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An Adaptive Multi-Focus Medical Image Fusion using Cross Bilateral Filter Based on Mahalanobis Distance Measure

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ABSTRACT

In this paper the Cross Bilateral Filter is used to fuse source images with the help of Mahalanobis distance measure. The proposed image fusion algorithm directly fuses two source images of a same scene using weighted average. The proposed method differs from other weighted average methods in terms of weight computation and the domain of weighted average. Here, the weights are computed by measuring the strength of details in a detail image obtained by subtracting CBF output from original image. The weights thus computed are multiplied directly with the original source images followed by weight normalization. This paper compares the few similar image fusion algorithms by considering the performance evaluation metrics like Entropy, Standard Deviation, and PSNR.

Keywords: Cross Bilateral Filter, Mahalanobis distance, Entropy, Standard Deviation, PSNR.

I. INTRODUCTION

The purpose of image fusion is to get much more detailed image from the available degraded images, the process of image fusion had broad area of applications such as medical diagnosis, surveillance, military, machine vision, robotics, enhanced vision system, biometrics, remote sensing, etc., one among that particularly in the field of medical image processing systems where the details of an image must be understood visually. There is enormous research is going on regarding to the enrichment of the clarity in the medical images, since such issue is becoming more important in area of diagnosis purpose. The fusion of images could be done in varieties of models but the thing is to get the fused image in an acceptable form. D.Peter [1] *et.al* proposed a image fusion algorithm based on Discrete Wavelet transform and it results PSNR of 30.1192dB. The problem with DWT is its poor spectral resolution, to overcome this Somakait Udomhunsakul [2] *et.al* proposed an image fusion algorithm based on Discrete SWT and it results PSNR of 32.8650dB. Here, the main limitation of this approach is that the fused image considers most of the redundant information available in the source images. S.T. Li [3] *et.al.* proposed new algorithm based on Curvelets which deals effectively with line singularities in 2-D and it results a PSNR of 38.0612dB. But the problem with curvelets is that it results poor directionality at the edges of the image. Q.G. Mio [4] *et.al.* proposed an algorithm based on Non sub-sampled Contourlet transform and it results the PSNR of 40.8101dB. There are various approaches for fusion of images in spatial domain also, those are by using the bilateral filter (BF) introduced by Hu. J *et.al* [27] has many applications in image de-noising, flash photography enhancement, image/video fusion etc. A variant of BF, Joint/Cross BF, which uses a second image to shape the filter kernel and operate on the first image, and vice versa was proposed in. Both of these papers address the problem of combining the details of images captured with and without flash under ambient illumination. In Rusinkiewicz et al. [35], BF has been used for multi-scale decomposition of multi-light image collections for shape and detail enhancement. In this paper, we propose a method for multi-focus medical image fusion which is based on the Cross Bilateral Filter with the help of Mahalanobis distance measure.

II. METHODS AND MATERIAL

1. Cross Bilateral Filtering

Bilateral filtering is a local, nonlinear and non- iterative technique which combines a classical low-pass filter with an edge stopping function that attenuates the filter kernel when the intensity difference between pixels is large. As both gray level similarities and geometric closeness of the neighboring pixels are considered, the weights of the filter depend not only on Mahalanobis distance but also on the distance in gray/color space. The advantage of the filter is that it smoothes the image while preserving edges using neighboring pixels. CBF considers both gray-level similarities and geometric closeness of neighboring pixels in first image to shape the filter kernel and filters the second image. The diagram for Image Fusion using Cross Bilateral Filter based on Mahalanobis distance measure is as shown in Figure1.

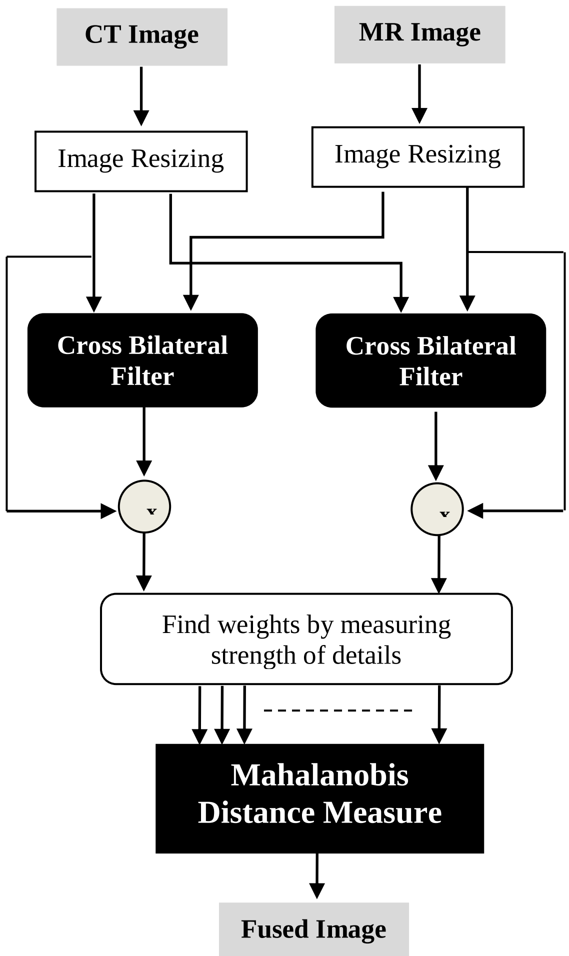

Figure 1. Diagram for Image Fusion using Cross Bilateral Filter based on Mahalanobis distance measure

The detail image, obtained by subtracting Cross Bilateral Filter (CBF) output from the respective original image, for CT and MR images is given by $CT_D = CT - CT_{CBF}$ and $MR_D = MR - MR_{CBF}$, respectively. In multi-focus images, unfocused area in CT image will be focused in MR image and the application of CBF on MR image will blur the focused area more compared to that of unfocused area in MR image. This is because the unfocused area in CT image anyway looks blurred with almost similar gray values in that area thereby making the filter kernel close to Gaussian. Now, the idea is to capture most of the focused area details in detail image MR_D such that these details can be used to find the weights for image fusion using Mahalanobis distance measure. Similarly, the information in MR image is absent in CT image and the application of CBF on MR image will blur the information in MR image. This is because; as the information in CT image is absent, the gray levels in that region have similar values thereby making the kernel as Gaussian.

2. Mahalanobis Distance Measure (Fusion Decision Rule)

The Mahalanobis distance takes the co-variances into account, which lead to elliptic decision boundaries in the 2D case, as opposed to the circular boundary in the Euclidean case. The Euclidean distance may be seen as a special case of the Mahalanobis distance with equal variances of the variables. Each variable that makes up a dimension may have a different variance relative to the other variables, therefore the elliptic or ellipsoid boundary may prove to give better segmentation results. Mahalanobis distance is the L2-norm of a "whitened" signal (or vector). In this context, whitening is the practice of removing all linear statistical dependencies from a signal (or vector) based on a Gaussian assumption.

3. Proposed Algorithm for Image Fusion

The algorithm for fusion of multi-focus medical images using Cross Bilateral filter based on the Mahalanobis distance measure is as shown in Figure 2.

. Initially, the images which are going to be fused must be registered first.

i. After registering the images, one more important step to be followed prior to move the original fusion process is that image resizing. That is the process of shaping the source images as equal to one another. This could show a positive impact on the entire fusion process.

iii. Once the image resizing is completed, there is an immediate requirement is that it should be checked for satisfying the requirement.

iv. If it is ok, then with the help of Cross Bilateral Filter extract the coefficients of the source images. In this process the filter plays a major role in selecting the desired coefficients from redundant information. This could lead the Cross Bilateral Filter as an adaptive filter in making decisions regarding to selection of image coefficients.

v. Finally after considering the desirable coefficients, there is a requirement to find the distances among them. By selecting proper distance measure an efficient and effective results can be achieved.

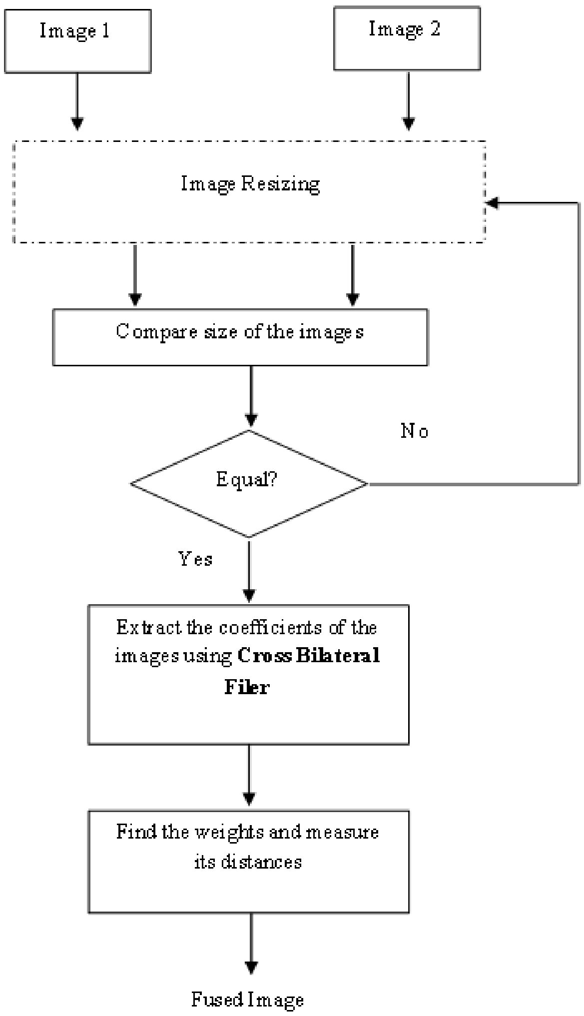

Figure 2. Algorithm for Image Fusion using Cross Bilateral Filter based on Mahalanobis distance measure

III. RESULTS AND DISCUSSION

1. Comparison of Various Medical Image Fusion Techniques

The proposed method performance was compared with the Contourlets, Curvelets, Discrete Stationary wavelet transform [Discrete-SWT], Dual tree complex wavelet transform [DT-CWT], Discrete Wavelet transform [DWT], Principal Component Analysis [PCA] and Simple Average method. Comparison of different medical image fusion techniques is as shown in table1.

	ENTROPY	STANDARD DEVIATION	PSNR
PROPOSED METHOD	**6.7375**	**56.8997**	**42.2838**
CONTOURLETS	6.1514	54.4706	40.8101
CUVRVELETS	5.9189	52.1582	38.0612
Discrete SWT	6.0528	45.0754	32.8650
DT-CWT	5.8625	35.8754	32.1753
DWT	5.9870	35.1490	30.1192
PCA	5.8792	45.3889	28.6018
AVERAGE	5.9868	34.9141	28.0784

2. Graphical Representation of Different Image Fusion Approaches

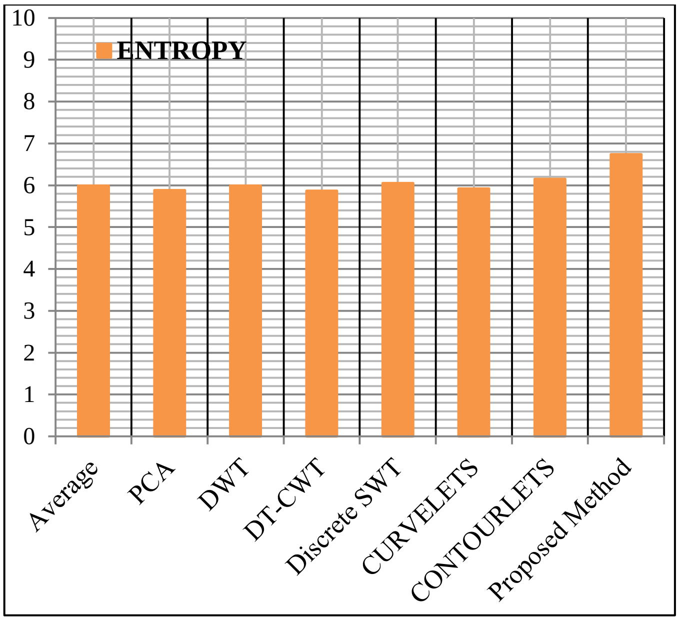

Figure 3. Graphical Representation of Entropy of various image fusion approaches

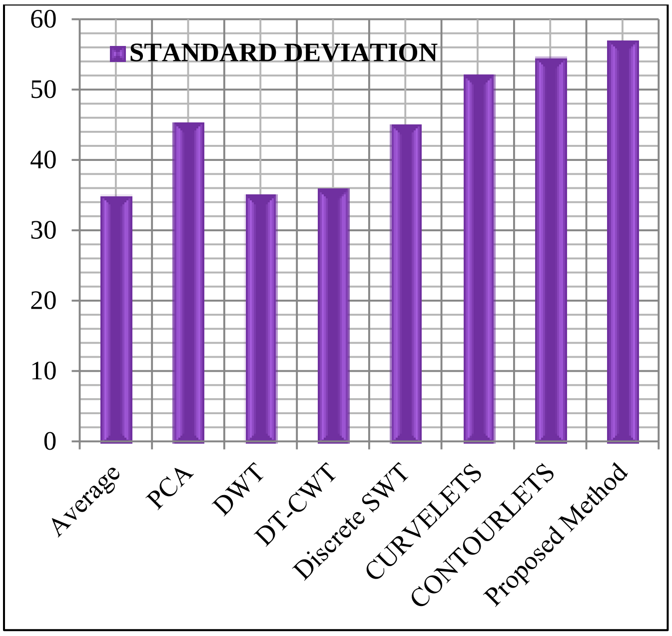

Figure 4. Graphical representation of Standard Deviation of various image fusion approaches

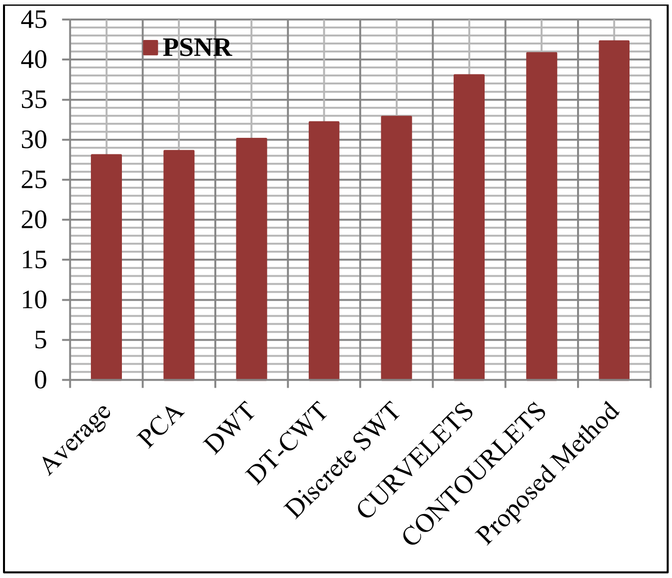

Figure 5. Graphical representation of PSNR of various image fusion approaches

IV. CONCLUSION

In this paper, an image fusion technique is proposed for multi-focused medical images of CT and MRI, which is based on Cross Bilateral Filter using Mahalanobis Distance Measure. This paper compares the results with various image fusion algorithms like Simple Average method, PCA, DWT method, DT-CWT method, Discrete SWT method, Curvelet transform, Contourlet transform. The resultant image had enriched visual quality.

V. ACKNOWLEDGEMENT

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