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Medical Image Fusion using Rayleigh Contrast Limited Adaptive Histogram Equalization and Ant Colony Edge Method

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Abstract: ***Image fusion can be broadly defined as the process of combing multiple input images into a single image without the introduction of distortion or loss of information. The motive of fusion of images is representing the relevant information from many individual images in a single image. Fusion is an important technique and is widely used in many fields such as remote sensing, robotics and medical applications. The term image fusion becomes important in the field of medical for the fusion of medical images known as medical image fusion. Medical image fusion is used to fulfill clinic requirements such as for the purpose of diagnosis and treatment. As there are various imaging modalities used in medical image fusion like MRI, CT, PET, SPECT etc. Hence to get complete, detailed and accurate information these images are to be fused. The propose work is Image Fusion using Rayleigh CLAHE (Contrast Limited Adaptive Histogram Equalization) and Ant colony Edge method. In the proposed method there is a fusion of MRI and CT images then histogram plot of both images are equalized by using the Contrast Limited Adaptive Histogram Equalization. Finally the edges of fused image that contains information are prevented from distortion by using Ant Colony Edge Method. The result parameters of propose technique is compared with Histogram equalization of MRI and CT images using Canny Edge Detection Method. The purpose of this is also to provide a comprehensive review of the existing literature available on image fusion and its quality metrics from already proposed techniques. The results are obtained by using MATLAB language and tools.***

Keywords: *Image Fusion, Medical Imaging, Medical image modalities, Rayleigh CLAHE, Ant colony edge method.*

1. Introduction

Image fusion the processes in which two or more than two images are combined into a single image which contains the necessary information of original input images. The input images that are combined to make single fused image are of same or from different modality. The main purpose of image fusion is information from different images to one single image, and this new fused image is more reliable as well as much easier to be understand by people with less effort [1]. The aim of image fusion is combining complementary as well as mutual information from many images to create a single fused image. Hence the new generated image contains a more accurate description of the data in image than individual image and also the fused image is much suitable for human visual and machine perception as well as for further image processing and analysis tasks [2]. The main objective of image fusion is that it extracts all the useful information from the input images Also it do not introduce any inconsistencies which will distract human observers. Image fusion plays an important role in the field of medical image fusion, military, remote sensing etc. Any fusion algorithm must satisfy two main requirements. The first one is that it is able to recognize the main features present in the input images which are to be fused and send them without any loss of detail into the final fused image. Another one is that the fusion method does not create any inconsistencies or artifacts.

2. Medical Image Fusion

Now a day, medical imaging plays an important role in number of applications such as for diagnosis, research, and treatment. Medical image fusion is used to combine multiple images, such as CT, MRI, PET, SPECT etc, into single image which contains more efficient information for diagnoses, treatment and other applications [5]. As there are various modalities used for medical image fusion like computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), positron emission tomography (PET) etc. Each of which provide different information for example, CT image gives information about dense structures like bones and implants with less distortion, but it cannot provide soft tissues information. In a similar way MR image provides soft tissues information but cannot gives the bones information or dense structures information. Instead of looking different images separately, physicians need the fused image which adds relevant information from many scanners into single image. It means that the single image cannot fulfill the clinical requirements. Hence the fusion of medical images is important. Another advantage of medical image fusion is that it reduces the storage cost by storing the single as well as more informative fused image instead of storing the multiple images differently like MRI which displays the non-anatomical information and CT which provides anatomical information [6]. Basically medical image fusion solves that problem in which single image cannot give both anatomical and functional information. As there are various medical modalities with each modality gives different information also to fuse these medical images there are various fusion algorithms

are present each having its own advantage and disadvantage.

3. Quality Metrics

The quality metrics are used to find the performance of fused image in terms of retaining important details, edges and quality of image. Quality metrics used in this research paper are:

1) Peak Signal-to-Noise Ratio (PSNR): It represents the peak signal to noise ratio, so the value of PSNR must be high for less noise in an image. Also higher the value of the PSNR better the fusion effect is and also better is the image quality. PSNR is measured in decibels (db).
2) Entropy: It defines the average amount of information in a digital image. [3]
3) Mean: The mean represents the average of pixel values of an image. So, the value of Mean should be high for better contrast in an fused image. [7]
4) Standard Deviation: This quality metric measures presence of contrast in the fused image. Standard deviation is a square root of variance Hence an image having high contrast have a high standard deviation and a low contrast image have a low standard deviation. [4]
5) Mean Square Error: The measure of image quality index is known as mean square error. Large value of man square means that the image is poor in quality.
6) These parameters are calculated and done comparison with the fusion of MRI and CT images using histogram equalized technique.

4. Related Work

S. Das et. al. proposed a multimodality medical image fusion method which was based on combined Activity Level Measurement and Contourlet Transform. In this firstly source medical images were decomposed by the Contourlet Transform. The low-frequency sub-bands were fused using the combined Activity Level Measurement and the high-frequency sub-bands were fused based on their 'local average energy' of the neighborhood of coefficients. The fused image is obtained by using inverse contourlet transform. To know the performance of proposed scheme different quantitative measures such as Mutual Information, Spatial Frequency and Entropy etc are used [8]. Shukla et. al. introduced a architecture with hybrid algorithm and the main feature of the hybrid architecture was that it was the combination of advantages of pixel and region based fusion in a single image which enhances the edges and structural details [9]. Al-Azzawi et. al. proposed an effective medical image fusion method and proves that the proposed method shows that the final fused image is more informative with less distortion [10]. V.P.S. Naidu et. al. proposed pixel-level image fusion using wavelets and principle component analysis. The different quality metrics are calculated by using reference image or without reference image.. Quality metric for simple averaging is also calculated and found that the simple averaging fusion algorithm displays degraded performance. The improved results are obtained by using wavelet with shift invariant property. The proposed method displays that in some metrics the wavelet method gives better results and in others PCA showed good performance [11]. Hamza et. al. proposed a multiscal image fusion algorithm in which the fused images were enhanced and were more human recognizable. The proposed method gives better results compared to wavelet based fusion methods. This method preserve significant features from different source without small limitations like artifacts [12] Cao et. al. proposed a *remote sensing image fusion method based on the PCA transform and wavelet packet transform. This* Proposed method not only preserves spectral information of original multi-spectral image, but also enhances spatial detail information of fused image [13]

5. Proposed Work

As in the proposed work there is a use of a method known as fusion of medical images of different modalities by the use of Rayleigh contrast limited adaptive histogram equalization method and to prevent the distortion of edges in the fused image there is an addition of an optimal algorithm which is ant colony edge method. Here the CLAHE which is basically developed for medical imaging is used as compare to histogram equalization and adaptive histogram equalization. As CLAHE does not amplify the noise present in the image. Array size of images which are to be fused plays an important role means that if the array size of both the images are equal then only the fusion process takes place else not. Operation of work methodology flow chart is explained in various steps. These are:

Step 1: Foreground Image (eg. MRI) and background image (eg. CT) are input.
Step 2: Apply Rayleigh contrast limited adaptive histogram equalization method to both foreground image as well as background image.
Step 3: Equalized form of Foreground Image and background images are obtained.
Step 4: By using image fusion method on the foreground as well as background image, the fused image is obtained.
Step 5: Array size of both the images are checked.
(i) If the array size of one image is not matched with the other one then "display output array size is not equal".
(ii) If array sizes of both the images are equal then fused form of image is obtained.
Step 6: Ant Colony Edge method is applied to the fused image.
Step 7: Finally the fused edge detected image is obtained with increasing PSNR, standard deviation and containing more information.

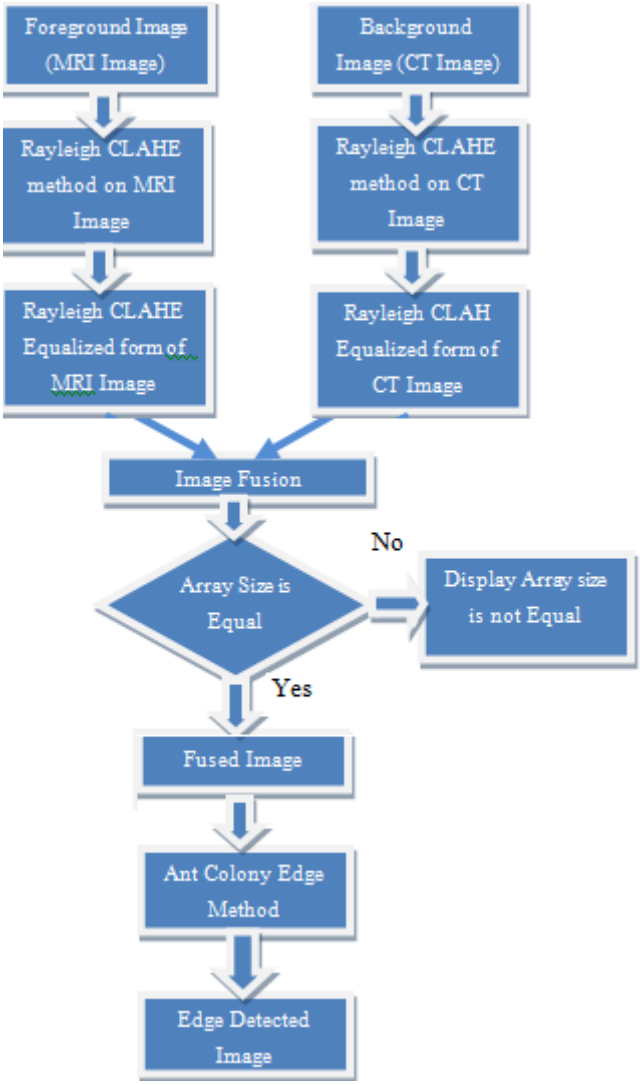

Figure 1: Flow Chart of Work Methodology

6. Experimental Results

The results obtained by using Set A of the two different medical imaging modalities

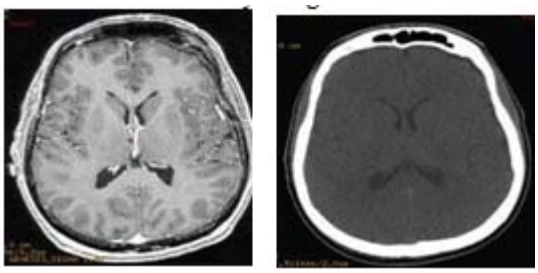

Figure 2: Set A of (MRI and CT) images

Figure 3: Fused Set A image using histogram equalization

Figure 4: Fused Set A image using Rayleigh contrast limited adaptive histogram equalization

Figure 5: Canny edge detected Set A fused image

Figure 6: Ant colony edge detected Set A fused image

The results obtained by using Set B of the two different medical imaging modalities

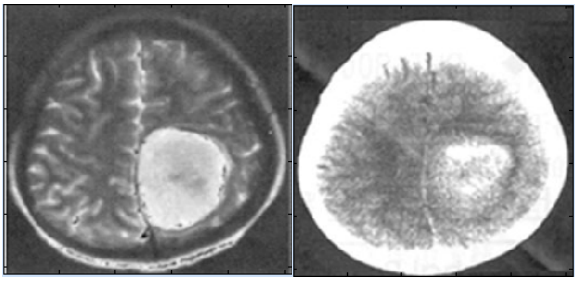

Figure 7: Set B of two medical images

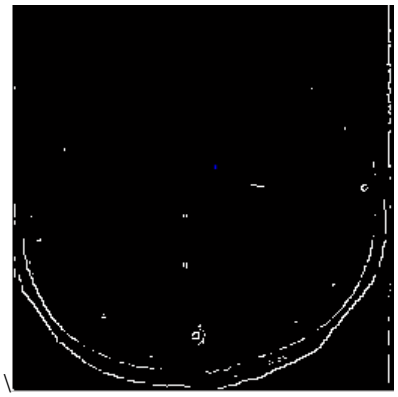

Figure 8: Canny edge detected Set B fused image

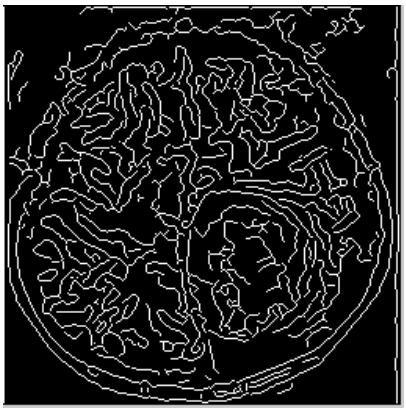

Figure 9: Fused Ant Colony Edge Detected Set B Image

Comparison of Edge detection using canny edge detection and ant colony edge method on set A and set B.

Table 1: Comparison of PSNR

Image Set	Fusion of images using HE and Canny Edge Method	Fusion of images using Rayleigh CLAHE and Ant Colony Edge Method
A	15.3222	25.1284
B	15.1136	20.5236

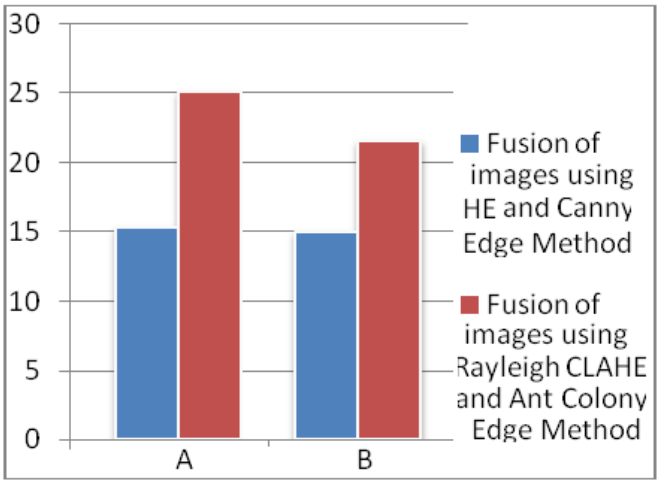

Figure 10: Bar chart showing comparison between PSNR

Table 2: Comparison of Entropy

Image Set	Fusion of images using HE and Canny Edge Method	Fusion of images using Rayleigh CLAHE and Ant Colony Edge Method
A	7.091	7.706
B	7.3404	7.6531

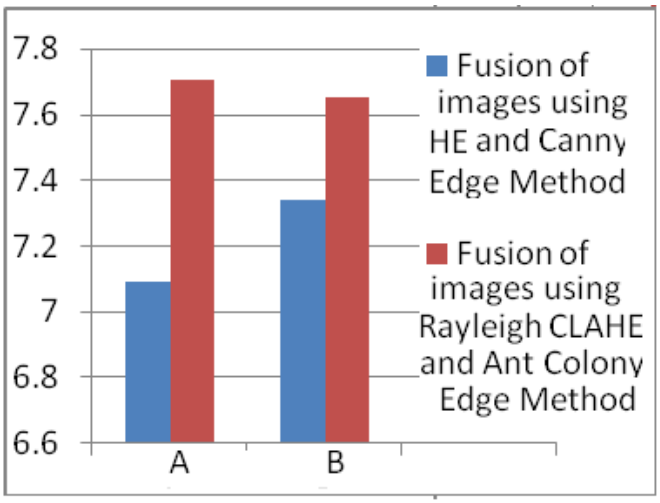

Figure 11: Bar chart showing comparison between Entropy

Table 3: Comparison of Mean Square Error

Image Set	Fusion of images using HE and Canny Edge Method	Fusion of images using Rayleigh CLAHE and Ant Colony Edge Method
A	1909.2568	199.638
B	2050.1689	451.2986

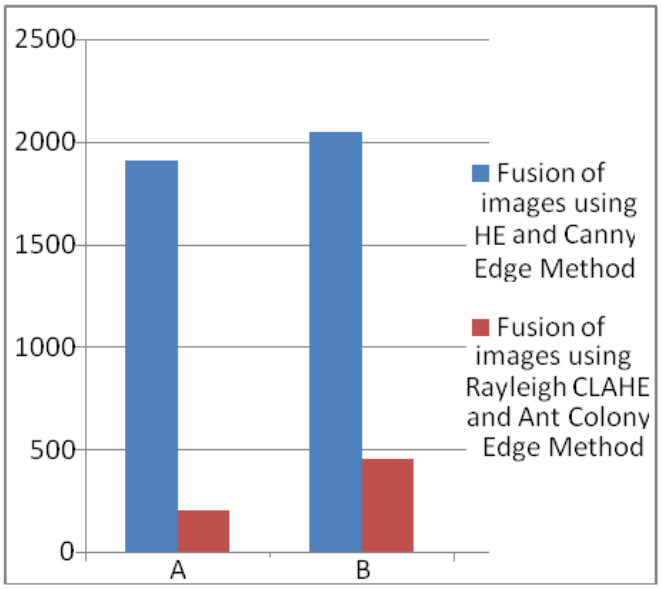

Figure 12: Bar chart showing comparison between Mean Square Error

Table 4: Comparison of Standard deviation

Image Set	Fusion of images using HE and Canny Edge Method	Fusion of images using Rayleigh CLAHE and Ant Colony Edge Method
A	61.6904	86.303
B	62.5378	86.2099

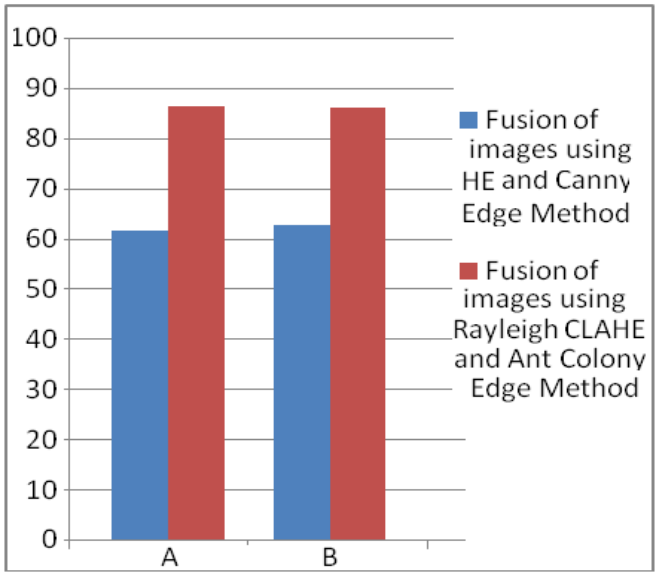

Figure 13: Bar chart showing comparison between Standard Deviation

Table 5: Comparison of Mean

Image Set	Fusion of images using HE and Canny Edge Method	Fusion of images using Rayleigh CLAHE and Ant Colony Edge Method
A	137.9454	143.5351
B	138.8395	150.1491

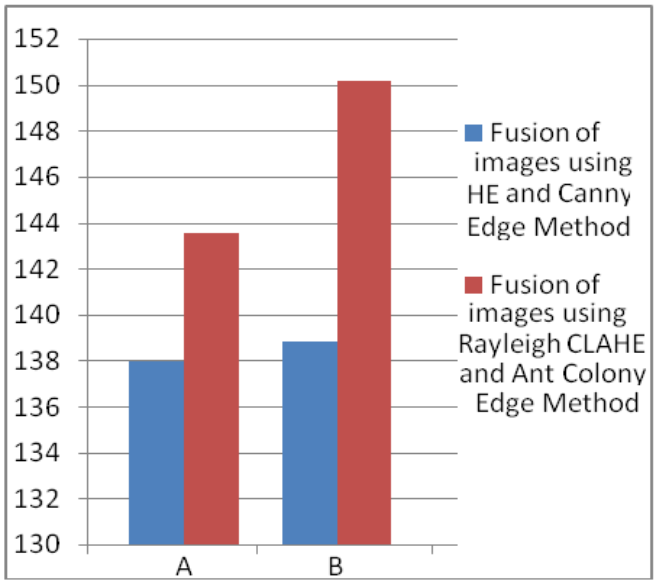

Figure 14: Bar chart showing comparison between Mean

7. Conclusion

In this the medical images are fused with two methods which are fusion of images by using histogram equalization and a proposed method which is fusion by using Rayleigh contrast limited adaptive histogram equalization method and the fused image edges are detected by using the Canny edge detection method and propose method which is ant colony edge method. A Rayleigh CLAHE method for image fusion using Ant colony Edge Detection based approach is used in the Proposed Method. The Rayleigh CLAHE approach is used in the proposed algorithm as it gives more visually pleasant images. The output results are compared qualitatively as well as quantitatively using quality measures.

8. Future Scope

As at present a lot of research had done in medical image fusion and also there will be a lot of further research is to be performed in coming years. In future there may be the use of HSF filter (Hypothesis Selective Filter) that is also used to enhance the image contrast which makes the image more clear and for the edge detection Hybrid method may be used in which there is a combination of both methods that are canny edge detection and ant colony edge method for edge detection of medical images to get the very less distortion in image and the image becomes more informative for the purpose of diagnosis as well as treatment.

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