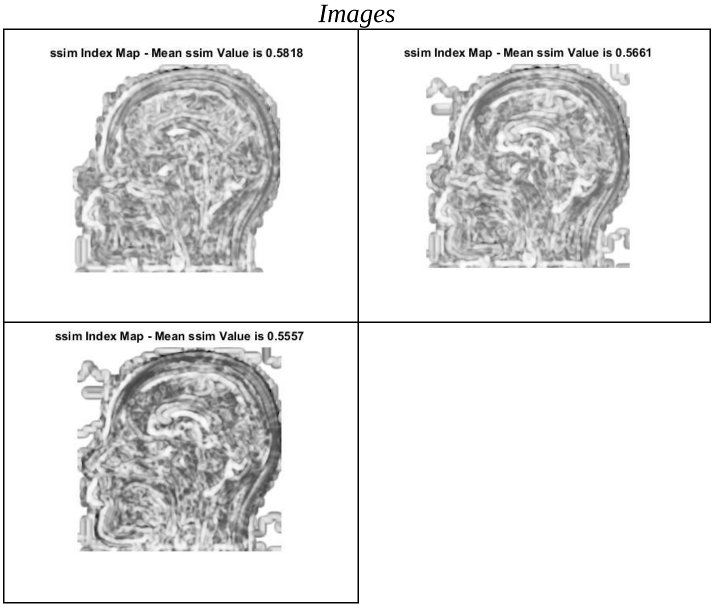


Figure 8: Results Comparison with SSIM for Wavelet Fused images

VII. CONCLUSION

A new image is obtained by fusing primary and gray scale values of the MRI and PET images. Based on the evaluation quality measures like SSIM, standard deviation and Correlation Coefficient, A high quality image is obtained with more desired information. The complexity of the algorithm can be reduced by developing a statistical database or neural networks in future.

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