Performance Evaluation of Medical Image Fusion Approaches

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Abstract

Combining the information from two or more images into a solitary image is known as image combination that can keep down all the essential features of the first images. The principle target of image combination is to generate an image which depicts a scene preferred or considerably higher over any single image concerning some important properties giving a useful image. These combination techniques are most vital in diagnosing and treating growth in therapeutic fields.This article focuses on the development and analysis of various fusion algorithms such as discrete wavelet transform (DWT), stationary wavelet transform (SWT), fast discrete curvelet transform (F-DCT) and dis-sub sampled shapelet transform (DS-ST). Also, the quality of the fused image has been evaluated using a set of quality metrics which is known as image quality assessment (IQA).

Keywords:image fusion, PCA, decimate wavelet, Un-decimated wavelet, Dis-sub sampled Shapelet transform (DSST), Curvelet Transform and Quality Assessment metrics

1. Introduction

The fundamental point of combination [1] is to integrate two or more images into a solitary image to get more applicable information than any of the information images. Image combination concept can be utilized to distinguish the items obviously better than the first info images. Indeed, even it has been demonstrated for all intents and purposes in old days. Because of its reliability and magnificence, this innovation has been pulled in by numerous scientists, for example, image analysis and understanding, video analysis, PC vision, satellite imaging, therapeutic determination and machine adapting even in the field of optical remote detecting, route help. The principle thought process of image combination is to build up an upgraded scene by incorporating the caught information from various sensors without presenting the antiques. Because of sensor constraints, satellite images exhibit high ghastly with low spatial resolution or the other way around. A few remote detecting applications require a solitary image that exhibit high spatial and ghastly resolution, which can't be acquired straightforwardly by the camera. Doctors discover hard to concentrate features that may not be ordinarily noticeable in images by various modalities. In this way the arrangement is Image Fusion. Structure the previous decades there are such a variety of algorithms have been produced for image combination applications by utilizing spatial and transformation areas.

All the condition of workmanship algorithms are based on previously mentioned classes. In any case, they were experiencing couple of constraints, for example, higher multifaceted nature, less solid, more calculations and less precision. Here, we made a study on all the current image combination algorithms furthermore presented a novel therapeutic image combination plan utilizing MR and CT images based on DS-STto enhance the execution of the combination framework.

2. Related Work

Based on the writing, image combination strategies can be comprehensively sorted into spatial and otherworldly space techniques too. In [2] the creator has talked about that spatial area combination techniques will produces spatial bends in intertwined image; though these spatial contortion issues can be all around took care of by phantom space strategies. For instance, pyramid transform in phantom space can be utilized to maintain a strategic distance from contortion.

2.1. Spatial Domain Fusion Methods

The fundamental spatial area techniques are depicted below. Be that as it may, the adequacy of these techniques shifts with the kind of images considered for combination. In every one of these strategies, the information is an arrangement of two or more images of the same scene taken from various modalities. The yield is a melded image which is required to have a superior visual quality than the info images.

2.2. Spectral Domain Fusion Methods

All the spatial area-based techniques have symptoms like lessening the difference of whole image. In any case, these are much helpful and easier if there should arise an occurrence of high differentiation and splendid images. Consequently, there is a prerequisite to examine the execution of phantom space-based combination strategies.

2.2.1. Wavelet Transform Algorithms

Figure 1disclose the block diagram of DWT based image fusion approach. Fused image has been obtained by taking the inverse DWT for the addition of extracted features of fusion images i.e., approximated, horizontal, vertical and diagonal coefficients.

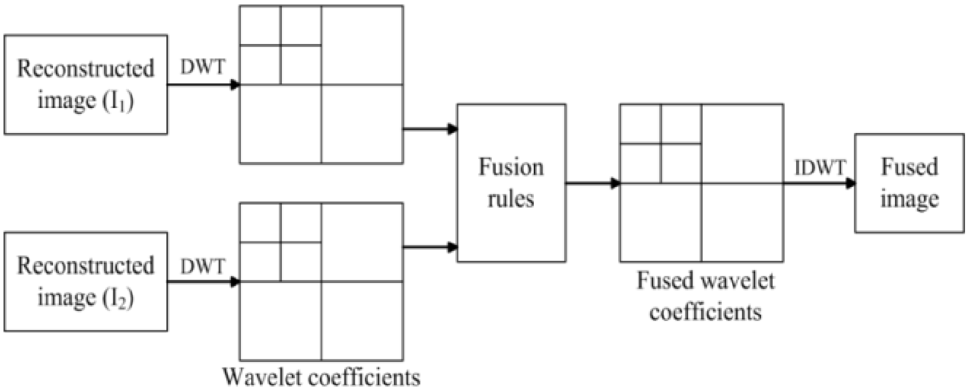

Figure 1. DWT based image fusion system

We also tested un-decimated wavelet transform i.e., stationary wavelet transform (SWT), which does not have decimation operation while decomposing the input image into subbands.

2.2.2. Fast Discrete Curvelet Transform (F-DCT)

Since Wavelet Transform takes block base to approach the peculiarity ofC^2, in this way isotropic will be communicated; geometry of peculiarity is overlooked. Curvelet Transform takes wedge base to approach the peculiarity ofC^2. It has point directivity contrasted and Wavelet, and anisotropy will be communicated. At the point when the course of congenial base matches the geometry of peculiarity attributes, Curvelet coefficients will be bigger. To begin with, we require pre-handling, and afterward cut the same scale from anticipating intertwined images as per chose region. Subsequently, we partition images into sub-images which are distinctive scales by Wavelet Transform. Subsequently, neighborhood Curvelet Transform of each sub-image ought to be taken; its sub-blocks are unique in relation to every other on account of scales.

- Resample and enlistment of unique images, we can adjust unique images and contortion so that those two have comparative probability dissemination. At that point Wavelet coefficient of comparable component will stay in the same greatness
- Using Wavelet Transform to deteriorate unique images into legitimate levels. One low-frequency rough component and three high-frequency point of interest components will be procured in every level
- Curvelet Transform of individual gained low frequency rough component and high frequency subtle element components from both of images, neighborhood interjection strategy is utilized and the points of interest of dim can't be changed.

According to definite standard to fuse images, local area variance is choosing to measure definition for low frequency component. First, divide low frequency$C_{jo}\,(k_1, k_2)$into individual foursquare sub-blocks, which are $N_1 \times M_1$(3×3 or 5×5), then calculate local area variance of the current sub-block:

$$STD = \sqrt{\frac{\sum_{i=-(N_1-1)/2}^{(N_1-1)/2} \sum_{i=-(M_1-1)/2}^{(M_1-1)/2} \left[C_{j0}(k_1+i, k_2+j) - \bar{C}_{j0}(k_1, k_2)\right]^2}{N_1 \times M_1}}$$

If variance is bigger, it shows that the local contrast of original image is bigger, that means clearer definition. It is expressed as follows:

$$C_{j0}^{F}(k_1, k_2) = \begin{cases} C_{j0}^{A}(k_1, k_2), STD^A \geq STD^B \\ C_{j0}^{B}(k_1, k_2), STD^A < STD^B \end{cases}$$

Regional activity $E_{j,l}$ (k1, k2) is defined as a fusion standard of high-frequency components. First, divide high-frequency sub-band into sub-blocks, then calculate regional activity of sub-blocks

$$E_{j,l}(k_1, k_2) = \sum_{i=-(N_1-1)/2}^{(N_1-1)/2} \sum_{i=-(M_1-1)/2}^{(M_1-1)/2} \left[C_{j,l}(k_1+i, k_2+j)\right]^2$$

Inverse transformation of coefficients after fusion, the reconstructed images will be fusion images.

3. Proposed Implementation

Images can be combined in three levels, in particular pixel level combination, feature level combination and choice level combination. Pixel level combination is embraced in this paper. We can take operation on pixel straightforwardly, and afterward melded image could be gotten. We can keep as more information as could reasonably be expected from source images.

Contourlet transform (CT) was introduced by Do and Vetterli in 2005 [9]. This transform is more suitable for constructing multi-resolution and multi-directional expansions, and capable in detecting the discontinuities at edge points and the smoothness along the contours. In the contourlet transform, a Laplacian pyramid (LP) [10] is employed in the first stage, while directional filter banks (DFB) are used in the angular decomposition stage. However, the contourlet transform does not provide shift-invariance and structural information; hence, it may not be the optimum choice for image processing applications such as image fusion. Recently, some approaches have been attempted to introduce image transforms based on the DFB with the capability of both radial and angular decomposition. The octave band directional filter banks [11] are a new family of directional filter banks that offer an octave-band radial decomposition as well. One more approach is the critically sampled contourlet (CRISP-contourlet) transform [12], which is understood using a one-stage non-separable filter bank. Using similar frequency decomposition to that of the contourlet transform, it offers a non-redundant description of the Contourlet transform. The second major drawback of the Contourlet transform is the incidence of artifacts that are caused by setting some transform coefficients to zero for nonlinear approximation during the fusion process. These unwanted artifacts occur in the areas with useful information; hence, there is a chance of losing important characteristics or information after the fusion process is completed.

The DS-ST consist a filter bank structure that divides two-dimensional signal or image into two parts which are shift invariant.

- A Dis-sub sampled pyramid structure that guarantees the multi scale property.
- ADis-sub sampled DFB Structure that offers directionality.

The depiction of DS-ST includes the following properties.

- Multi-resolution.
- Multi-direction.
- Shift invariant.
- Regularity.
- J+1 redundancy, where J is number of decomposition levels.

DSST fusion system is implemented as follows.

Step-I: Auto registered images A and B from different sensors are individually subjected to DS-ST, Band pass coefficients are obtained as shown in fig. 2a

Step-II: Further directional components are obtained by one more level of decomposition as shown in the Fig. 2b. The final decomposed components are one approximated and 8 detailed directional components after 3 levels of decomposition.

Step-III: Apply fusion rules to the decomposed coefficients.

Step-IV: Final fused output image will be obtained by applying inverse DS-ST

3.1. Quantitative Analysis of IQA

Here, we used image quality metrics to measure the output fused image quality which is obtained by using existing and proposed algorithms. Those are:

1. Mean Square Error (MSE)

$$MSE = \frac{1}{m \times n} \sum_{i=0}^{m} \sum_{j=0}^{n} \left(A_{i,j} - B_{i,j}\right)^2$$

Where, A= first input image

B=Second input image

i, *j*= number of rows and columns

2. Peak Signal to Noise Ratio (PSNR)

$$PSNR = 10 \times \log_{10} \frac{255^2}{MSE} \text{ (For grayscale)}$$

$$PSNR = 10 \times \log_{10} \frac{1}{MSE} \text{ (For binary)}$$

4. Experimental Results

In this section, all the experiments that have been done in MATLAB are presented. Various images have been tested with existing and proposed image fusion algorithms. Figure 2 shows that the original images to be fused and wavelet fused image.

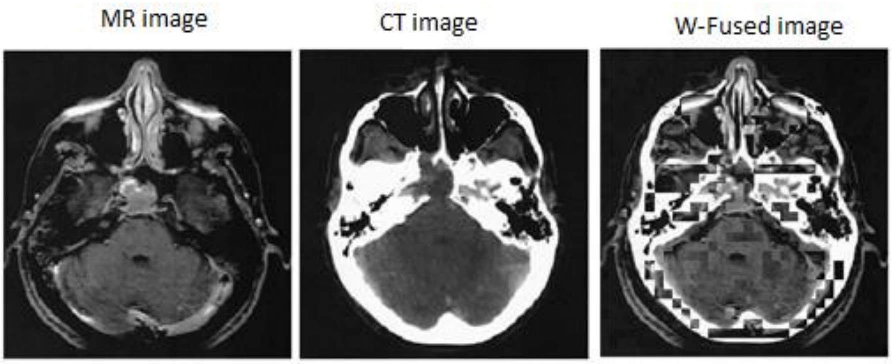

Figure 2. MR, CT images and wavelet fused image

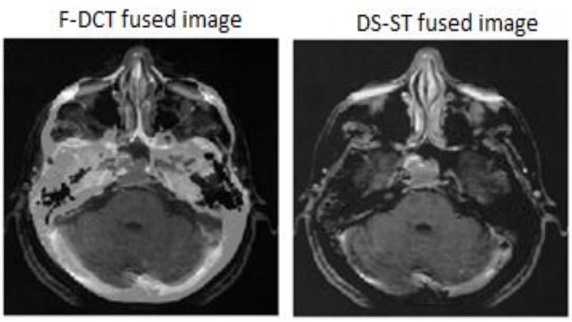

Figure 3. FDCT and DS-ST fused images

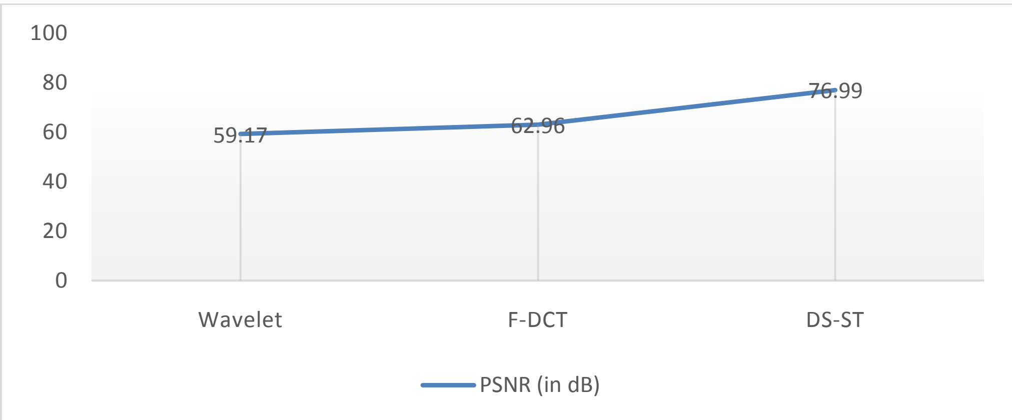

Figure 4. Comparison of PSNR values

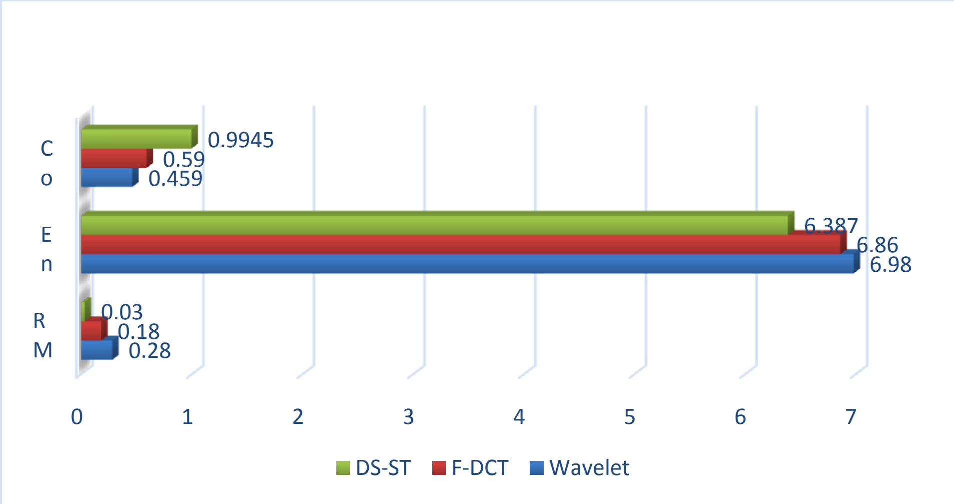

Figure 5. Performance evaluation using IQA

Figure 3 shows that the output fused images obtained by F-DCT and DS-ST respectively. Comparison of PSNR values is given in figure 4, where the proposed fusion algorithm has got 76.99 dB with well enhanced quality. Other quality metrics has given in figure 5. By observing all the simulation results, we can conclude that the proposed algorithm has got the better performance over all existing schemes.

5. Conclusion

The proposed image fusion method performs superior to the conventionalimage fusion techniques. The experiments indicate that the method is very effective also we calculated few quality metrics to prove that the proposed fusion technique effectiveness. It shows more robustness and efficiency in terms of PSNR, RMSE, CC and Entropy. In the future work we will continue to focus on the application of recent progress of multi-resolution analysis theory in 3D medical image fusion.

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