Severity Analysis of Mitral Regurgitation Using Multi-Objective Firefly Optimization Method

P. Abdul Khayum, R. Sudheer Babu

Abstract--- Normally the blood flows from left atrium to left ventricle. Mitral valve regurgitation is the spilling of blood in reverse direction from left ventricles to left atrium through mitral valve. Mitral valve regurgitation does not produce any symptoms in its initial state. In this paper, we concentrate on the severity analysis of mitral regurgitation using multi objective firefly optimization method. Severity analysis is done using various steps this includes preprocessing method. Preprocessing techniques reduces the noise, which is present in the image dataset using aquarium-power filter. Subsequently the filtered image performs the multi-objective firefly optimization method to find the severity of the mitral valve regurgitation and the segmentation is done by SVM. Firefly optimization algorithm performs the function of feature extraction, classification and the quantification. From the outcomes, our proposed technique achieves better accuracy in the segmented and optimization method in contrast with the existing technique.

Keywords: Mitral Regurgitation, Mitral valve, SVM segmentation, Echo cardiogram, Segmentation, Quantification, Firefly optimization

I. INTRODUCTION

Mitral regurgitation is the abnormal reverse flow of blood from the left ventricle to the left atrium [1]. Echocardiography is used to detect mitral regurgitation easily. But the quantification of Mitral Regurgitation is very difficult to calculate. No single technique or feature can be utilized to explain the severity of MR. So the quantification of all the components is considered and an integral approach is to be adopted. PISA (Parallel Image Segmentation Algorithm) technique is a very important technique to quantify the MR see table i.

Table. i Normal values of MR severity investigation

Quantifying parameter	mild	Moderate	Severe
EROA	<20	0.20-0.39	0.40
RF	<30	30-59	60
R-Volume	<30	30-49	50

The flow of convergence zone is very important part of the jet which is used for jet quantification. PISA technique has some limitations. Using this technique, regurgitated flow and EROA values are to be calculated. The limitation of PISA technique is it is very difficult to calculate the quantification values Previously quantification of MR disease, see table ii is done by PISA technique [2].

- The orifice area of regurgitated is rarely rounded. Thus the PISA is not a perfect hemisphere.
- Measurement of PISA radius is difficult.
- Alignment with the direction of flow is impossible at some times.
- Usually, multiple jets are present.

Table. ii Parameters of quantification method

Qualitative (Visually)	Semi quantitative	Quantitative
Jet size (flow convergence and vena contracta)	Vena contracta size	PISA method
LV size	Convergence zone flow size	Volumetric method

PISA technique is having some limitation. To overcome this problem, the proposed method is to be introduced. In the proposed method, Firefly optimization procedure is to be introduced for analyzing the severity of mitral valve regurgitation and the segmentation is performed by using SVM

Visual assessment of MR severity is based on flow convergence zone. It is also used to measure the volume of MR jet and the orifice area of regurgitate by PISA method. In this method, it is very difficult to measure the size of convergence zone. This quantification method has several limitations. Before the quantification method, the abnormal images are to be segmented by many of the segmentation method like FCM (Fuzzy C-Means,) segmentation, ANN, K- means FCM. By this technique, over segmentation may occur. For that, there is a change to segment the affected area of jet. One may use the crude semi quantitative analysis for quantification of jet. The MR severity is also characterized by the driving pressure of left ventricle.

II. RELATED WORK

Mitral valve regurgitation is a heart disease which is caused due to the reverse flow of blood through the left atrium to left ventricle. It has no symptoms at the last stage and needs the early prediction technique. For that purpose, In 2018 Lior Gorodisky, Yoram Agmon, Moshe Porat, Sobhi Abadi , Jonathan Lessick [3]. They explained to test the severity of

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evaluating the mitral valve regurgitation by using the cardiac magnetic resonance (CMR) 4D velocity vector.

In the last few years, researches have shown their interest towards medical image processing. In 2018 Shin Watanabe, Kenneth Fish, Guillaume Bonnet, G. Carlos, Santos-Gallego, Lauren Leonardson, J. Roger. Hajjar, Kiyotake Ishikawa [4]. Proposed to predict early clinical symptoms in severe AMR (Acute Mitral Regurgitation) using echocardiographic and hemodynamic assessment.

MR severity is determined by using different techniques. In 2018 Frank levy, Sylvestre Marechaux, Laura Iacuzio, Elie Dan Schouver, Anne Laure Castel, Manuel Toledano, Stephan Rusek, Vincent Dor, Christophe Tribouilloy, Gilles Dreyfus [5]. They explained that to examine the productivity and accuracy of the determination of MR severity and LV volume in patient with isolated degenerated primary MR using newly automated fast 3DTTE (3 Dimensional Transthoracic echocardiography) software.

Pulmonary regurgitation is also a congenital heart disorder. Here also the severity of the disease detection is the difficult task which requires the quantification method. In 2018 Claudia Dellas, Laura Kammerer, Verena Gravenhorst, Joachim Lotz, Thomas Paul, Michael Steinmetz [6]. They explained that the pulmonary regurgitation (PR) is a common disease in patient with congenital heart disorder and dedicated to mortality and morbidity in the long term.

Therapy treatment given for moderate IMR remains unclear. In 2018 Ashley E. Morgan, Yue Zhang, Mehrzad Tartibi, Samantha Goldburg, Jiwon J. Kim, Thanh D.Nguyen, Julius Guccione, Liang Ge, Jonathan W. Weinsaft, Mark B. Ratclife[7]. They explained that the determination of myocardial viability Ischemic Mitral Regurgitation (IMR). The key contribution of the research is summarized as follows.

- Collect the dataset from the net source.
- The collected dataset undergo the preprocessing and feature extraction operation using aquarium-power filter.
- Then apply the proposed Multi objective Firefly optimization algorithm for the severity analysis, classification and accuracy measure.
- Then the segmentation is performed using the SVM classifier.

III. PROPOSED APPROACH

Mitral valve regurgitation is also called as mitral regurgitation or mitral incompetence or mitral insufficiency. Mitral valve regurgitation is a rule for which our mitral valve of heart is always open and this allows the blood to flow in backward direction in our heart. If the mitral valve regurgitation occurs the heart stops pumping blood throughout our body parts and make us feel tired and cause difficulties in breathing. This can be avoided by the treatment of MVR which depends on the severity condition of the disease. If the leakage condition is mild, there is no necessary for the treatment of this disease, if it is in severe condition, we need a heart surgery to the curve or replacement of valve. Nevertheless we failed to take treatment it may cause a sudden death. This mitral valve regurgitation has no symptoms, people's have to check their body by consulting cardiologist or surgeon to find out the early intervention.

In early days they used echocardiography to detect the affected part and the quantification is done using the PISA technique. By using this echocardiography and quantification we get the severity values. The obtained severity value is not so accurate so that we have introduced multi objective Firefly Algorithm. In this proposed method we get the accurate value and to predict the severity of MR disease. Fig1 shows the block diagram of proposed method is given by as follows. The collected data set undergo the preprocessing and feature extraction using aquarium power filter. Apply multi objective firefly optimization procedure to the processed image, the algorithm performs the classification and quantification process. Finally the segmentation is done by using SVM classifier.

A. ECG Data set

The required echocardiogram data set is taken from the net source. This image of data set is to perform the feature extraction, classification, quantification and segmentation.

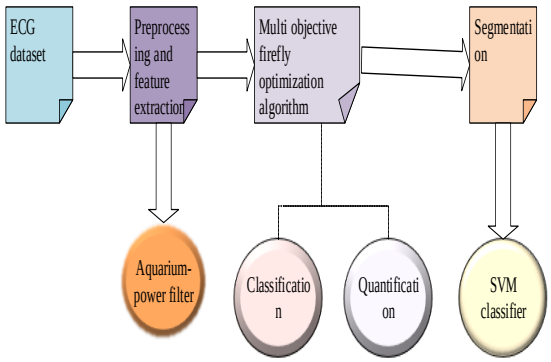

Fig.1 Proposed system

B. Preprocessing:

Preprocessing is a process of eliminating the unwanted noise and disturbances from the echocardiogram image.

C. Multi Objective Firefly Optimization algorithm

Firefly Algorithm is one of the Protective warning mechanisms, it is a novel approach develop to solve optimization algorithm, here we have to use firefly for finding severity, accuracy, precision. In order to perform random walks more efficiently, we can get the best solution s_*^t which reduce the combined objective through the weighted sum using (1).

$$Z(w) = \sum_{k=1}^{K} x_k f_k, \sum_{k=1}^{K} x_k = 1 \quad (1)$$

Here, where are the random numbers which is drawn from a uniform distributed unit[0,1]. In order to ensure, a rescaling operation is operates after producing K uniformly distributed number.

If a firefly algorithm is not dominated by others in the sense of pareto front, calculated using (2).

$$w_i^{t+1} = s_*^t + \beta_t \sum_i^t \quad (2)$$

Where s_*^t is the best solution.

Iteration proceed reduces the randomness and can be achieved by same manner for simulated annealing and other random reduction techniques using (3).

$$\beta_t = \beta_0 0.9^t \tag{3}$$

Where β_o is the initial randomness factor.

Application oriented multi-objective firefly optimization is illustrated as,

Pseudo code for multi objective firefly optimization algorithm

1.	*Define objective functions* $\psi_1(\Phi),.....,\Psi_k(\Phi)$ *where* $\Psi = (\Psi_1,.....,\Psi_d)^T$
2.	*Initialize a population of n fireflies (ECG MR images)* $\Psi_i(i = 1,2,.....,n)$
3.	*while* $(t < 20)$ *(mild)*
4.	*for* $i, j = 1:n$ *(all n fireflies)*
5.	*Evaluate their approximations* PF_i *and* PF_j *to the Pareto front*
6.	*If(t <50)*
7.	*Moderate and when all the constraints are satisfied*
8.	*else*
9.	*If(t>50) (Abnormal) and when all the constraints are satisfied*
10.	*if* PF_j *dominates* PF_i *,*
11.	*Move firefly i towards j using (2)*
12.	*Generate new ones if the moves do not satisfy all the constraints*
13.	*end if*
14.	*if no non-dominated solutions can be found*
15.	*Generate random weight* W_k^* *(k=1,.....,K)*
16.	*Find the best solution* s_*^t *among all fireflies Z in (1)*
17.	*Random walk around* s_*^t *using (2)*
18.	*end if*
19.	*Update and pass the non-dominated solutions to the next iterations.*
20.	*End*
21.	*Sort and find the current best approximation to the Pareto front*
22.	*Update* $t \leftarrow t+1$
23.	*end while*
24.	*Post process results and visualization*

IV. SEGMENTATION

Normally SVM is used for classification purpose but in our research we use SVM for segmentation purpose to provide novelty. SVM classifier is to segment the image based on the pixel value of the image. Using SVM segmentation, this is to avoid the over segmentation.

V. RESULTS AND DISCUSSION

The proposed multi objective firefly optimization is elaborated in Matlab 16. Matlab is a multipurpose numerical computing environment and the programming language developed by Mathworks. MATLAB allows plotting of data and functions, manipulating the matrix, algorithm implementation and user interface creation in other languages. The proposed firefly optimization algorithm is used to classify, and quantify the severity of mitral regurgitation. The accuracy of MR jet is calculated using (4), and precision using (5).

$$accuracy = \frac{(TN + TP)}{(TN + TP + FN + FP)} \tag{4}$$

Here TN is true negative, TP is for true positive, FN is false negative and FP is for false positive, subsequently sensitivity measures using (6) and specificity measures calculated using (7).

$$precision = \frac{TP}{TP + FP} \tag{5}$$

$$Sensitivity = \frac{TP}{TP + TN} \tag{6}$$

$$Specificity = \frac{TN}{TP + TN} \tag{7}$$

A. Echocardiography Data set

The Echocardiography data set image is taken from the net source. Fig.2 shows the original image.

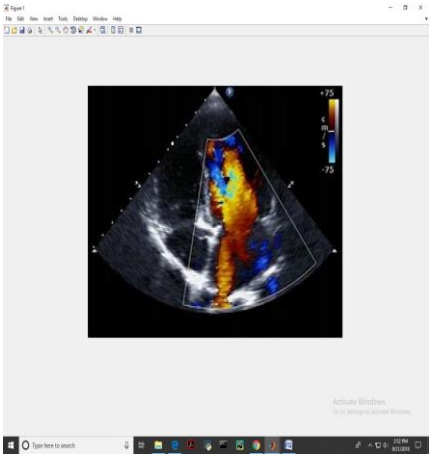

Fig.2 Original data

B. Preprocessing and Feature Extraction

Preprocessing is the process of removing noise and remove the unwanted distortions from the image using Aquarium-power filter. In this filter, it adds the noise to the

image and applying filtering operation to the noisy image. Fig.3 shows the preprocessed image.

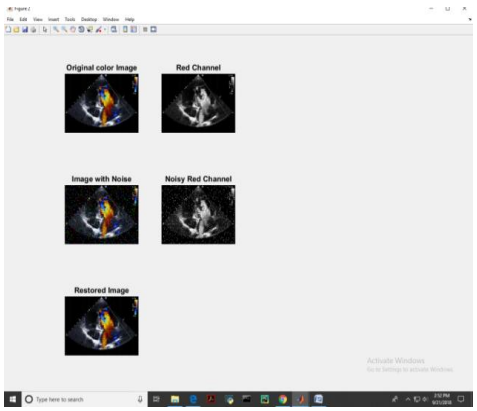

Fig.3 Preprocessed image

In this filter, it adds the noise to the image and applying filtering operation to the noisy image. After the filtering operation, the image is restored as the noise less clear image.

C. Classification and Segmentation

Here, our proposed SVM classifier is used for segment the affected part from the image. This technique will reduce the over segmentation during processing in Fig.4.

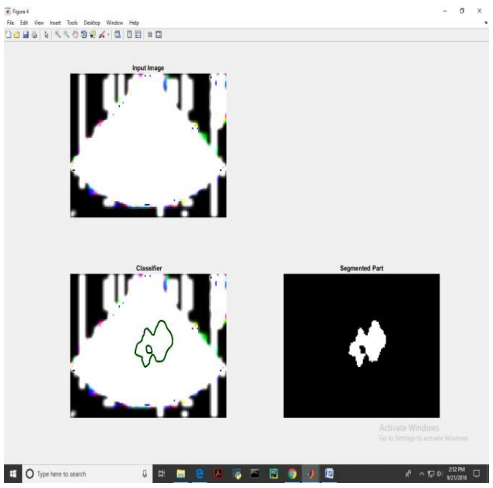

Fig.4 Segmented image using SVM

D. Quantification using multi objective firefly optimization

This algorithm gives the better solution and better accuracy which is used to solve the multi objective optimization. In our proposed system, accuracy is 99%, sensitivity is 96% and specificity is calculated as 97%.The following Fig.5 explains the comparison of FCM segmentation, Region growing method and our proposed SVM technique.

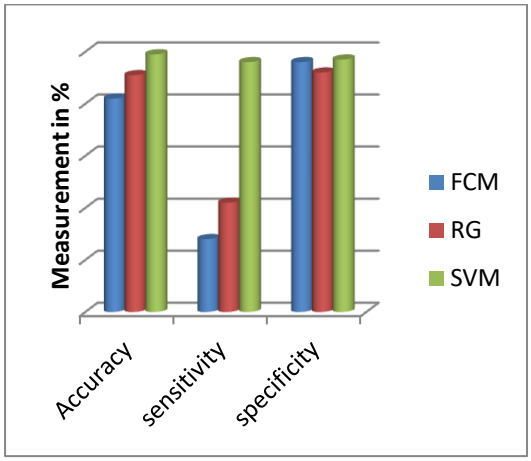

Fig.5 Comparison of various segmentation techniques

CONCLUSION

Normally image is processed by many method like classification, segmentation, edge detection.. etc, these all process are done in different techniques since it shows outperform because of its complexity. The main focus of this paper is the brief study of the image processing in mitral valve regurgitation, to classify, quantify and segment the MR image. The proposed Multi Objective firefly optimization achieve 99% of accuracy measure to classify and quantify MR images subsequently segmentation is done by SVM technique using pixel value of the images in the specified region.

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