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ComparativePerformanceAnalysis of Pre-Processing Techniques in CT Angiogram Images

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ABSTRACT

Cardiovascular disease is the most common killer worldwide. The technology advancement has successfully postponed someone obtaining cardiovascular disease and increased healthy life expectancy. Cardiovascular diseases are mostly caused by unhealthy life style, heredity or aging. The abnormalities of anatomy and physiology in cardiovascular system such as blood vessel blockage, valve defect, and abnormal heart muscle. The epicardial and pericardial fats presenting on the walls of the heart cause some lifethreatening diseases are typical characteristics of cardiovascular diseases. Even though manual screening is available but they are very much time consuming and inefficient. One of the best diagnosis modalities to detect the abnormalities are the medical imaging systems such as i) Ultrasound system ii) X-Ray Computer Tomography and iii)MRI. This paper discusses on seven different preprocessing methods available in literature and found the optimum technique for enhancing the coronary CT images. The performance of all the techniques has been tested on the real time images obtained.

KEYWORDS:*Bottom-hat transform, CLAHE, epicardial and pericardial fats, Median filter*

I. INTRODUCTION

Every 34 seconds a human being experiences a Coronary Artery Disorder, which accounts for approximately 1 out of every 6 death on the global scale. Coronary Catheter Angiography (CCA) and Coronary CT angiography (CCTA) have been used for a wide range of medical applications. CCA is invasive technique (using a large needle) to detect blocks. CCTA is non-invasive technique (using a small needle) placed in the arm or hand.

Computed Tomography (CT) is one such medical imaging method employing tomography where reconfigurable hardware can be successfully employed. Tomography refers to the process that generates a cross-sectional image of an object from a series of projections collected by scanning the object from many different directions. Among the various alternatives available for projection data acquisition like X-rays, magnetic resonance, radioisotopes, ultrasound, our analysis pertains to two-dimensional X-ray absorption tomography.

Therefore early detection and prevention of stenosis through medical imaging is very important. For this cardiologist widely uses CCA and CT images to diagnose the heart diseases like fat deposition, soft plaque, Calcium-Score Atherosclerosis and stenosis. Preprocessing which is the fundamental step in the automatic detection of heart diseases is investigated in this paper.

The important reason for main focus on preprocessing is because the CCA images are many times degraded by several problems like noise, uneven illumination, poor contrast and variation in capturing. Preprocessing helps to remove the noise and enhance the image for early detection of the disease.

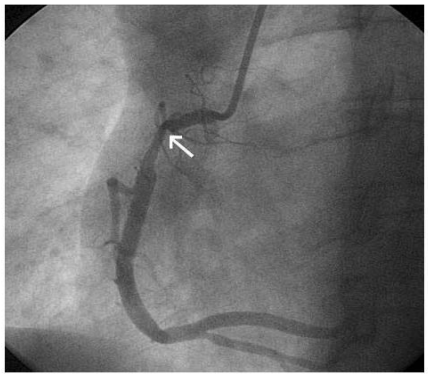

Fig. 1. CCA image with plaque

Figure 1 shows an example of CCA image. Some of the common signs of CDA which are plaque, calcium deposition and stenosis.

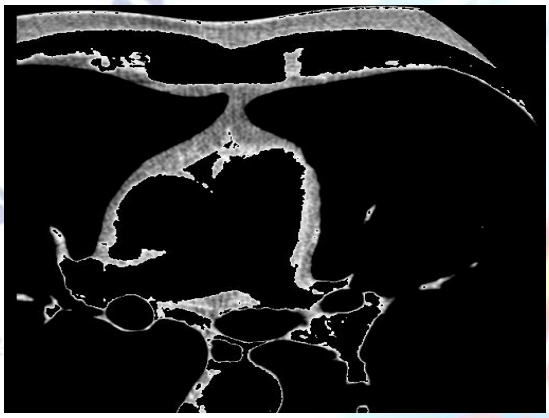

Fig 2.CCTA Image with fat deposition

The rest of this paper is organized as follows. Section II gives the study of existing approach. The materials used in this study are discussed in section III. The various preprocessing methods analyzed for the enhancement of CCA images are explained in section IV. The results are explained in section V.

Finally, Section VI presents the conclusion and discussion

II. STATE OF ART

Few investigations in the past have confirmed that the goodquality of CCA and CT images are required for accurate and early diagnosis of plaque. On a survey, it is predicted that nearly 12% of the images cannot be analyzed for detection because of their poor quality. Therefore an enhancement in the CCA image quality is very much essential in the diagnosis of stenosis. So to enhance the quality, preprocessing of images should be applied. In medical image registration, the utilization of external skin markers is inspired since they permit the attainment of any imaging modalities in which the positions of markers can be accurately defined. Registration using skin markers does not vary respecting to the amendment in the image patterns, stimulated by the pathologies [6]. Skin markers must have the features like easier usage, precise attach and non-interference with the diagnostic region of the images. However, some errors occur because of the flexibility of the body, hence the chosen areas of the body must be quite stable for fixing markers. Sinha*etal*[7] endorsed the rigid cardiac MRI and PET image registration by scrutinizing the error using cardiac landmarks.

The head-and-hat algorithm [8] was initially presented by Pelizzari et al for brain image registration. This method demonstrates the contours of one image of the set (usually higher resolution) as a surface (head) and the contours of the remaining image set as a series of points (hat). Then the algorithm defines the optimum rigid transformation and reduces the mean squared deviation (MSD) between the elements of the hat and the surfaces of the head through the Powell minimization algorithm [9].Dey *et al*[10] employed SPECT image as a mediator in thorax CT and SPECT image registration. Turkingston*et al*[11] exploited cross-correlation measure for the firm orientation of dynamic cardiac PET images to cardiac templates. In the preprocessing stage, the authors applied Contrast Limited Adaptive Histogram Equalization technique to improve the contrast and for enhancing the plaque authors considered mean filter for image smoothing before enhancing. But mean filter does not have monotonically decreasing frequency response and it is not the best filter for image smoothing. Based on the details obtained by studying the existing works, the importance of preprocessing in CCA image was understood. The main importance of this work is to present a comparative study on various enhancement techniques available in research work. From the study and the obtained result, this work suggests a simple and efficient method for the preprocessing stage.

III. MATERIALS

To evaluate the performance of our algorithm, the CCA and CCTA images were obtained from the publicly available Databases and real time data are obtained from reputed hospitals.

IV. METHODS

In our work, various preprocessing methods have been used to enhance the digital CCA images. This work was tested with some common methodology that was introduced previously for the improvement of contrast level and removal of noise.

A. Contrast Enhancement using Bottom-hat transform

A common technique for the enhancement of contrast of an image is the use of morphological operation like bottom-hat transform. The bottom-hat transform is performed by obtaining the difference between closing of original image with the original image.

$$Bhat(f) = (f \bullet b) - f \quad (1)$$

Where $(f \bullet b)$ denotes the closing operation and f is the original image.

The closing of an image 'f' by structuring element 'b' is defined as dilation of 'f' by b, followed by erosion of the result with the structuring element b.

$$(f \bullet b) = (f \textit{ dilation } b) \textit{ erosion } b \quad (2)$$

A disk shaped structuring element was considered since it gives a good result for image enhancement.

B. Contrast Enhancement by Histogram Equalization

To enhance the contrast of color retinal images, histogram equalization is applied on the green channel of the color image. The Histogram equalization of image f is defined by Where floor() rounds down to the nearest integer. L denotes the number of possible intensity levels in the image f and Pr(rk) denotes the probability of occurrence of intensity level rk.

C. Removal of Noise by median filter

Median filter is most suitable when our image is affected by impulse noise or salt and pepper noise. It involves finding the median value in a local neighborhood and it is a non-linear operation. To simultaneously reduce noise and preserves edges in color fundus images, median filtering is more effective than the convolution.

D. Enhancement using Contrast Limited Adaptive Histogram Equalization

Contrast Limited Adaptive Histogram Equalization (CLAHE) partition the green channel of the retinal image into contextual regions and then histogram equalization is applied to each region. This equalizes the distribution of used gray levels and makes the hidden features more visible. CLAHE process on small region of image rather than the entire image itself.

V. EXPERIMENTAL RESULTS

The effect of different preprocessing techniques was evaluated on images from publicly available standard database

A. Result of Contrast Enhancement using Bottom-hat Transform

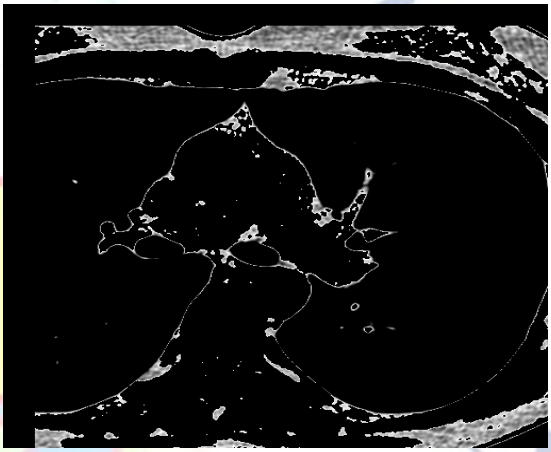

Fig. 3. Output of Bottom-hat transforms

B.*Contrast Enhancement by Histogram Equalization*

The image enhanced by histogram equalization is shown in figure 4.

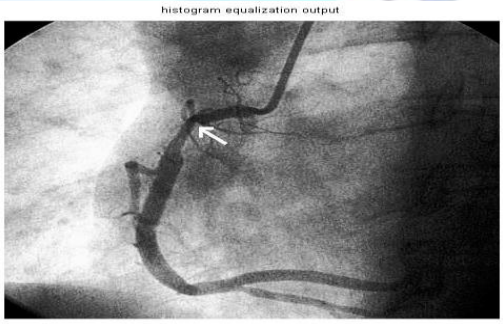

Fig. 4. Output image Enhanced image by histogramEqualization

C.Result of Removal of Noise by median filter

The CCA image which is affected by salt and pepper noise

is shown in figure 5

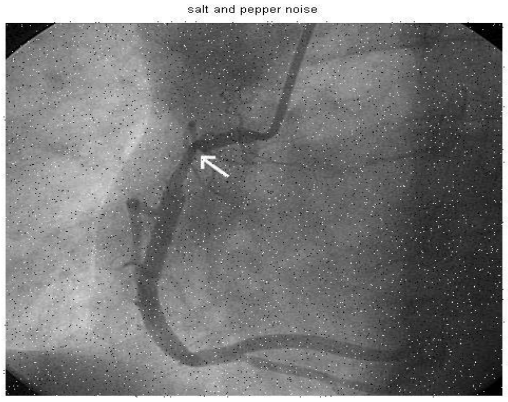

Fig. 5. Image affected by salt and pepper noise.

The output of median filtering is shown in figure 5

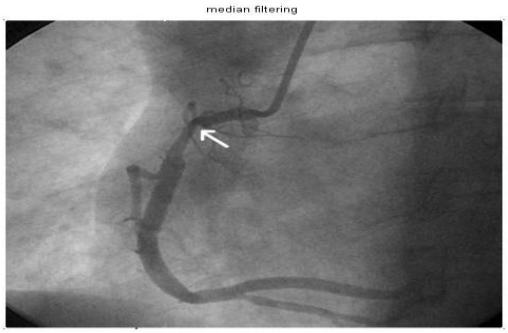

Fig. 6. Output of median filter

D. Result of Enhancement using Contrast Limited Adaptive Histogram Equalization

The resultant enhanced image by performing CLAHE on the green channel is shown in figure 6

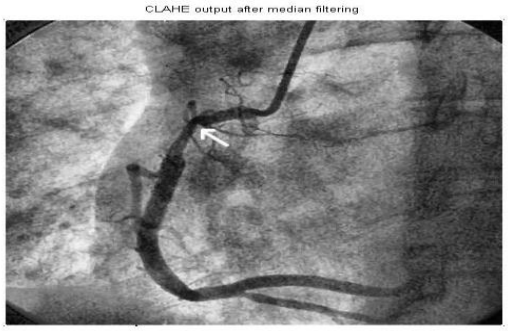

Fig. 7. Output image enhanced by CLAHE

The CCA image which is affected by Gaussian noise is shown in figure 7

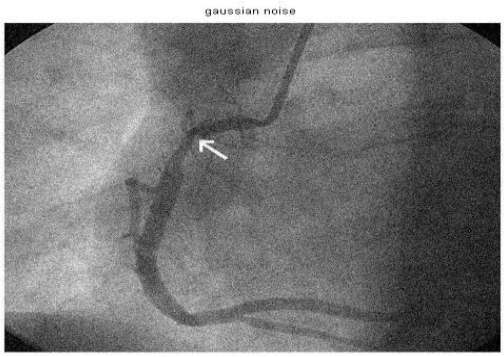

Fig. 8. Image affected by Gaussian noise

The output of Gaussian filtering is shown in figure 7

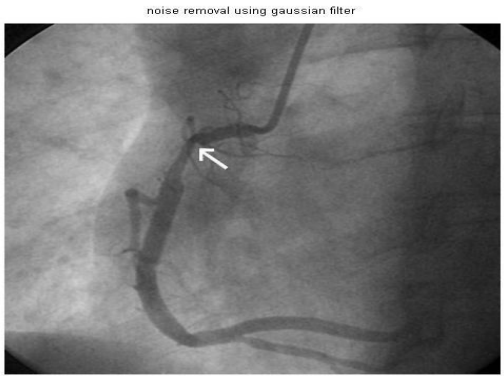

Fig. 9. Output of Gaussian filter

E. Result of Optimal preprocessing technique

The green component of the original RGB image isextracted and shown in figure 3. This image is applied to a median filter and the output obtained and the filtered image is enhanced by CLAHE and the result is shown in figure 8

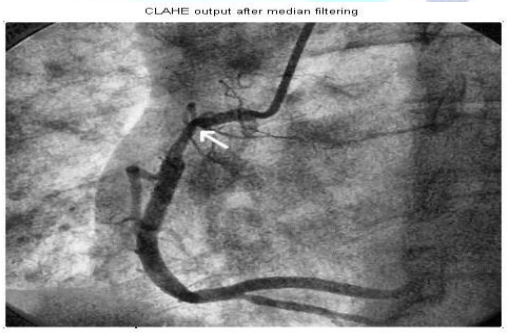

Fig. 10. Output of Optimal preprocessing technique

VI. CONCLUSION

This paper investigated and compared five different Preprocessing methods of CCA and CCTA images and found an optimum technique for preprocessing. This work evaluated the diagnostic accuracy of the proposed method in terms of

image-based criteria. Even though, the morphological top hat operation gives a good result; it failed to remove the noise completely. Median filter produces good result against noise but the features are not enhanced. Robustness and accuracy have been evaluated by our optimum technique on publicly available databases and it is found to be high when the result was consulted with an expert.

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