International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 03 | June-2015 ww.irjet.net p-ISSN: 2395-0072

Computation of Cardiac Quiescent in Mitral Valve Region

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Abstract - ***Cardio Vascular Diseases (CVDs) are the major cause for death. In this paper the disease is identified by using Doppler echocardiography and it shows the entire view of the heart in accurate manner. The main reason for accuracy is it is the amalgamation of both M-mode and B-mode echocardiography. From this video the disease which present in the Mitral Valve is noted. Here the disease which is taken into account is called as Mitral Regurgitation (MR). The calculation will be done to identify the severity of the disease (i.e.) how much severe the disease affect the patient will be computed through the method called Proximal Iso-velocity Surface Area (PISA) and this work will be done by using MATLAB software. From this the grading of the severity can be analyzed and according to that the doctor can treat the patient.***

Key Words: *Doppler echocardiography, Cardio Vascular Disease (CVD), Mitral Valve, Mitral Regurgitation (MR), Proximal Iso-velocity Surface Area (PISA).*

1. INTRODUCTION

The echocardiography used in this paper is Doppler echocardiography. This echocardiography has the base. They are M-Mode echocardiography and B-Mode echocardiography. The Doppler echocardiography works under Doppler Effect. The process is done with the help of transducer. When it is placed over chest it emits ultrasound reflected from flow of blood. When the flow move towards the transducer, the frequency of reflected sounds increases. When the flow moves away, the process will get reversed. Through this the flow rate is determined. This describes the resistance of flow like viscosity of blood, radius of lumen, length of the vessel, etc,

The Mitral Regurgitant (MR) is the disease and it is caused due to the outflow of blood from the mitral valve to the left ventricle. The severity of this disease is diagnosed by using Proximal Iso-Velocity Surface Area (PISA). PISA proximal flow acceleration shows concentric series of hemispheric rings of alternating colors, each ring denoting an isovelocity of aliasing. The diameter of the ring closest to the regurgitates orifice is measured and, in severe mitral regurgitation, usually approaches1 cm. With this process the status of the disease can be examined and the further process is described below.

2. METHODOLOGY

2.1 Motivational Overview

The input video is taken from the Doppler echocardiography and it is transformed to frames with the help of MATLAB (R2011a) software. These frames have RGB colors. In addition to this it also consist of cyan color. Out of these frames six sample frames are taken into account for the process of segmentation. In this process the cyan is signified as Mitral Regurgitation (MR) disease and this disease is segmented out with the help of Gaussian Mixture Model (GMM). The segmented frame with the input sample frame is shown in fig 1 and it can be verified in [1], [2].

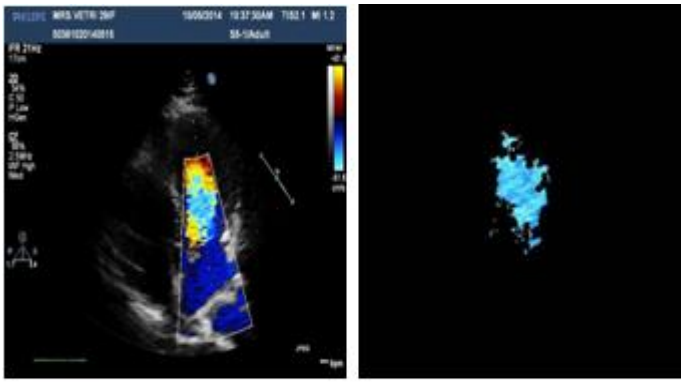


Fig -1: Input Frame with Segmented Diseased Frame

From the input frame the description for the colors are as follows.

- Flow that is moving away from the transducer is encoded in blue
- Flow that is moving toward the transducer is encoded in red
- The severe oddity in the heart signifies mosaic pattern

The overview of the proposed scheme is depicted in fig 2.

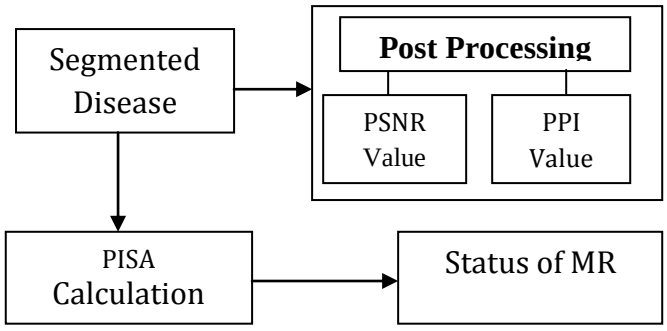


Fig -2: Proposed Block Diagram

The frame of the segmented disease is shown in fig 1. From that the post processing work is done.

2.2 Post Processing

The post processing contains two process in this paper. They are PPI which is abbreviated as Pixel Per Inch and the other is the Peak Signal to Noise Ratio (PSNR).

PPI is measured in terms of Pixel Per Centimeter (PPCM). It also measures the pixel density of the Image. In this paper it determines the amount of cyan color which present in the image will be taken into account. It is calculated with the help of vertical or horizontal density but it has lower diagonal. The process to calculate PPI is described below.

First parameter to calculate PPI is d_p (i.e.) calculating the resolution for the diagonals in pixels and the formula is shown in eq.1.

$$d_p = \sqrt{{w_p}^2 + {h_p}^2} \quad (1)$$

The PPI calculation is $PPI = \frac{d_p}{d_i}$ (2)

where

- d_p is resolution of diagonals in pixels
- w_p is width of diagonals in pixels
- h_p is resolution of height in pixels
- d_i is size of the diagonal in inches

With this process the PPI value is calculated.

The Peak Signal to Noise Ratio is mainly used to evaluate the quality of the image. In PSNR the noise is considered as the error. Calculating the PSNR value is the basic thing. Normally the PSNR value should be in high range.

2.3 Proximal Isovelocity Surface Area (PISA)

The Proximal Isovelocity Surface Area (PISA) is a method mainly used in echocardiography and it guesstimates the valvular deficiency and it mostly prefers the disease called Mitral Regurgitation.

The principle of this method is that when fluid or liquid passes through a gap or the small hole in a flat surface, it shows the flow speed just proximal to that gap. It is denoted as Flow Convergence Zone and that leakage of fluid is calculated using PISA. This effect is also called as coanda effect.

In this work the disease taken into account is Mitral Regurgitation (MR). MR is the disease which causes due to the seepage of blood flow in the mitral valve region. While breathing, in the course of inhale the mitral valve will be in opened condition and there the outflow of fresh oxygenated blood flows to the left ventricle commencing left atrium. In course of exhale the mitral valve should be in closed position since the outflow of blood is seen in that area. This outflow of blood is termed as Mitral Regurgitation (MR) disease and this is calculated by using PISA method.

To calculate the severity some of the parameters are estimated. They are as follows,

1. Regurgitant Flow (RF)
2. Effective Regurgitant Orifice Area (EROA)
3. Regurgitant Volume (RV)

2.3.1. Regurgitant Flow (RF)

The Regurgitant Flow represents the leakage of blood takes place in the mitral valve. This can be calculated with the help of PISA radius. An indigent method to calculate the valvular disease is the PISA radius. In practice they used to calculate the radius for hemisphere. But to have more accuracy in this the radius is calculated only for that diseased area which is represented in fig 1. Since the diseased area is in irregular shape the circle is drawn over that area and the radius is calculated for that circle.

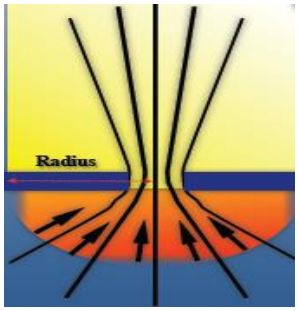


Fig- 3: Computation of radius in leakage area

Fig- 4: Aliasing velocity

The radius which is calculated for the flow area or for that leakage area is pictorially represented in fig 3 and the aliasing velocity is shown in fig 4. After calculating the radius the Regurgitant flow has to be calculated and the formula is written below.

$$RF = 2\pi r^2 * V_a \quad (3)$$

Where

r -Radius, V_a –Aliasing Velocity

2.3.2. Effective Regurgitant Orifice Area (EROA)

The EROA is calculated using the RF parameter and it can be obtained from the formula given below.

Area of the orifice = Regurgitant Flow / Peak velocity

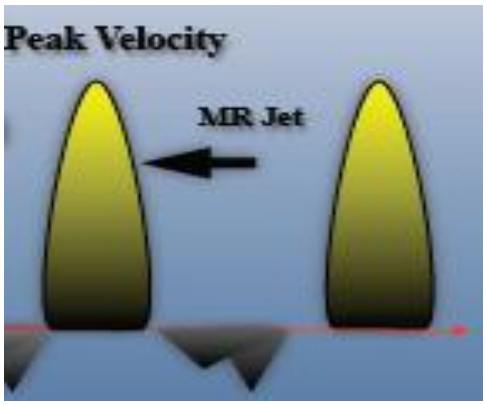


Fig -5: Computation of peak velocity

The V_{max} is also called as peak velocity and it is from the signal of heart beat rate and its sample is shown in fig 5. Here the signal which comes as high throughout the video is taken as peak and for this the velocity is calculated. The formula to calculate area is shown in eq.4.

$$EROA = \frac{2\pi r^2 * V_a}{V_{max}} \quad (4)$$

This is one of the important parameter to grade the mitral Regurgitation disease in this work.

2.3.3. Regurgitant Volume (RV)

The Regurgitant Volume is the product of the EROA and the length and width of the disease area. This formula to calculate this parameter is given below in eqn.5.

$$RV = \frac{2\pi r^2 * V_a}{V_{max}} * length \quad (5)$$

2.4. Grading of Disease

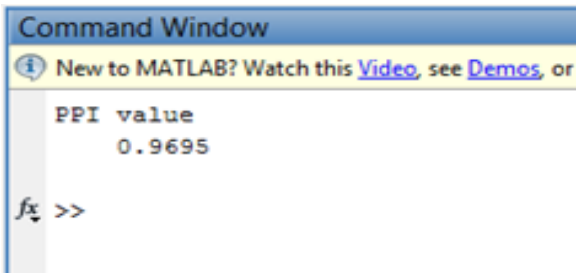
After calculating these parameters the status of the disease is noted. With the help of this the doctor treats the patient. The 3 stages of disease are mild, moderate and severe. The disease is mild when the blood flow towards orifice and the disease is said to be severe when the blood flow away from the orifice. The status of the disease is tabulated below.

Table -1: Grading of Mitral Regurgitation Disease

PARAMETER	MILD	MODERATE	SEVERE
Regurgitant Flow (RF)	<30	30-50	>50
Effective Regurgitant Orifice Area (EROA)	<0.2	0.2-0.4	>0.4
Regurgitant Volume (RV)	<30	30-50	>60

3. RESULTS

Out of six sample frames the only one frame is taken into account for post processing. The post processing contains Pixel Per Inch (PPI) and Peak Signal to Noise Ratio (PSNR) and it is processed with the help of MATLAB (R2011a) software. In this work the particular color taken into account is cyan color. It is also known as Mitral Reurgitation (MR) disease. The output for PPI and PSNR value for one segmented disease frame is shown in fig 6 and 7.



Fig– 6: PPI Value

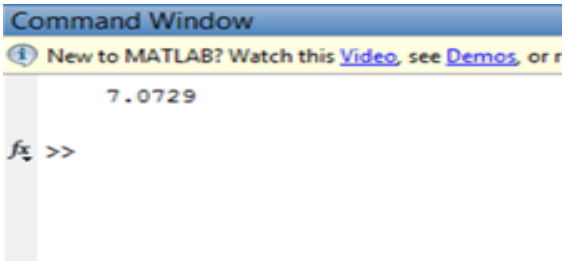


Fig- 7: PSNR Value

The Regurgitant Flow represents the leakage of blood takes place in the mitral valve. This can be calculated with the help of PISA radius. An indigent method to calculate the valvular disease is the PISA radius. The value of radius and RF is shown in fig 8.

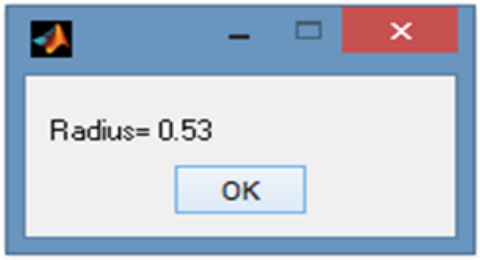


Fig- 8: Radius of diseased area

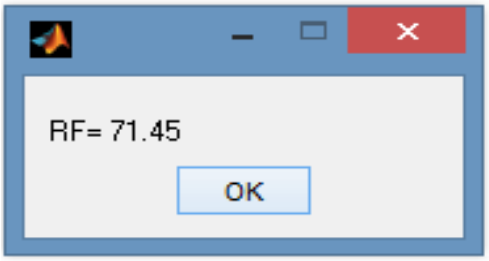


Fig- 9: Regurgitant Flow Value

The EROA is calculated by the amalgamation of RF parameter and peak velocity.

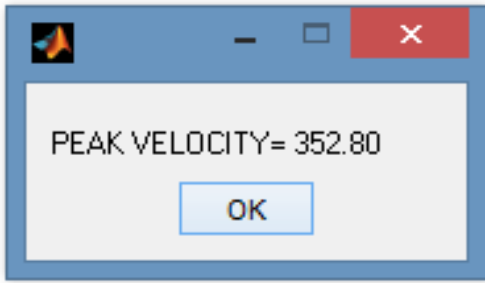


Fig- 10: Peak Velocity

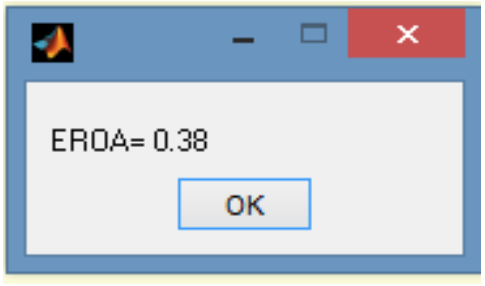


Fig-11: Effective Regurgitant Orifice Area

The Regurgitant Volume is the product of the EROA and the length and width of the diseased area. The Output of RV is shown in fig 12.

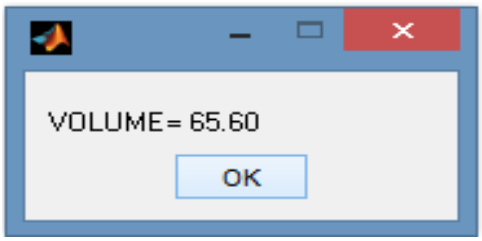


Fig-12: Regurgitant Volume Value

From the parameter outputs the doctor checks that value with the grade table. By comparing the values the doctor evaluate the status of the disease whether it is mild or moderate or severe. But in this case when comparing the parameters output with the grade table it surely proves

4. CONCLUSIONS

The proposed work intends to find the leakage of blood in mitral valve region and it is also termed as Mitral Regurgitation (MR) disease. With the help of the input video the leakage was trailed and it is segmented by using Gaussian Mixture Model (GMM) and this segmented frame has diseased area. After this process, the post processing work is done. Through that the quality of segmented frame is found. Then the major work done in this paper is grading of severity of the disease and it is calculated with the help of Proximal Iso-velocity Surface Area (PISA) method. From these process finally, the framework gives an accurate view of the Mitral Regurgitation disease which comes from the Doppler Echocardiography and these result indicates that the PISA method makes progress with accurate grading.

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BIOGRAPHIES

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Ms. G.N.Jayabhavani is currently working as Assistant Professor in IFET College of Engineering , Villupuram. She has completed her Master degree in the field of Communication System at SASTRA University, Thanjavur. In the year 2013. She holds 12 publications out of which 6 in IEEE and rest in Scopus Indexed journals. She has also presented papers in several poster presentations.

