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Image Fusion of Mammography Images using Genetic Algorithm (GA)

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ABSTRACT

Image fusion process plays a indispensable role in the domain of medical, remote sensing, security, geo-spatial, astronomy and computer aided diagnosis applications of medical images. In recent years mammography is to detect of X-ray mammograms by using image processing segmentation based algorithms considerable attention and has become an major problem in medicine to identify the diagnosis results. one of the process proposed for identification and diagnosis of breast cancer, a genetic algorithm is used to fuse the X-ray mammograms. The image quality metrics are used to examine the fused images. To begin with process the X-ray mammograms images are collected from standard MIAS database and then the digital mammogram images are improved by applied median filter. The genetic algorithm maintain two bounds and elements data and produce better functioning differentiate to basic standard discrete wavelet transform techniques grounded image fusion techniques. The final diagnosis results compare the different image quality measure parameters to evaluate the proposed GA based image fusion algorithm.

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INTRODUCTION

Computer stimulated identifies different diagnoses and therapy robust that depend on image processing methods and are dramatically increased in current innovative medicine.

Early days, series of medical research data collected from different medical institutes in processing and detection of different and similar diagnosis are identified by experts using some standard image processing techniques has commenced to increased. Image fusion has been very popular in medical imaging in the present days. The discrete wavelet transforms (DWT) based image fusion techniques have been projected by many researchers in the past. The Evolutionary computational algorithms being used in the image fusion process has been an evolving technology. These advancements technology is used to determine the need for algorithm process development which will give complete idea and a major stimulation for novel algorithms in signal and image processing. The image fusion finds its importance in application areas such as satellite imaging, radar imaging, surveillance systems, etc. The image sensors might not be able to capture all the details of the images in many situations. Image fusion is an emergency process and important role in complete change of the quality of the image and also assessing the image quality parameters.

Image Fusion Techniques:

Image fusion is a operation of mixing two or additional different images to form a latest image which carry advanced data from the origin images i.e., original application particular data should be conserved and the artifacts information should be reduced in the fused image. The main purpose of image fusion is to raise the spatial and spectral resolution from many lower quality images. Based on this major advantage image fusion has become an popular subject for many scientific researchers.

The image fusion can be executed at three standard independent processing actions concording to the level at which the fusion occur properly: pixel, feature and decision level.

1. *Pixel level fusion:*

Pixel-position fusion is done on a pixel-by-pixel basic method. It create a fused image in which data related with every pixel is found from many of pixels in input images to increase the carry out of image processing function as segmentation.

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2. ***Feature level fusion:***

Advanced-defined fusion at characteristic level involve an origin of targets validity in several information sources. Its need mainly origin of salient features which are subject on their units such as pixel brightness, edges or textures. All These similar information from input images are fused.

3. ***Decision-level fusion:***

Decision-based fusion composed of unifying the data at a top level of generalisation, which mixing the valid results from a series combination of algorithms to produce a final fused decision. From Input data are processing by separately for data removal. The resulted data is then mixed by employ decision rules to support common interpretation and decision.

The image fusion mechanism or process may be extensively separated into two groups - spatial domain fusion and transform domain fusion.

The spatial domain fusion approaches include averaging method, select maximum/minimum method, Principal Component Analysis (PCA), Intensity-Hue Saturation (IHS) based methods and high pass filtering based techniques. The main drawback of spatial field near is that, they create spatial distortions in the mixed images. The spatial distortions are well hold by transform domain approaches such as Laplacian pyramid based transform, Discrete wavelet based transform, Curve let transform based etc. Image Fusion techniques set out from the basic method of pixel averaging to many experienced and state-of-the-art methods such as multi-resolution and neural network based fusion.

Wavelet transform which is a multi-resolution analysis preserved spectral characteristics of Medical images better than the regular methods such as Averaging, Intensity Hue saturation (IHS), Principle Component Analysis (PCA), etc. By applying wavelet transform alone, the fusion result is often not good. To address this pixel based image fusion methods are integrated with discrete wavelet transform and Evolutionary Algorithm (Genetic Algorithm).

Design of Basic Genetic Algorithm (GA):

A change of algorithms have been developed from nature. Genetic algorithm is one of the basic and most familiar developed algorithms. *Genetic Algorithms (here onwards called as GA)* are based on common selection invented by Charles Darwin. GA produce use of the basic description, producing and a set of range mechanism. Highest achivable performance with natural interchange of genetic material between parents. Issues are formed from parent genes. Fitness of problem is evaluated. The suitable discreate are permitted to cover only.

GA's are generally used in various applications such as mapping Optimization, System recognation and restraint, Image Processing, variable Optimization of Controllers, Multi-Objective Optimization, etc. Algorithm

The genetic algortihm is used in image fusion process and the implemention flow chart is shown in figure 1.

Case Study: Breast Cancer identification using Genetic Algorithm (GA):

This paper demonstrate a new set of image investigation tools developed for the resolve of aiding radiologists with the undertaking of finding and characterizing breast wounds in image data gained using magnetic resonance imaging (MRI) and FMRI functional magnetic resonance imaging. MRI is progressively being used in the clinical specifying as an accessory to x-ray mammography (which is, it, the basis of breast cancer screening programs worldwide) and ultrasound. from these imaging modalities, MRI has the maximum sensitivity to invading cancer and to different types of common disease. MRI is the most authentic way for measuring tumour magnitude and range compared to the gold standard histopathology. It besides displays great assure for the an ended screening of junior women (with denser, more radio opaque breasts) and, potentially, for women at maximum danger.

Breast MRI currently has two large defects. First, although its sensitivity is high its quality is comparatively inadequate; i.e. the process distinguishes more false positives. Second, process required various high-resolution image intensities before, during and after the gain of a variance factors. The great volume of information induces the work of clear explanation by the radiologist both composite and time-taking process. These defects have actuated the research in producing image fusion techniques to enhance the efficiency and accuracy of clear explanation by the radiologist.

Image Fusion Methods:

Pixel level Average method: it is one of genius process and is a canonical and direct technique and fusion must be attained by uncomplicated averaging comparable pixels in each given image as follows:

$$I(a,b) = \frac{I_1(a,b) + I_2(a,b)}{2}$$

Pixel grade Weighted average method: the total some weights to the single images and execute the averaging technique as follows:

$$I(a,b) = \frac{W_1 * I_1(a,b) + W_2 * I_2(a,b)}{W_1 + W_2}$$

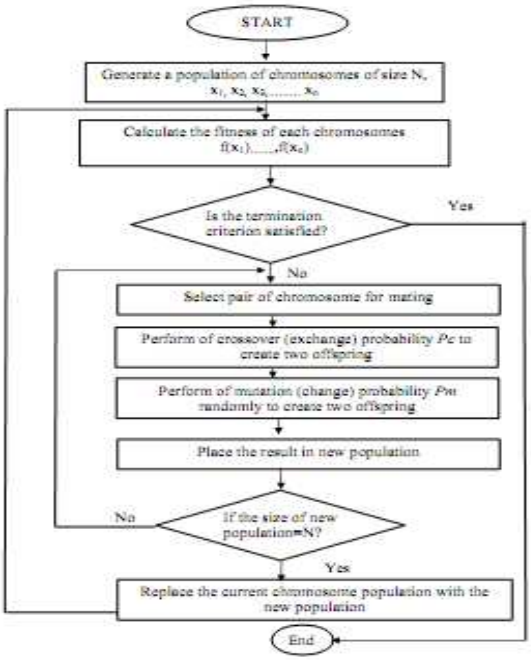

Fig. 1: flow chart for implementation of genetic algorithm.

where W1 and W2 are the weights.

Pixel grade weighted average method using GA: the oldest method the weights are approximated using the GA and a new optimized image is held from the average method using the optimized weights.

$$I(a,b)=\frac{GA(W_1)*I_1(a,b)+GA(W_2)*I_2(a,b)}{GA(W_1)+GA(W_1)}$$

Where GA (W1) is the optimized value of weight W1 and GA (W2) is the optimized value of weight W2.

DWT based image fusion: In wavelet image fusion process, the origin images I_1(a, b) and I_2(a, b) are decayed into estimation and particular coefficients at involved grades using DWT. The estimation and particular coefficients of both images are mixed using fusion rule f. The fused image will be achieved by considering the inverse discrete wavelet transform (IDWT) as:

$$I(a,b)=\frac{DWT\{I_1(a,b)\}+DWT\{I_2(a,b)\}}{2}$$

The fusion process employed is only averages the estimation coefficients and selected the particular coefficient in every sub band with the maximum magnitude.

Weighted average DWT based image fusion: In this current method extra weights are preferred along with the DWT of the images. The fused image can be achieved by acquire the inverse discrete wavelet transform (IDWT) as:

$$I(a,b)=\frac{W_1*DWT\{I_1(a,b)\}+W_2*DWT\{I_2(a,b)\}}{W_1+W_2}$$

Weighted average DWT based image fusion using GA: In the present method extra weights are approximated by using GA along with the DWT of the images. The fused image can be acquired by considering the inverse discrete wavelet transform (IDWT) as:

$$I(a,b)=\frac{GA(W_1)*DWT\{I_1(a,b)\}+GA(W_2)*DWT\{I_2(a,b)\}}{GA(W_1)+GA(W_2)}$$

Performance Metrics:

The execution of medical image fusion algorithms are measured in terms of Signal to Noise Ratio (SNR), Peak Signal to Noise Ratio (PSNR), Root Mean Square Error (RMSE), Normalized Cross Correlation (NCC), Universal Image Quality Index (UIQI), Fusion Factor (FF), Fusion Symmetry (FS) and Mutual Information (MI). The rich of the algorithms can be examined in the bearing of different types of noises.

Image fusion execution process estimated methods form an necessary division in the evolution of image fusion techniques. In the current situation various functioning analysis quantifies that have been offered in the area of image fusion and also analyses the outcome of fusion formation on the construction of fusion conspire. Expressive practicles on employing these quantify to compute a pair of widely used image fusion techniques are also represented to proved the usage of the measures, as well as to verify their rightness and strength.

Signal to Noise Ratio (SNR):

$$SNR=10\log_{10}\left(\frac{Energy_{signal}}{Energy_{noise}}\right)$$

where $Energy_{signal}$ is the sum of the squares of the signal values and $Energy_{noise}$ is the sum of the squares of the noise samples.

SNR show that the error of the approximation is small and, therefore, among different image fusion methods the ones that exhibit higher SNR's can be considered of better execution.

Peak Signal to Noise Ratio (PSNR):

$$PSNR = 10\log_{10}\frac{225^2}{\sum_{m=1}^{S_1}\sum_{n=1}^{S_2}[z(m,n)-o(m,n)]^2}$$

where z(m, n) and o(m, n) denote the intensity of the pixel of the estimated and original image, respectively, at location (m, n). The size of the images is $S_1 \times S_2$.

Root Mean Square Error (MSE):

The RMSE between a reference image R and the fused image F is given by

$$E_1 = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(R(i,j)-F(i,j))^2}$$

We had limited ways to build mention image using input images. From the practicles, we used the following procedure to compute RMSE. First, RMSE value El is computed between source image A and fused image F.

$$E_1 = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(I_1(i,j)-F(i,j))^2}$$

Similarly E2 is computed as RMSE between source image B and fused image F.

$$E_2 = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(I_2(i,j)-F(i,j))^2}$$

Then the overall RMSE value is obtained by taking the average of E1 and E2.

$$RMSE = \frac{(E_1+E_2)}{2}$$

Smaller RMSE value suggests good fusion quality.

When determining the functioning of an image fusion technique using the above observed metrics, we need understanding of the original image (ground truth). For that reason these matrices can be used only with synthetic (simulated) data.

Normalised Cross Correlation (NCC):

It is one of the familiar technique used in image processing as a measured to calculate the stage of sameness (or dissimilarity) betwixt two likened images. The main benefit of the normalized cross correlation compare with the simple cross correlation is that it is low sensitive to linear varies in the amplitude of brightness in the two likened images. Furthermore, the Normalized Cross Correlation is confined in the range between –1 and 1.

The normalized correlation for two time series can be defined as

$$\varphi'_{xy}(t) = \frac{\varphi_{xy}(t)}{\sqrt{\varphi_{xx}(0)\varphi_{yy}(0)}}$$

Universal Image Quality Index (UIQI):

UIQI measures the similarity between two images (I1 & I2) and its value ranges from -1 to 1. UIQI is equal to 1 if both images are identical. UIQI measure is given by

$$UIQI = \frac{m_{ab}}{m_a m_b}\frac{2xy}{x^2+y^2}\frac{2m_a m_b}{m_a^2+m_b^2}$$

Where x and y denote the mean values of images I1 and I2 and m_a^2, m_b^2 and m_{ab} denotes the variance of I1 , I2 and covariance of I1 and I2.

Mutual Information (MI):

The receprocal data (MI) evaluates the stage of dependence of two images. Its value is zero when I1 and I2 are independent of each other. MI between two source images I1 and I2 and fused image F is given by

$$MI = \sum_{(f,a)} P_{FA}(f,a)\log_2\frac{P_{FA}(f,a)}{P_F(f)P_A(a)} + \sum_{(f,b)} P_{FB}(f,b)\log_2\frac{P_{FA}(f,b)}{P_F(f)P_b(b)}$$

and $P_A(a)$,$P_B(b)$ and $P_F(f)$ are histograms of images A, B and *F*, $P_{FA}(f,a)$ *and* $P(f,b)$ are the joint histograms of F and A, and F and B respectively. Higher MI value indicates good fusion results.

Fusion Factor (FF) and Fusion Symmetry (FS):

The authors in also use the MI measurement with the name Fusion Factor (FF) and express that large FF shown that large information has been changed from the source images to the fused image. However, they point out that large FF still cannot indicate whether the source images are fused symmetrically. Therefore, they employ a concept called Fusion Symmetry (FS) given in the equation

$$FS = abs\left(\frac{MI_{FA}(f,a)}{MI_{FA}(f,a)+MI_{FA}(f,b)} - 0.5\right)$$

To hold the uniformity of the fusion process in connection to two input images. The smaller the FS, the better the fusion process performs.

Based on their interpretation, the FF has to be given importance, when one of the two sensors is deficient. When both sensors are of high quality, then the FS parameter is also of significant and an algorithm with comparatively smaller FS has to be taken.

Results:

The series of experimentations were conducted and functioning estimation were consider on various images. The two algorithms of DWT and the mentioned Genetic Algorithm method were enforced with MATLAB latest version.

The investigation is conducted in different number of images from MIAS database and some of them are shown below in figure 2, 3, 4, and 5 along with the numerical values in Table 1. The numerical values of the execution parameters namely PSNR, NCC, IQI, MI and FS test the efficiency of the algorithm deliberated.

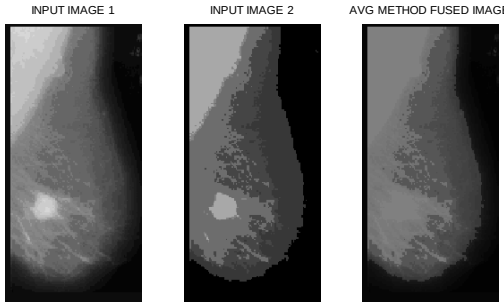

Fig. 2: Image Fusion using averaging method.

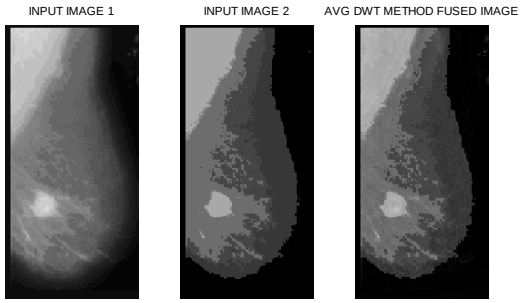

Fig. 3: Image fusion using DWT method.

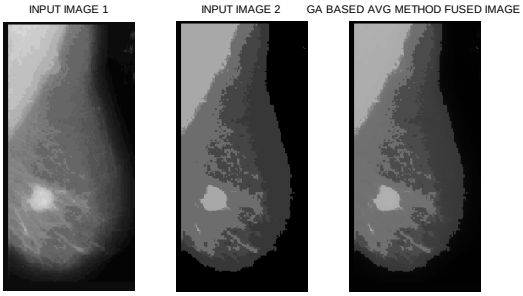

Fig. 4: Image Fusion using GA averaging method.

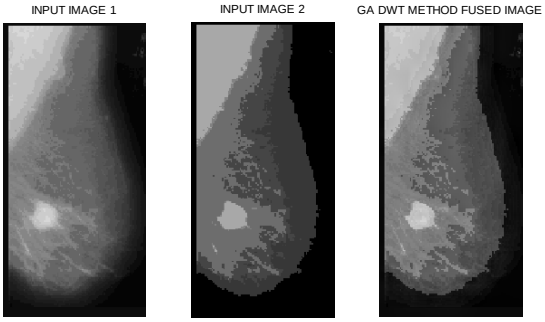

Fig. 5: Image fusion using GA with DWT.

Table 1: Image Fusion Evaluation Parameters.

S. NO.	Parameter	Average Method	DWT method	GA– Average Method	GA – DWT Method
1	RMSE	25.1409	14.2611	21.3067	9.9624
2	PSNR	20.1232	25.0477	21.5605	28.1636
3	NCC	0.7904	0.9085	0.8321	0.9608
4	MI	1.9385	1.4753	2	1.4882
5	UIQI	0.8190	0.7953	0.6991	0.9398
6	FS	0.0354	0.0336	0.0083	0.0327

Conclusion:

In general when the images from Figure 2, 3, 4 and 5 are observed much difference in the outputs is not noticed. But this difference can be elaborated from the parametric response of these images, which is presented in the Table 1. It is observed from the table 1 that DWT method gives a much better response than the Averaging method and the GA-Averaging method. But it can also be observed that the method proposed by the authors i.e., the Genetic Algorithm based Discrete Wavelet Transform method is giving much better response than the latter methods.

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