Research Journal of Recent Sciences _____ ISSN 2277-2502
Vol. **3(6),** 83-89, June **(2014)** *Res.J.Recent Sci.*

Segmentation Methods for Severity Regurgitation: A Comparative Analysis

Pinjari Abdul Khayum[1], P.V. Sridevi[2] and M.N. Giriprasad[3],
[1]ECE Department, G. Pulla Reddy Engineering College, Kurnool, INDIA
[2]AU College of Engineering, Andhra University, Visakhapatnam, INDIA
[3]JNTUA College of Engineering, Anantapur, AP, INDIA

Available online at: www.isca.in, www.isca.me
Received 14th April 2014, revised 25th May 2014, accepted 1st June 2014

Abstract

Today, an inclusive evaluation of valvular incompetence plays a significant role in clinical cardiology. Also, an accurate evaluation of Regurgitant Volume (RV) in cardiac patients with Valvular Regurgitation (VR) is crucial to analyze the progression of the disease, which can then decide the suitable time for surgical treatment or further treatment. Numerous techniques and algorithms have been developed for the assessment of Valvular Regurgitation. These techniques perform the assessment process with the aid of Proximal Isovelocity Surface Area (PISA), also called as Proximal Flow Convergence method (PFC). In these existing techniques, the VR and regurgitation severity are evaluated successfully. But, it is not sure that the performance of all these techniques is high in their regurgitation evaluation process. Thus, to evaluate the performance, a comparative analysis is required among the existing techniques. Hence, in this paper, a comparative analysis is performed for revealing the performance of three existing regurgitation techniques. Among these three techniques, the first one illustrates the quantification of mitral regurgitation by anisotropic diffusion segmentation via PFC method. While, the other two works demonstrates the severity of Mitral Regurgitation (MR) and Aortic Regurgitation (AR) by using the PISA method. The performance of the regurgitation methods are evaluated by the performance measures such as accuracy, specificity and sensitivity. Moreover, the performance of the aforementioned three works is compared with the other segmentation method in order to validate their efficiency in regurgitation assessment process.

Keywords: Regurgitant Volume (RV), Proximal Isovelocity Surface Area (PISA), Proximal Flow Convergence method (PFC), Mitral Regurgitation (MR), Aortic Regurgitation (AR), Regurgitant Fraction (RF), Effective Regurgitant Orifice Area (EROA).

Introduction

Medical imaging is a significant method, which produces the detailed pictures of the human body for clinical purposes in order to disclose, diagnose or inspect disease[1]. Nowadays due to the advancement in technology and increasing utilization of Doppler Echocardiography (DE), the recognition and characterization of regurgitant valvular heart disease have been done straightforwardly[2]. Doppler Echocardiography is a non-invasive technique, which is superior in the detection of cardiac response to physiologic maneuvers. Doppler echocardiography is used to estimate the occurrence of Valvular Regurgitation in small, selected groups, composed chiefly of normal volunteers[3]. Valvular Regurgitation can be used to determine indirectly, semi quantitatively and quantitatively by DE. Valvular Regurgitation can be estimated semi quantitatively by jet area ratios. Quantitative measurements of Valvular Regurgitation include the computation of Regurgitant Volume (RV), Regurgitant Fraction (RF), and the Effective Regurgitant Orifice Area (EROA)[4]. MR or AR is the heart disease, where the valve does not close properly and doesn't close tightly when the heart pumps out the blood. The techniques like quantification of regurgitation and detection of valve regurgitation severity plays a major role in medical field for further surgery or replacement processes. The existing techniques discover the severity and quantify the regurgitation by means of PISA method. PISA measurement, also called as "flow convergence" method which can be used in Echocardiography to estimate the area of an orifice through which the blood flows. Here, we have analyzed three existing techniques that are explained in the following sections. The following first section reviews the anisotropic diffusion segmentation method for the evaluation of MR via PFC Method. After that the severity of Mitral Regurgitation and quantification of Aortic Regurgitation by utilizing PISA method. The performance analysis results are shown in section 5 and section 6 gives the conclusion of the paper.

Anisotropic Diffusion Segmentation method for the quantification of Mitral Regurgitation via PFC Method

In this anisotropic diffusion segmentation method[5], the input color Doppler Echocardiography image is given to the processing stage. In the processing stage, the RGB color space image has been changed into YC_bC_r color model. Then, the image is segmented using non-linear anisotropic diffusion method. The segmented image is utilized to measure the MR. PFC method using color Doppler has been recognized as a reliable and precise quantitative approach. Using PFC technique on the segmented image, EROA is computed.

The Severity of Mitral Valvular Regurgitation with Doppler Echocardiography using PFC Method

In this technique[6] the percentage of backward flow of blood, regurgitant flow rate, EROA, RV, RF in MR have been measured exactly using DE image that works on the color Doppler mapping techniques using PFC. In the preprocessing phase, the RGB color space image has been converted into Y Cb Cr. Then non-linear anisotropic diffusion method is used to segment the image. The PFC technique has been employed to measure the Valvular Regurgitation by the analysis of the converging flow field proximal to evaluate the mildness, severity and eccentricity of a mitral regurgitant lesion. Moreover, this research presents a review of qualitative and quantitative parameters useful in evaluating the MR severity. The severity of Mitral Regurgitation is the major cause for the development of ventricular dilatation and dysfunction.

Quantification of Aortic Regurgitation using Proximal Isovelocity Surface Area Method

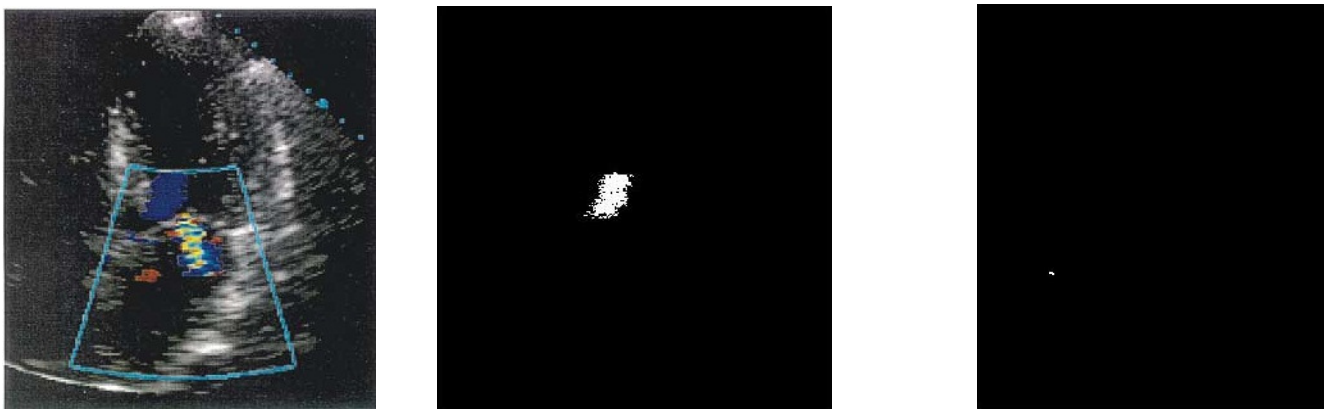
The main goal of the current research[7] is to generate an effective image processing based approach that can accurately measure the effective regurgitant orifice area (EROA) in aortic regurgitation by using the DE image with the aid of PISA. There has been a considerable attention in the PISA technique to analyze the severity of valvular and congenital heart diseases. In the pre-processing phase, the color Doppler Echocardiography image with RGB color space is subjected to Wiener filtering. Then, the image has been quantized using color quantization by NBS/ISCC color space that has made the evaluation of AR. In addition to these, the PISA technique is utilized for the calculation of quantitative parameters such as Vena Contracta (VC), EROA, RV, RF, EROA and more of AR.

In another approach in the pre-processing phase, the color Doppler Echocardiography AR image is subjected to Gaussian filtering[8]. Followed by the filtering we employ image enhancement to enhance and improve the quality of the image. Contrast enhancement of color images is done by transforming an image into a color space that has image intensity as one of its components. Here L*a*b* color space is used. After enhancement Fuzzy k means clustering is employed for segmentation. It is a pixel based segmentation which clusters the image pixels into homogenous regions. In addition to these, the PISA technique is utilized for the calculation of quantitative parameters such as VC, EROA, RV, RF and more of AR.

Performance Analysis

The performance of regurgitation techniques, described in the above two sections are analyzed with the Conventional segmentation technique is given in Jeny Rajan et al[9] and Nandagopalan et al[10]. The input and segmented image results of proposed and conventional segmentation method are shown in figure 1. The segmented image results are utilized in the PISA quantitative parameters computation process.

The performance of mitral and aortic severity regurgitation process is compared with the conventional segmentation based on their severity regurgitation process. In these techniques the performance analysis is done by means of statistical measures, to compute the efficiency of those techniques in severity quantification. Based on the PISA quantitative parameters, the images exploited in performance analysis process are categorized into mild, moderate, severe. The PISA quantitative parameters such as EROA, RV and RF are measured from the given input mitral and aortic regurgitant image. To perform the severity regurgitation process, the quantitative parameter's values of the mitral and aortic regurgitation are listed in the below table 1.



(i) **(ii)** **(iii)**

Figure 1
(i) Input Color Doppler Image (ii) Segmented Image from Proposed Segmentation Method (iii) Segmented Image from Conventional Segmentation Method

The performance of proposed severity regurgitation processes and conventional segmentation based severity regurgitation is tabulated in the following table 2 and 3.

The statistical measures performance analysis of proposed MR, AR regurgitation segmentation and conventional segmentation method[9] results are shown in the table 4 and 5.

In table 4, the mean value of accuracy, sensitivity and specificity measures of proposed segmentation method has achieved 86%, 66%, 100% respectively. Compared to conventional segmentation method, the statistical measures of proposed segmentation have provided high performance result. This high performance result shows that our proposed segmentation is accurate in categorizing the MR regurgitation images into specified severity classes.

The mean performance of proposed segmentation method in accuracy, sensitivity and specificity measures are 86, 83, 91 values, which are shown in table 5. When compared to conventional segmentation, the proposed segmentation has achieved 20% accuracy result. Thus, this high performance of proposed AR regurgitation segmentation shows that it is precise in classifying the severity of AR regurgitation images. The graphical representation of the both segmentation methods performance analysis comparison results are shown in the following figure 2 and 3.

Table-1
Values of EROA, RV, and RF evaluated for Mitral and Aortic Regurgitation by PISA Method

Quantitative Parameters	Mitral			Aortic		
	Mild	Moderate	Severe	Mild	Moderate	Severe
RV (ml)	<30	30-59	≥60	<30	30-59	≥60
RF (%)	<30	30-49	≥50	<30	30-49	≥50
EROA (cm^2)	<0.20	0.20-0.39	≥0.40	<0.10	0.10-0.29	≥0.30

Table-2
Performance of MR Severity Regurgitation Process of Proposed Segmentation Method

Images	Severity of MR regurgitation Segmentation Method				Conventional Segmentation method			
	RV(ml)	RF (%)	EROA (cm^2)	MR Severity Regurgitation	RV(ml)	RF (%)	EROA (cm^2)	MR Severity Regurgitation
1	29	20	0.15	Mild	32	49	0.25	Moderate
2	42	31	0.28	Moderate	28	15	0.1	Mild
3	65	72	0.45	Severe	48	35	0.3	Moderate
4	48	32	0.25	Moderate	52	43	0.28	Moderate
5	73	52	0.9	Severe	22	12	0.05	Mild

Table-3
Performance of AR Severity Regurgitation Process of Proposed Segmentation Method

Images	Quantification AR Regurgitation Segmentation Method				Conventional Segmentation method			
	RV (ml)	RF (%)	EROA (cm^2)	AR Severity Regurgitation	RV (ml)	RF (%)	EROA (cm^2)	AR Severity Regurgitation
1	10	23	0.02	Mild	42	33	0.24	Moderate
2	27	15	0.09	Mild	22	28	0.03	Mild
3	48	32	0.15	Moderate	72	68	0.5	Severe
4	69	80	0.59	Severe	66	52	0.35	Severe
5	72	68	0.4	Severe	80	55	0.7	Severe

Table-4
MR Severity Regurgitation Performance analysis with Conventional Segmentation Method

	MR Regurgitation Segmentation Method			Conventional Segmentation method		
	Accuracy	Sensitivity	Specificity	Accuracy	Sensitivity	Specificity
Mild	80	50	100	60	50	66
Moderate	80	50	100	60	100	50
Severe	100	100	100	60	0	100

Table-5
AR Severity Performance analysis with Conventional Segmentation Method

	MR Regurgitation Segmentation Method [3]			Conventional Segmentation method [8]		
	Accuracy	**Sensitivity**	**Specificity**	**Accuracy**	**Sensitivity**	**Specificity**
Mild	100	100	100	80	100	75
Moderate	80	50	100	60	0	75
Severe	80	100	75	60	33	100

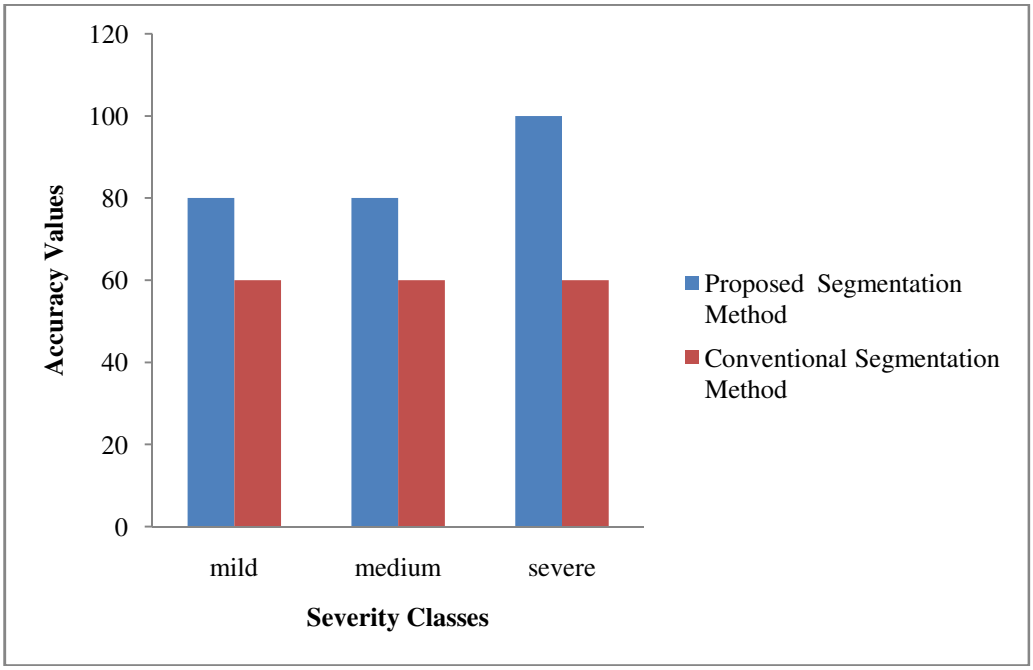


Figure-2(i)
Accuracy

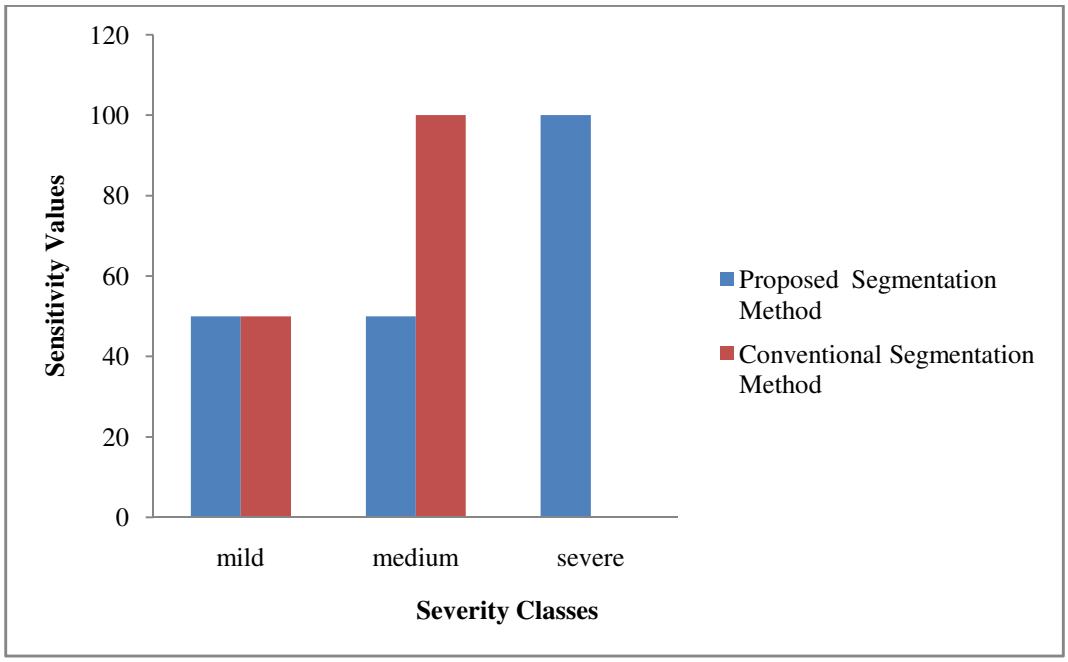


Figure-2(ii)
Sensitivity

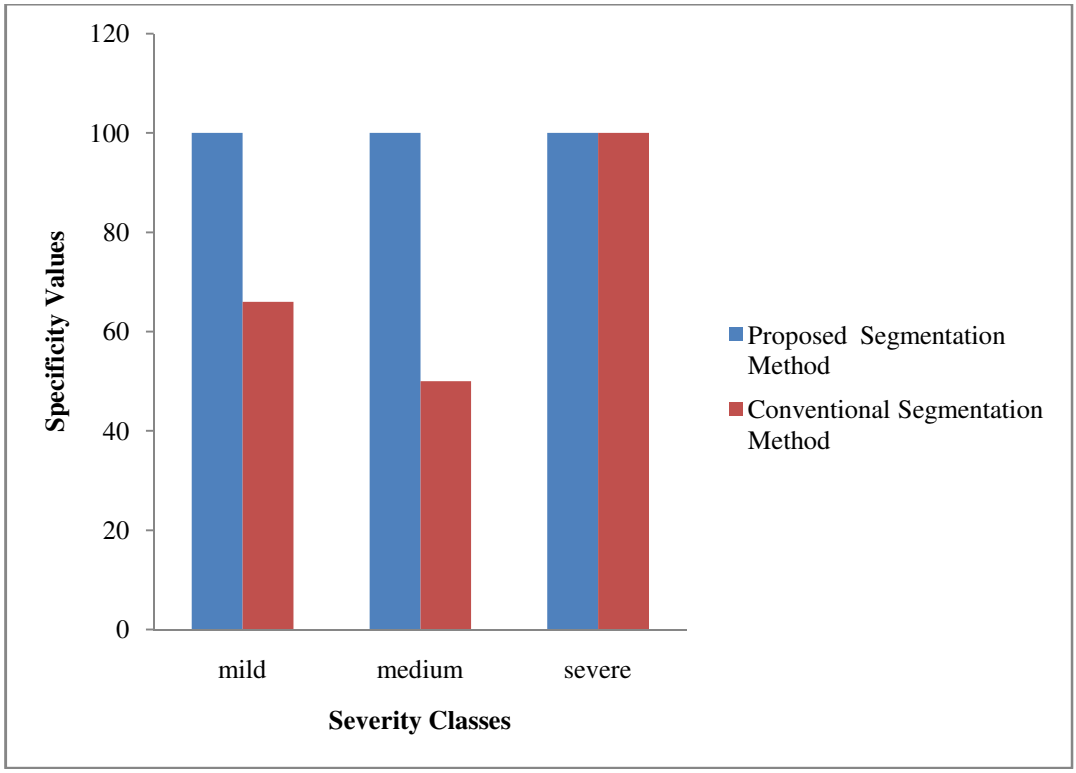


Figure-2(iii)
Specificity
Graphical Representation of MR Severity Performance Analysis with Conventional Segmentation Method

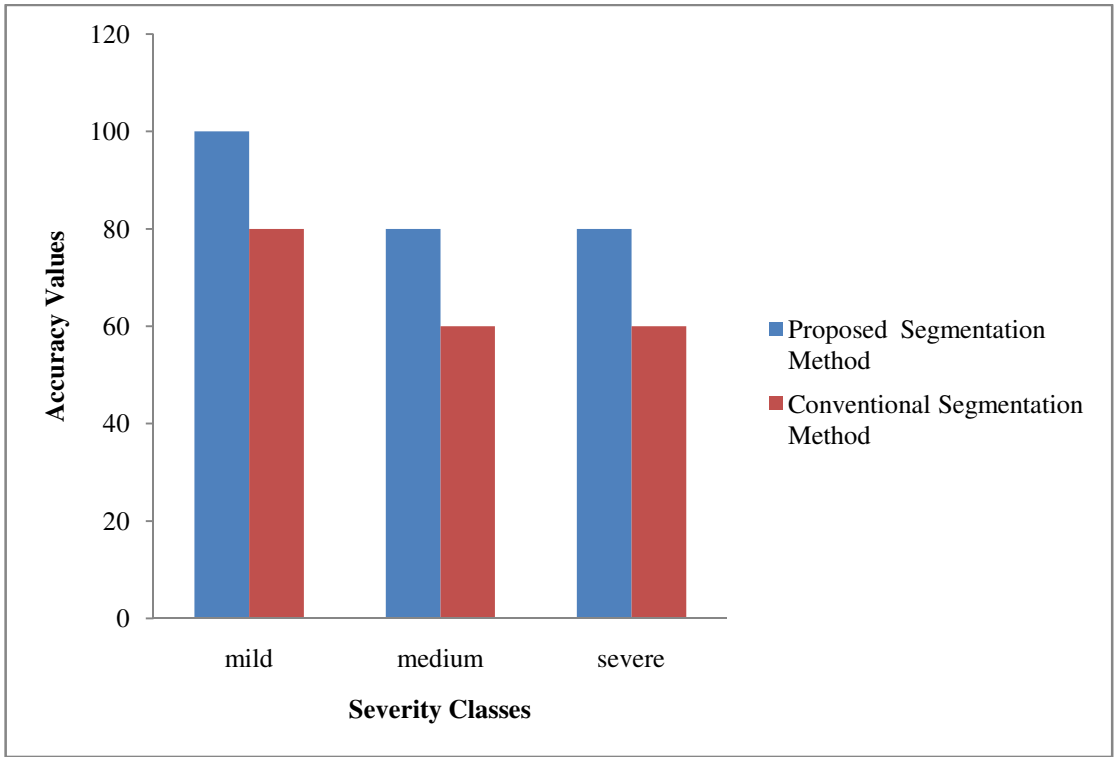


Figure-3(i)
Accuracy

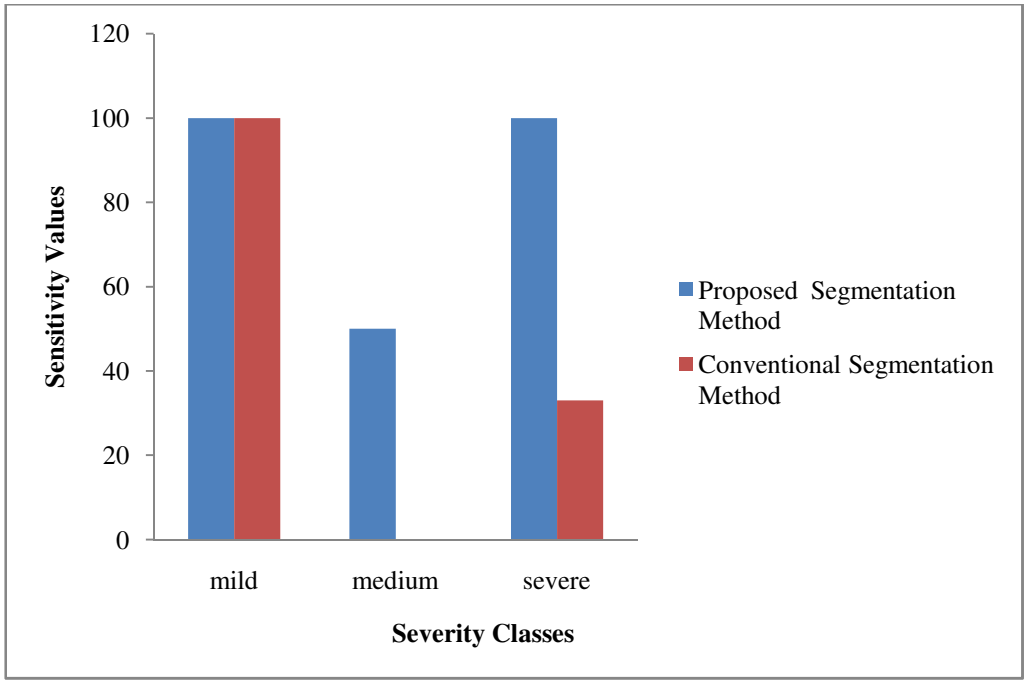


Figure-3(ii)
Sensitivity

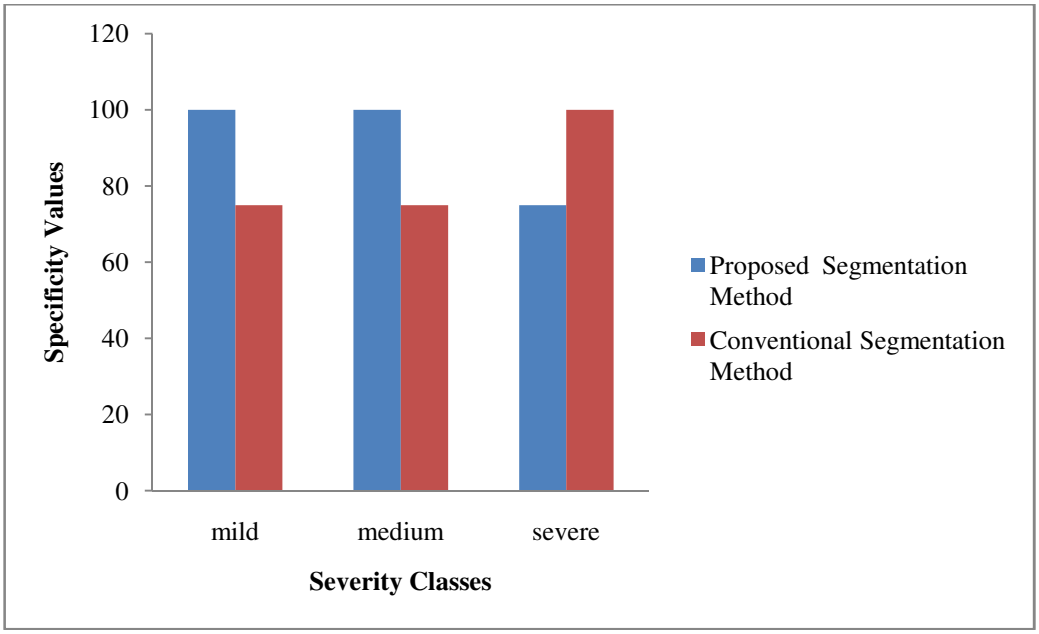


Figure-3(iii)
Specificity

Graphical Representation of AR Severity Performance Analysis with Conventional Segmentation Method

The figure 2 to 3 (i) (ii) and (ii) shows the graphical representation of accuracy, sensitivity, and specificity measures of MR&AR severity regurgitation proposed segmentation method performance compared to the conventional segmentation method. It shows that the accuracy, sensitivity and specificity measures in this severity classification processes are nearly same (or) higher than the conventional segmentation method. Also, the mild, moderate, severe severity classes have given higher accuracy, sensitivity and specificity result than the conventional segmentation method. But these severity classes moderate and severe performances lacks in sensitivity and specificity measures. However, this low performance of

sensitivity and specificity measure will not affect the segmentation process because the sensitivity and specificity is only slightly lower than the conventional segmentation as well as the accuracy level of both classes are nearly same (or) high when compared to this low level result of conventional segmentation method.

Conclusion

In this paper, a comparative analysis was conducted for evaluating the performance of proposed segmentation based severity regurgitation techniques with existing conventional segmentation techniques. From this performance analysis, we found that our proposed segmentation method for the mitral valve quantification process has given high performance than the existing segmentation algorithm. Moreover, the performance comparison process in severity of valvular regurgitation techniques has shown that our techniques has classified the input color Doppler images into mild, moderate, and severe based on quantitative parameters and radius of PISA with high accuracy than the existing techniques. Thus, our technique were providing high severity regurgitation accuracy and achieving exact segmentation from the input color Doppler images. Hence, our MR and AR severity regurgitation segmentation techniques were performing well in their regurgitation process.

References

1. Kumar P., Clark M., Eds. Clinical Medicine, 6th ed. London, UK: *Elsevier Saunders Limited*; (406), ISBN 0702027634 **(2005)**

2. Girish S. Shirali, Three dimensional echocardiography in congenital heart defects, *APC*, **1(1)**, 8–17 **(2008)**

3. Steven J. Fowler, Jagat Narula and Swaminatha V. Gurudevan, Review of Noninvasive Imaging for Hypertrophic Cardiac Syndromes and Restrictive Physiology, *Heart Failure Clinics*, **2(2)**, 215-230 **(2006)**

4. Bonita Anderson, Echocardiography: the normal examination and echocardiographic measurements, Chapter 13: Doppler Quantification of Regurgitant Lesions, 2nd Edition, *MGA Graphics*, Australia, 336, May **(2007)**

5. Abdul Khayum Pinjari, Giriprasad M.N. and Sridevi P.V., Anisotropic diffusion segmentation for the quantification of mitral regurgitation using proximal flow convergence method, *IEEE Explore*, ICCCN, Karur, India, 1-7, **(2008)**

6. Abdul Khayum Pinjari, Giriprasad M.N. and Sridevi P.V., Evaluation of the Severity of Mitral Valvular Regurgitation with Doppler Echocardiography Using Proximal Flow Convergence Method, *JCS*, **5(2)**, 115-122 **(2009)**

7. Abdul Khayum Pinjari, Sridevi P.V. and Giriprasad M.N., An efficient approach for quantification of aortic regurgitation using proximal isovelocity surface area method, Springer- Verlag, New Yark, USA, *Pattern Recognition and Image Analysis*, **20**, 542-550 **(2010)**

8. Abdul Khayum Pinjari, Sridevi P.V. and Giriprasad M.N., Quantification of Aortic Regurgitation Using Proximal Isovelocity Surface Area: An Effective Segmentation Approach Based On Fuzzy Clustering, *IJMEI*, Inderscience Publishers, UK, **4(1)**, 73-87 **(2012)**

9. Jeny Rajan, Kannan, Thomas Francis, Kesavadas and Chandrasekhar, M.R Brain Volume Analysis using BrainAssist, In Proceedings of *ICSCI*, Hyderabad, India, January **(2008)**

10. Nandagopalan, Adiga, Dhanalakshmi and Deepak, "Color doppler echocardiographic image analysis via shape and texture features, *In Proceedings of the ICBBI*, 139-143 **(2010)**