Hybrid Image Fusion using Curvelet and Wavelet Transform Using PCA and SVM

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ABSTRACT
The main aim behind fusing of image is to assimilate the integral multi view data (can be multi-sensor or multi temporal) into a state-of-the-art image which consist of data the quality of which cannot be acquired otherwise. The approved data fusion techniques may be acceptable to consolidate a medical image i.e. black and white image (susceptible to all wavelengths of apparent light) with high resolution and small resolution multi-spectral image. This is on account of that they can alter the spectral attributes of the multi-spectral data. Image fusion is an imposing province as for its relevance to various applications. It is required for making the input images more accurate. Fusion of Remote sensing images can not only enhance the spatial resolution for the original multispectral image, but should also perpetuate the spectral information to an absolute degree. Image fusion in the medical field has transformed the medical analysis with the improvement in the certainty and performance of diagnosis or interpretation which are facilitated by computer. Here, in this paper Curvelet and Wavelet technique is used for image fusion. The SVM and PCA algorithms are also used in this paper. The paper is implemented by using Matlab simulator.

KEYWORDS
Curvelet and Wavelet Transform, Support Vector Machine (SVM), Fisher Kernel, PCA, PSNR, RMSE, BER

1. INTRODUCTION
In the field where there is perception by computer, the technique with which the data of two images are fused together so as to retrieve a new fused image which contains all the important data of both images is known as Image fusion technique. It is the case where combining the information takes place. The fused image which is acquired is more informational as compared with the input images which are fused together. There are three different traditional data fusion categories; that are Feature level, Pixel level and Decision level. At different levels, different algorithms of image fusion are used on the basis of application. This technique that used for fusing is enormously applicable in different research areas such as Medical Imaging, Remote sensing, Satellite Imaging, Robotics, Military applications and many more. By Image Fusion more than one image are merged in such manner that it preserves the maximum enviable attributes of each image. Image fusing is done between a medical image and a multi-spectral imagery, the result obtained is a fused image of both the images which contains the spatial resolution or verdict and quality traits of both the medical imagery and the multispectral imagery. The substantial extent of research is supervised over the last ten years. Here, in this paper, a preface of Curvelet and Wavelet algorithms are given together with a technique of image fusion, and at last the decision is made on the basis of the results attained which were compared with the previous scheme. It has been found from previous research that wavelet-based schemes achieve better results as compared to the standard techniques. Especially, in terms of reducing the colour distortion, wavelet technique performance is far better. The
systems which combine both the standard methods and the wavelet transforms yield superior results when compared with alone i.e. either with the standard or traditional methods or with the elementary that is simple systems based on wavelet. Scheme which inculcates the wavelet based techniques gives better results but the results can also be enhanced by implementing models which are more sophisticated for infusing detailed information. But these types of systems often have requirements related to better or greater set-up.

2. LITRATURE SURVEY

This section discussed the research work that has been done in last few years. Image fusion is the most promising field of research in which all researchers are interested. A literature review goes beyond the pursuit for information or knowledge and it involves the recognition and connection of relationships among the literature and our research field.

Anand, Narasimhan and Saravanan in “Performance Evaluation of Image Fusion Using the Multi-Wavelet and Curvelet Transforms” [1] suggested an algorithm for fusing two different medical images on the basis of multi-wavelet and Curvelet transform along with different image fusion techniques. Results obtained after fusion were appraised and correlate according to the performance measures like PSNE, RMSE, Correlation Coefficient and Entropy. They observed that technique based on Curvelet transform gives better curved visual details than that from multi-wavelet transform algorithm.

Alparone, Baronti, Garzelli and Nencini in “The curvelet transform for fusion of very-high resolution multispectral and panchromatic images” [22] present a novel technique for image fusion. This technique is acceptable for panchromatic sharpening of multi-spectral bands on the basis of MRA (multi-resolution analysis). The experiments were performed on higher intensity Multi-Spectral + Panchromatic image of QuickBird. This manifest that the prospective approach which is based on the Curvelet method significantly surpass the advanced methods of image fusion in the terms under the conditions of spectral dependability, geometric and radiometric.

In “An Image Fusion Using Wavelet and Curvelet Transforms” by Mamatha and Gayatri, [7] a state-of-the-art approach was presented for fusing of digital images with the support of Curvelet transform. They obtained higher correlated coefficient and the value of entropy when compared with the system supporting wavelet technique.

In paper “An Advanced Image Fusion Algorithm Based on Wavelet Transform-Incorporation with PCA and Morphological Processing” [23] by Zheng, Essock and Hansen, a novel method of image fusion named Advanced DWT that contain Principal Component Analysis and morphological transforming into typical fusion strategy based on DWT. The presented technique is better than five pyramid method and regular DWT techniques. This estimation is based on four quantitative attributes i.e. Image Quality Index, Entropy, Root Mean Square Error (RMSE) and Spatial Frequency.

Other work in this research field is in “Multimodal Medical Image Fusion using Redundant DiscreteWavelet Transform” by Singh, Vatsa, and Noore. [4] Wojnar and Pinheiro in “Annotation of Medical Images Using the SURF Descriptor” proposed an approach supported by SURF keypoints Descriptor and SVM. The extraction of attributes a Fast-Hessian detector was used. By applying SURF descriptor the results of accuracy achieve is over 96 percent which exhibit an improved analysis of lung images.

The paper on “Performance Optimization of Image Fusion by using Meta Heuristic Genetic Algorithm” written by Tiwari [3]. The author adds the concept of region based into image fusion so as to improve the traditional IHS technique, wavelet method, pattern recognition method and neural network method.

Taher, Wahed, Tawal and Fouad in “Image fusion approach with noise reduction using Genetic Algorithm” [2] introduced a state-of-the-art approach which outsets with reduction of noise in image by utilizing Genetic Algorithm (GE). The Curvelet transform algorithm is applied after Genetic Algorithm for the disintegration of image so as to obtain a multi-focused fused image. Results retrieved indicate that Curvelet transform proven to be efficient and persuasive in the detection of image exertion around the curves. This enhances the characteristics of the acquired images fused.
3. **Methodology**

Methodology used in this paper involves various phases. The first step is loading of the images on which further pre-processing and fusion algorithms are applied. In the pre-processing step low-frequency background noise is removed and the intensity of the individual particles images are normalized. After performing the step of pre-processing, image fusion algorithms are applied. In this paper two image fusion algorithms are applied namely; *Curvelet and Wavelet Transform*. After this principal component analysis is used and then the enhancement of image is done by using an SVM algorithm. The flowchart of methodology is shown below:

![Methodology Flowchart](image)

As shows in the above methodology flow chart, our first step is to load images.

### 3.1 Load Images

The images of CT and MRI are loaded. The medical images are taken and the database is created with 30 medical images. The CT image and MRI image of same organs is loaded on which pre-processing is performed in second phase. Figure 1 shows the CT image and Figure 2 shows the MRI image.

![Figure 1: CT image](image)

![Figure 2: MRI image](image)

### 3.2 Pre processing

In the pre-processing phase unwanted noises are removed. Sometimes the distortion occurs when two or more images are captured at distinctive viewpoints of arena. In such cases, nearly all the commodities remain identical nevertheless there can be a little change in shapes. Before beginning with the fusion of images, the problem of distortion should be taken care of. For fixing the problem of distortion, there should be surety that every picture element in images which are correlated shows the affiliation amidst those images. Image registration can be used for this [20].

The pre-processing of CT/MRI images is done in following steps;

Firstly, the both CT and MRI images components which are in R, G, B scale are converted into grey color.

Secondly, the equating and balancing of intensity of grey color image is done. Lastly, the image is resized into its normalize size.

### 3.3 Fusion Algorithms

There are two image fusion algorithms used in this paper which are named as Wavelet Image Fusion Algorithm and Curvelet Algorithm for Fusing Images.
3.3.1 Wavelet Algorithm for Image Fusion: In this image fusion algorithm following steps are performed. [1]

**Step 1:** There are two source input images i.e. CT image and MRI image. Both images are registered initially.

**Step 2:** The decomposition steps are implemented or executed for both the images.

**Step 3:** Maximal frequency fusion decree i.e. PCA is put forward for carrying out fusion among coefficients of wavelet.

**Step 4:** SVM is applied on the fused image.

**Step 5:** The inverse of wavelet transform is performed so as to acquire the fused images.

The figures showed below shows the decomposition of the CT and MRI images. Wavelet transformation is applied on both the images.

Figure 4 and Figure 5 shows the decomposition of both CT image and MRI image along with the Wavelet transform algorithm.

3.3.2 Curvelet Image Fusion Algorithm: In this algorithm Ridgelet coefficients are generated. In this algorithm for fusing image subsequent phases are involved [18]:

**Step I:** Initially the two input images are registered (i.e. CT and MRI images).

**Step II:** Both of input images are then analyzed and a set of Curvelet (Ridgelet) coefficients are achieved.

**Step III:** Then the maximal frequency decree PCA is put forward for carrying out fusion among coefficients of Curvelet generated in second step.

**Step IV:** SVM is applied on the fused image.

**Step V:** In the end, the opposite of Curvelet transformation is executed for acquiring the merged images.

Figure 6 and Figure 7 shows the Curvelet transformation image fusion algorithm applied on both Ct image and MRI image.
3.4 Image Fusion Method

Principal Component Analysis (PCA) method: The PCA technique is the technique which is based on vector space transform and is utilised to reduce the dimensionality i.e. from multi-dimensional datasets to the lower dimensions [18]. In PCA methods following steps are involved:

Firstly, from the input images, column vectors are generated and then after the covariance matrix of two column vectors is estimated.

Secondly, from the covariance matrix, the Eigen values and Eigen vectors are calculated.

Finally, the column vector and the values of the Eigen vector are normalized that further exact like the weight characters. Every picture element of both the load images i.e. CT and MRI images is multiplied by these weight values. [18]

3.5 Enhancement of Image

Support Vector Machine (SVM) method: A SVM method is a classification method which shows discrimination between two classes, by fitting an OSH i.e. Optimal Separating Hyperplane. OSH was given by a scientist named Gunn in the year of 1998. SVM actually maximizes the margin between two classes of training sequence [21]. In this research work Fisher kernel is used. It was named after a statistician named Ronald Fisher. This function calibrates and evaluates the correlation between two commodities supporting by the group of calculations for every commodity.

This is the kernel that embraces Fisher score and the fisher score is defined by the following equation;

\[ U_x = \nabla_{\theta} \log P(X|\theta) \]

where, \( \theta \) is a group of criterion.

Therefore, the Fisher kernel can be delineated by;

\[ K(X_i, X_j) = U_{X_i}^T I^{-1} U_{X_j} \]

where, \( I \) is the Fisher information matrix.

4. RESULTS AND DISCUSSION

In this section of paper, different parameters are discussed and estimated which are further used for the comparison of our proposed approach with the previously used approach.

4.1 Performance Measures for Image Fusion

In this paper the performance measures for Image Fusion involves PSNR, RMSE, CC, BER and Entropy. This means the efficiency of the prospective approach can be estimated with the support of these parameters.

4.1.1 PSNR: It stands for peak signal to noise ratio. This section estimates the ratio of peak signal and noise signal among the two or more images in decibels (dB). It shows a measure of the peak error or it gives the proportion of the utmost attainable signal strength to the strength of noise signal which alters the constancy of its depiction [19]. It is delineated by the following equation;

\[ \text{PSNR} = 10 \times \log \left( \frac{L^2}{\text{RMSE}} \right) \]  

(1)

4.1.2 RMSE: It stands for Root Mean Square Error and can be estimated amidst the images by using subsequent equation;

\[ \text{RMSE} = 1/MN \sum_{m=1}^{M} \sum_{n=1}^{N} (R(m,n) - F(m,n))^2 \]  

(2)

If the estimated value of RMSE is less than the performance of the fusion algorithm is better [1].

4.1.3 Correlation Coefficient (CC): It is the measure of the similarity amidst the eccentric images with the merged images. Correlation coefficient diverges in the midst of +1 and -1. If result is nearby the positive side i.e. +1, it exhibits that the merged image is highly correlated with the reference image and if the result is nearby the diminished side i.e. -1, it indicates both merged and reference images are eminently antithetical. The equation for estimation CC is as follows;

\[ \text{CC} = 2 \text{Cr} \text{F} \]  

(3)

Where \( \text{Cr} = \text{Ir}(I_L) \text{Nj}=1 \text{Mi}=1 \)  
\( \text{F} = \text{If}(Nj=1 \text{Mi}=1(I_L)) \)  
\( \text{Crf} = \text{If}(Nj=1 \text{Mi}=1 \text{Ij If}(i,j)) \)

4.1.4 Entropy (H): Entropy in an image is delineated as a calibration of information capacity [1]. If value of entropy is increased after the fusion, it shows that the information is enhanced and the fusion performances are
better. For estimation the entropy following equation is applied.

\[ E = \sum_{g=0}^{L-1} p(g) \log_2 p(g) \]  

(4)

4.1.5 Bit Error Ratio: It is a decisive attribute which is beneficial for estimating the schemes whose operation is performing transmission of digital data beginning at one place to another. In a transmission system, a bit error ratio is delineated as the amount about which errors ensue. The definition of BER can be interpreted by a simple question:

\[ BER = \frac{\text{No. of errors}}{\text{Total no. of bits transmitted}} \]  

(5)

4.2 The Experimental Results of Metrics

Two source images i.e. CT image and MRI image are taken. In this research work, 28 CT and MRI images are used for obtaining different results. In the following figures, result obtained from the proposed approach is highlighted. Figures shown below, shows the graphical representation of PSNR, RMSE, BER, Entropy and Correlation Coefficient (CC) between the previous and proposed work.

Figure 8: Comparison of PSNR of previous and proposed work

Table 1: Comparison of PSNR previous and proposed work

Figure 8 shows the graphical representation of PSNR of both previous and proposed work and table 1 shows the comparison of values of PSNR between the previous and prospective method.

Figure 9 shows the graphical representation of RMSE of both the previous and proposed work.

Table 2 Relation of RMSE previous work and prospective work

The table shows the relation amidst values of Rot Mean Square Error between the previous and proposed method. The result shows the better RMSE values than the previous method.

Figure 10: Correlation Coefficient of previous and proposed work

Table 3 Comparison of CC previous and proposed work
Figure 10 shows the graphical representation of CC of both previous and proposed work and Table 3 present the relation amidst the values of CC between the previous and proposed method.

Table 4 Comparison of BER previous and proposed work

Figure 11: Bit Error Rate of previous and proposed work

Figure 11 shows the graphical representation of BER of both previous and the prospective work and Table 4 exhibit the relation amidst values of Bit Error Ratio (BER) between the previous and proposed method. This shows the better Bit Error Ratio (BER) values than the previous method.

Figure 12 shows the graphical representation of Entropy (H) between the previous and proposed work.

Table 5 Comparison of Entropy previous and proposed work

The following table shows the comparison of values of Entropy (H) between the previous and proposed method. This shows the better Entropy values than the previous method.

All the experiments performed shows that the approach which is proposed in this paper is more decisive and potent when compared with the all previous techniques used. This shows that the proposed system is much efficient as compared with the previous system. All the parameters are calculated just to verify the efficacy of the system.

5. Conclusion

The CT images show the information related to bone like bone injuries, lung and chest imaging whereas the MRI images show the information related to soft tissues. In this paper two image fusion algorithms; Curvelet and Wavelet image fusion algorithms are applied on the two different input images (CT and MRI images) and then Principal Component Analysis method applied on transform coefficients. The experimental results obtained from all the experiments shows that the approach proposed in this paper is more efficient as compared to the previous approach.

The proposed algorithm in this paper is more decisive and potent and is much more effective as compared to the previous system. All the parameters are estimated just to authenticate the efficacy of the system.

6. Future Scope

Although, the results acquired from the technique proposed in this paper are promising but this approach is limited to achieving an image from the set of images stored in the dataset. The work can be extensive on the different images and on more than single image at the same time. Future work may involve; the consideration of more attributes for the enhancement of characteristics or quality of the no. of pixels and it also extends for the perpetual no. of subjects. The different
algorithms can be utilised for the enhancement of accuracy in the fusing of images.

REFERENCE


