Analysis and Detection of Atherosclerosis using Ivus Image Segmentation Technique

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Abstract --- Analysis and detection of coronary artery plaque using ivus soft computing technique is very important for non-invasive imaging modalities. It can detect the risk for heart attack at very early stage and give the better results, the myocardial infarction interpretations and analysis at early stage is important to detect the possible risk of heart attack. Descriptions of region of interest (ROI) is of great importance for Cardiologist because their expectation in an image is to have better resolution that can highlight the ROI to greater extent and can also differentiate the two layers of coronary artery wall i.e. inner wall of coronary artery called the background, which is a region of vessel inner wall and outer wall is called foreground which is the region of interest i.e. plaque deposits. In this proposed paper, the CT angiogram scan has been taken and is converted to DICOM images frame by frame and then the imaging technique of image pre-processing has been applied to the CT scan DICOM images like image conversion , intensity adjustment, removal of noise and smoothening of acquired images using Mat lab techniques followed by computation of overlapping binary layer using label matrix, computation of distance transform using process of segmentation and then retrieval of features i.e. feature extraction. Usually in digital imaging and communication in medical it consists of major four steps that will be applied on acquired ivus image as pre-processing then scanned ivus medical image be segmented, extraction of features from the image and finally the ivus image classification are the digital imaging steps that will give the desired or expected output with accuracy.

Keywords **----** Dicom, CT Scan, Region of interest (ROI), Myocardial infarction, intra vascular ultrasound imaging (IVUS).

INTRODUCTION: Myocardial Infarction (MI) is a leading cause of cardiac arrest and deaths among the people of the entire globe. Now it has become common in day to day life resulting in the loss of life in comparison to female‘s coronary artery disease is more in numbers in men but now even the case is steeply growing in females. According to the world health organization (WHO), about 20 million people lost their life with this deadliest disease of coronary artery (CAD), and about 70:30 million Indians have had CAD and MI. Cardio Vascular Disease (CVD) is the cause of 50 % of overall death and is due to the accumulation of excess of proteins, cholesterol and lipids deposition in the inner wall of a coronary artery. In today‘s era it is one of the most challenging diseases of heart. In order to access the anatomy of coronary artery the cardiac magnetic resonance (CMR) can be used because it can identify the ultra-fast breath-hold with high accuracies. Coronary artery plaque will be identified on the basis of the presence of circumferential or eccentric wall thickening due to the blockage or deposition, these depositions have to be visually assessed and geometrically analysed with accuracy to achieved better results. The proposed work is based on the technique in which intravascular ultrasound images are recorded by inserting the gauze wire into the coronary artery and moving pictures are acquired these pictures are blurred images in which region of interest (ROI) are hidden due to noises next step is to apply the image pre processing technique by using marker controlled watershed modified segmentation algorithm. The marker controlled modified watershed algorithm works well for the identification of region having two layers i.e. inner and outer layer that can be differentiated for unique identification. The ROI can be obtained by designing markers that will distinctly visualize the layers of coronary artery and plaque deposition boundaries with exact size in terms of measurement so that the stent of suitable length can be performed in order to do so the scanned moving pictures has to be converted to format called Digital Imaging and Communications in Medicine (DICOM) and then each frame has to be observed carefully the one which is well differentiated will be selected for applying image pre processing technique like setting of image attributes and image conversion , then the image reconstruction is done using opening and closing lobes followed by image erosion and dilution to highlight the fine details in the region of interest (ROI).

II. RELATED WORK: As today the heart disease is rapidly growing, so in the department of radiology there is a great need to develop a radiological tool also in computer science it is needed to develop the soft computing technique to analyze and detect coronary artery plaque deposition which results in the loss of life to many people throughout the globe. At present time the computed tomography (CT) scan are being used by various cardiologist this technique no doubt works with spatial resolution, higher speed, sophisticated electrocardiographic synchronization but although it non-invasive still it has several limitation that results in the area of research gap for the researchers to develop a new technique to overcome this problem and reduce the death

rate of heart attack patients. This technique cannot be used for routine diagnostic although it gives better results in stenosis of coronary artery regions [2].

The coronary angiography is invasive technique and it is used worldwide for the analysis and detection of plaque depositions in the coronary artery still it has risk of myocardial infection, strokes and death in addition to this non-invasive technique like nuclear imaging and electrocardiography is also being used by cardiologist still there are several limitations in quantifying, visualizing and to predict the stability of atherosclerosis in the coronary artery, even in the case of magnetic resonance angiography(MRA) this technique cannot be used in developing stage of plaque deposition which is the major challenge for the researchers and scientist at present time to develop a new techniques to fulfil this research gap by developing new technique as this presented in this paper i.e. analysis and detection of coronary artery plaque using ivus and soft computing technique using image segmentation [5] .

For the cardiologist it is a great need that researchers may develop a better tools and technique which will give clear visualization of spatial filtered imaging of arteries which can distinctly differentiate and identify the artery walls and plaque deposition i.e. artery wall (outer region) and plaque boundary (inner region) both accuracy at early stage, It can be done by improving the resolution in diagnostic process as discussed in the paper published, by Ankur Sharma et.al [3].

In the research paper title ―Calcification Detection in Coronary Arteries Using Image Processing by Kuldeep Goyal et. al. In the department of Electrical Engineering, scientist, DIPR, Defence R&D Senior scientist, Philips DCRUST Murthal, Organization (DRDO), India have been highlighted the technique in their papers by using vessel enhancement diffusion filter using Digital imaging and communication in medicine (DICOM), in this they have taken 24 –slice Computed Tomography Scan image of the heart as today cardiologist are using 64-slice CT scan machine in angiography technique for better visualization of the coronary arteries using little dose of contrast this was not possible with earlier tools and methodologies. The centerline extraction algorithm by Michiel schaapa, et.al.have used CTA data in clinical used other than this various methods has been used but no standard technique is operational which can more efficiently and accurately detect blockage at early stage with better outcome.[4] .

Various Imaging techniques like high-frequency duplex sonography, Intravascular sonography (IVUS), IVUS elastography, magnetic resonance imaging (MRI), coronary artery angioscopy and optical coherence tomography have been challenging and potentially used to detect the vulnerable plaque in coronary artery with promising result but among these techniques ultrasound imaging has the advantages of being widely available and capable of displaying morphological features of plaques, as well as the entire vessel of artery .In addition to the imaging morphological information, certain biomarkers such as inflammatory markers also been suggested to be associated with ACS. [19]

Coronary artery plaque was identified on the basis of the presence of circumferential or eccentric wall thickening. Action of the MRA data was used as an overall roadmap and simulated a catheter based arteriogram.Lesions with moderate and critical North American Symptomatic Carotid Endarterectomy Trial stenosis by initial independent assessment were subject to consensus grading with the use of both visual assessment and geometric analysis [20]

Efficient analysis of the carotid arteries requires that the vessel wall and lumen be segmented. The most efficient manner to accomplish this is using automated or semi-automated segmentation techniques. Since 3D carotid automated or semi automated segmentation techniques have not been fully developed to be sufficiently robust, we used manual segmentation techniques to develop our carotid analysis techniques. It is important to note that our techniques will work equally well with segmented results generated by either semi-automated or an automated algorithms. [17]

Two-dimensional Frequency Domain Optical Coherence Tomography (FD-OCT) is becoming the method of choice in accessing vessel and plaque morphology, since it produces high resolution tomographic images of the internal vessels micro structure. Traditionally in an IVUS reconstruction method we use the 3-D catheter path (extracted from two orthogonal angiographies), and the lumen borders of the IVUS frames that correspond to the R-peak of the ECG signal (due to the catheter movement inside the vessel). The catheter in each R-peak frame (which is in the center of the image) is used for guiding the vector that places the lumen borders in the 3- D path [18]. Coronary MRA is a rapidly evolving as a new non-invasive technique although coronary MRA presently has limited clinical applications, it has a great potential in the diagnosis of coronary artery stenoses with a higher degree of accuracy, especially in the proximal and middle region or segment, but is challenging for the distal coronary arteries. Magnetic resonance imaging (MRI) technology has some limitations, which makes it difficult to have better result of the coronary arteries. These limitations are secondary to the coronary arteries of smaller diameter (2.7 to 3.5 mm), rapid movement caused by respiratory and cardiac contractions, and the surrounding epicardial fat so it may also be difficult to distinguish the coronary arteries from the parallel running coronary veins during the interpretation of coronary MRA, i.e. the left circumflex artery. Future research should focus on the development of optimal respiratory compensation strategies by improving spatial and frequency domain filtering to visualize greater lengths of coronary arteries and faster acquisition of the data for better quality images [8]

III. OBJECTIVES OF THE PROPOSED WORK:

To Analyze and detect coronary artery plaque using ivus and soft computing image segmentation technique in three steps:

1. To implement an marker controlled extended image segmentation algorithm that will show the region of blockage.

2. To measure the actual volume of soft plaque deposition embedded deep inside an artery by differentiating between the plaque region and inner artery wall region i.e foreground and background of an image.

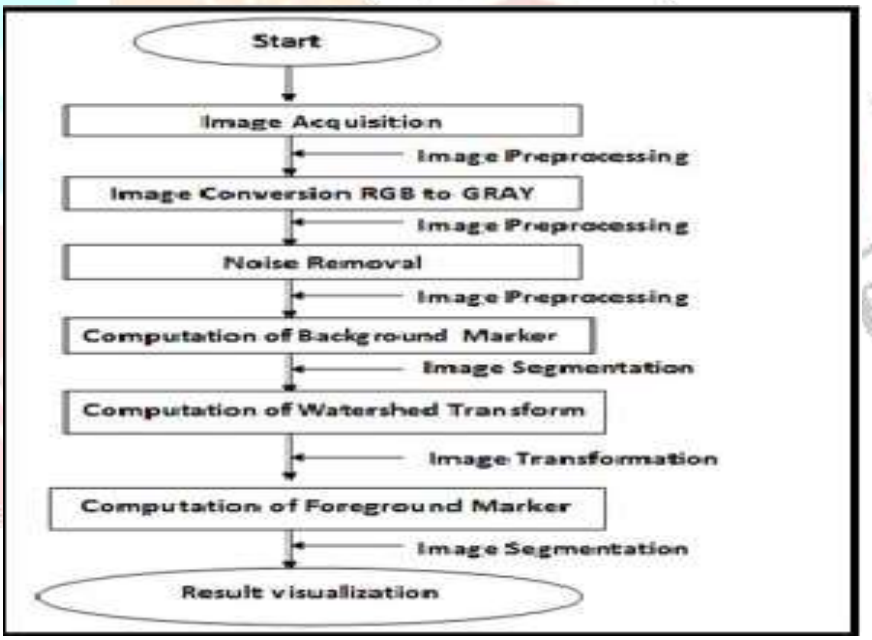
3. To classify the characteristics of plaque using both transverse and longitudinal view of an artery

4. To visualize the plaque region with better view showing plaque region and inner wall of artery distinctly for the cardiologist to operate

IV. ALGORITHM OF THE PROPOSED APPROACH:

The proposed approach is based upon the intravascular ultrasound imaging technique with this technique the live scan of heart will be acquired which are moving pictures and then using the digital image processing technique of mat lab software moving pictures will be converted to several frames which are blurred images that needs to be pre-processed by converting from RGB to GRAY SCALE and then other attributes of scan image will be set like image intensity, removing speckles(noise) from images using suitable filter and then image will be further processed by applying marker controlled watershed modified segmentation algorithm which will highlight the region of interest(ROI) by differentiating the two layers of coronary artery i.e. plaque containing region(blockage) and the artery wall. This can be performed by using markers for image segmentation and image reconstruction method of image processing and then the region, size and
quantification of plaque will be viewed and measured efficiently and accurately and it is expected that this technique will be of great help to the cardiologist as well as for the heart attack patients of today's world as it is a major challenge for researchers and scientist to eradicate this deadliest disease.

DIAGRAMETIC VIEW OF PROPOSED ALGORITHM



RESEARCH METHODOLOGY:

Step-1: This work is proposed after the depth analysis and study of heart anatomy and its physiology which gives the better idea of heart diseases and its consequences i.e. blockages Attack in human through-out the globe.

Step-2: All the possible parameters that are reason for coronary artery (CAD) have been investigated for better detection of plaque.

Step-3: The scan video of heart is converted into slice of images than pre-processed and normalized for further [processing as discussed below.

Step-4 Feature extraction using marker controlled watershed segmentation is acquired after image normalization.

Step-5: Region of interest (ROI) is detected and analysed which shows the quantification and actual size of the plaque deposition in the inner coronary artery.

Step-6: Visualization of results and then comparison with the actual results of the cardiovascular images.

VI. RESULTS OF THE PROPOSED APPROACH:

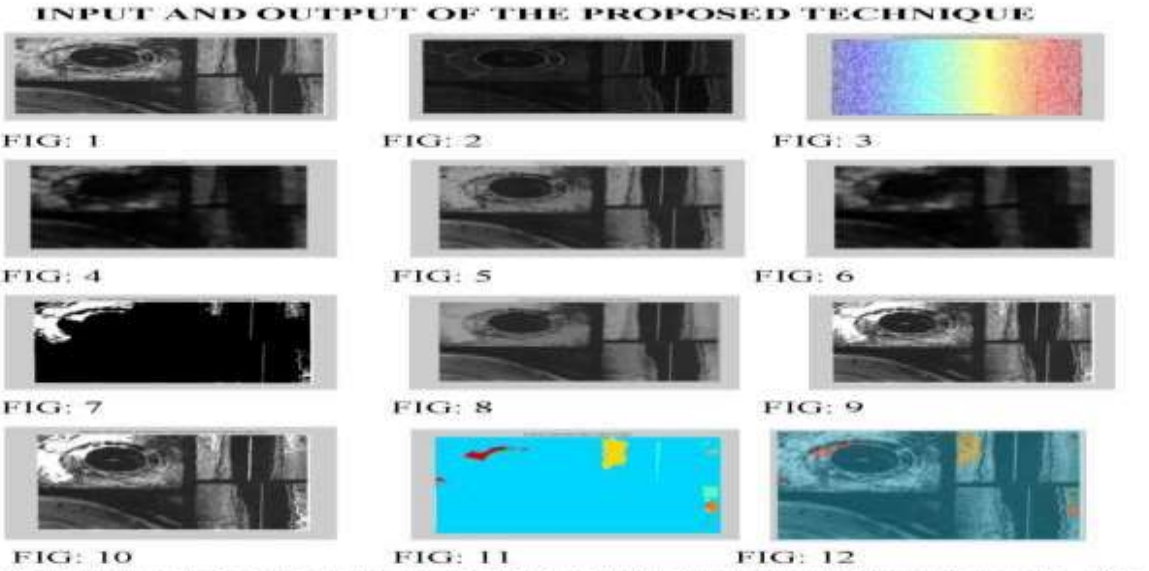


FIG: 1 Conversion of colori image rgb into gray scale; FIG: 2 Application of gradient magnitude Image into gray scale; FIG: 3 Watershed transform of gradient magnitude (Lrgb); FIG: 4 Opening (Io); FIG: 5 Opening by reconstruction (Iobr); FIG: 6 Opening-closing (Ioc); FIG: 7 Opening-closing by reconstruction (Iobrcbr); FIG: 8 Regional maxima of open construction (fgm); FIG: 9 Modified regional maxima superimposed on original image (fgm4); FIG: 10 Markers and object boundaries superimposed on original image (I4); FIG: 11 Colored watershed label matrix (Lrgb); FIG: 12 Plaque visualization.

VII. RESULTS DISCUSSION:

In the above figure images are the scan of heart. These images are being scanned using a gauze wire inserted into the coronary artery and moving pictures of the heart have been recorded. These moving images are then converted from moving pictures to dicom images using dicom viewer frame by frame as shown in fig above, it shows the different region of blood and oxygen flow from different parts of the body to the heart these images are blurred pictures which reduces the visibility of region of interest (ROI).These images are corrupted due to the presence of noise in an image which is needed to be reduced using image pre-processing and images segmentation technique of Mat lab. The above images are the results of the plaque deposition in the inner wall of the coronary artery, it shows the narrowing of the region of blood flow inner view due to deposition of plaque and the quantification of the plaque at different location that are the region of interest for the cardiologist for the better detection and measurement of artery region and plaque boundaries. In the above images the deposition of plaque is detected and measured at different location distinctly which shows the region of interest (ROI).

VIII. CONCLUSION:

The proposed work in this research paper is based upon the investigation of all the parameter of non invasive imaging modalities which is a need for cardiologist to dealt with the deadliest problem of cardiac arrest and myocardial infarction which causes the loss of life not only in Indian sub continent but to the millions of people all over the world. The result obtained using ivus and imaging technique will be of great importance to analyze and detect the Coronary Artery Disease (CAD.)

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