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Soft Computing and Signal Processing

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Proceedings of ICSCSP 2018, Volume 2

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Preface

The International Conference on Soft Computing and Signal Processing (ICSCSP 2018) was successfully organized by Malla Reddy College of Engineering & Technology, an UGC autonomous institution, during June 22–23, 2018, at Hyderabad. The objective of this conference was to provide opportunities for the researchers, academicians, and industry persons to interact and exchange the ideas, experience, and gain expertise in the cutting-edge technologies pertaining to soft computing and signal processing. Research papers in the above-mentioned technology areas were received and subjected to a rigorous peer review process with the help of program committee members and external reviewers. ICSCSP 2018 received a total of 574 papers, each paper was reviewed by more than two reviewers, and finally, 156 papers were accepted for publication in two separate volumes in Springer AISC series.

We would like to express our sincere thanks to Chief Guest Dr. S. B. Gadgil, Outstanding Scientist, Associate Director, RCI, DRDO, and keynote speakers Mr. Aninda Bose, Senior Editor, Springer Nature; Dr. C. Suchismita, Professor, NIT Rourkela; and Dr. Rishu Gupta, Senior Application Engineer, MathWorks, India.

We would like to express our gratitude to all the session chairs, viz., Dr. Ram Murthy Garimella, IIIT Hyderabad; Dr. Chandra Sekhar, Osmania University; Dr. Mohammed Arifuddin Sohel, Muffakham Jah College of Engineering and Technology; Dr. Samrat Lagnajeet Sabat, HCU; Dr. Malla Rama Krishna Murty, ANITS, Visakhapatnam; Dr. Mohana Sundaram, VIT, Vellore; and Dr. Suresh Kumar Nagarajan, VIT, Vellore, for extending their support and cooperation.

We are indebted to the program committee members and external reviewers who have produced critical reviews in a short time. We would like to express our special gratitude to Publication Chair Dr. Suresh Chandra Satapathy, KIIT, Bhubaneswar, for his valuable support and encouragement till the successful conclusion of the conference.

We express our heartfelt thanks to our Chief Patron Sri. Ch. Malla Reddy, Founder Chairman, MRGI; Patrons Sri. Ch. Mahendar Reddy, Secretary, MRGI,

Sri. Ch. Bhadra Reddy, President, MRGI; Convener Prof. P. Sanjeeva Reddy, Director, ECE and EEE; and Organizing Chair Dr. M. Murali Krishna, Dean.

We would also like to thank the organizing secretaries, viz., Dr. S. Srinivasa Rao, HOD, ECE; Dr. D. Sujatha, HOD, CSE; and Dr. G. Sharada, HOD, IT, for their valuable contribution. Our thanks also to all the coordinators and the organizing committee as well as all the other committee members for their contribution in the successful conduct of the conference.

Last but not least, our special thanks to all the authors without whom the conference would not have taken place. Their technical contributions have made our proceedings rich and praiseworthy.

New Jersey, USA
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Hyderabad, India

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A Graphical Computational Tool for Computerized Ventricular Extraction in Magnetic Resonance Cardiac Imaging



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Abstract In this research, a graphical computational tool for segmenting the ventricles (both left ventricle and right ventricle) using images that are taken from cardiac MRI has been developed and tested. The purpose of this research is to develop a tool to aid cardiologists in the extraction of clinically relevant medical information such as ejection fraction and stroke volume from the patient's cardiac MRI images. The tool has been developed to allow the user to load any cardiac MRI image and performs segmentation upon the click of a button. Moreover, along with all other above-mentioned features, it will provide a cardiac disease prediction framework for extracting clinically relevant medical information and clinical parameters from the patient's cardiac MRI images and for assisting cardiologists and cardiac

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researchers for creating patient-specific personalized cardiac treatment plans based on the extracted cardiac parameters such as left ventricular ejection fraction and stroke volume.

Keywords Segmentation · Cardiac MRI · Left ventricle · Right ventricle

1 Introduction

Across the globe, cardiac diseases are one of the major reasons for deaths. In 2011, the United Nations generated a death chart in which people dying of cardiovascular diseases were 33.7%, cancer deaths were 12.5%, and tumor-related deaths were 12.5%. The estimation predicts that by 2020, cardiovascular deaths would reach the top of the death chart. In order to understand the anatomy behind cardiac ischemia, coronary arterial network provides effective opportunities. In parallel, research is being done in cardiology to evaluate the functioning of a patient's heart. This circumstance makes cardiologists for distinguishing cardiac ailments precisely by taking very less amount of time. For assisting cardiologists and doctors, medical image processing is being used to facilitate the extraction of information from patient images [1–4]. In this work, a graphical computational tool has been developed in order to segment the cardiac MRI images, which can help provide clinically relevant medical parameters such as ejection fraction and stroke volume.

With a rapid increment of heart anomalies in patients, investigating patient's heart through the extraction of MRI images and through using other data had become the tough task for neurologists or specialized doctors who are in biomedical field. Magnetic resonance imaging (MRI) image segmentation is being utilized as a part of numerous biomedical applications in order to visualize and to measure the patient's heart functioning [5]. Proper usage of MRI by performing segmentation provides clear-cut information about the position, type, and size of a ventricle or tumor or other objects of interest. Proper treatment can be given in a very less time, considering the complete details of a ventricle or tumor or other objects of interest [6].

In the early stages, segmentation is usually performed manually by medical specialists, which is tedious and had a major possibility of error occurrence [7]. In order to prevent these, many techniques were discovered in order to segment MRI images properly, which are error-free or the ones that possess few errors [8]. The techniques that are introduced for proper segmentation of MRI images got classified as pixel-based, model-based, threshold-based, and region-based [9]. The complete procedure is guided using the computer without any scope for human errors [10].

For the purpose of segmenting the images that are generated from MRI, fuzzy c-means clustering technique had been used [11]. Along with fuzzy c-means clustering, connected component analysis, noise removal from the segmented image is done [12]. It had been the dominating and most widely used approach that gives efficient results

when segmentation of MRI images is performed [13]. It deals with combining similar components or objects of same cluster or not similar objects that are taken within other clusters [14]. This technique is used in my research to segment the images that got generated from MRI [15].

This graphical cardiac MRI segmentation tool will be free of cost and accessible to all cardiac researchers, cardiologists, and doctors in any part of the world [16]. It will be a stand-alone independent GUI-based software platform for easy-to-use user-friendly approach which will help a lot to facilitate cardiologists in order to minimize the need for manual tracing or user intervention [17]. However, it will support all medical image data types (such as NIFTI, DICOM, PNG).

2 Methodology

In general, there are three categories of segmentation: high-level segmentation, low-level segmentation, and medium-level segmentation [18, 19]. MRI is presently a common modality used by cardiologists for diagnosing heart sickness noninvasively. Many imaging techniques, for example, computed tomography (CT), are generally utilized as modalities or technologies in order to extract clinical information and cardiac parameters for gaining an understanding of a patient's heart disease. Magnetic resonance imaging (MRI) is most generally utilized since this single methodology is non-obtrusive, free of radiation, and approved by radiologists and specialists other than CT scans, ultrasonography, PETs. MRI can satisfy an extensive variety of patient's information requirements [20–29].

2.1 MRI Frames Segmentation

A graphical user interface is developed which allows uploading the cardiac MRI images (which are produced from the cardiac MRI machine) into it and performing particular image segmentation operations in order to obtain clinically relevant medical information, e.g., EDV, ESV, and SV.

After uploading an image, following operations take place in order to segment the uploaded cardiac MRI image. Figure 1 provides the complete information about the methodology involved.

2.2 MRI Frames Processing

In general, MRI machine resembles a long, narrow tube. When you are put within the tube, you are encompassed by a magnetic field. The human body is comprised of various elements, a large portion of which is magnetic. The magnetic field encompassing

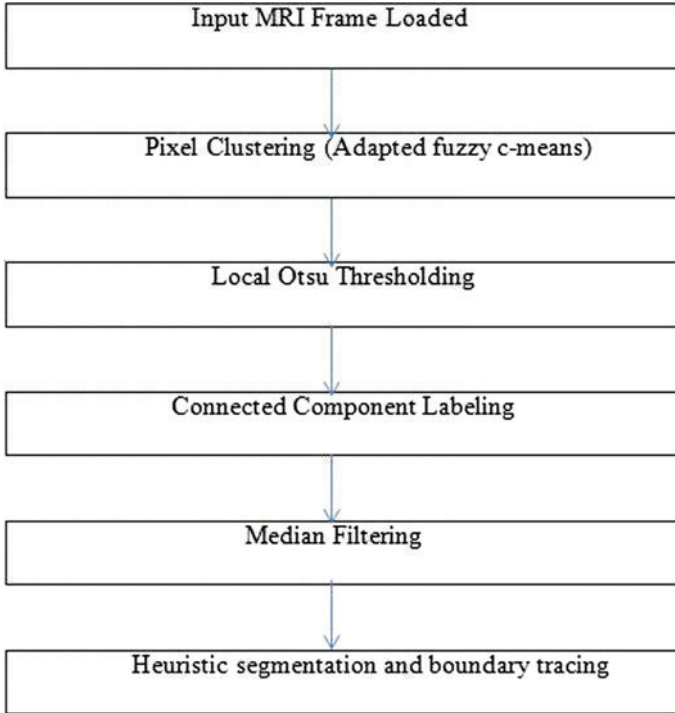


Fig. 1 Methodology for segmenting both the ventricles (left and right ventricles)

your body responds with the magnetic components inside your body to transmit a radio signal. For instance, your body contains a lot of hydrogen atoms, and those particles are exceptionally magnetic. The MRI machine's magnetic field energizes the hydrogen atoms, in your body, which thus generates a small radio signal. A computer reads the radio signal that got generated and transforms it into an image that can be observed on a computer monitor. In MRI, each and every image is called a slice. One MRI exam produces several image slices, which can be stored on a computer called a slice.

This section presents the algorithms used to segment the ventricles in the cardiac MRI images. The entire procedure is described sequentially step by step. From earlier research, the three methods explored—max flow, adaptive k , and fuzzy c -means clustering—are compared for segmenting left and right ventricles. Pixels are grouped into clusters in fuzzy c -means clustering. This groups the pixels in terms of connectivity, intensity, or distance, which brings about pixel classification. The pixels that are in separate clusters are not the same as another. In this clustering, n number of pixels are clustered following a particular measure. The center points are determined in each and every cluster. It can be observed in Eq. (1):

$$w_k = \sum_j \frac{d(\text{center}_k, x)^{\frac{2}{m-1}}}{d(\text{center}_j, x)^{\frac{2}{m-1}}} \quad (1)$$

The centers of the cluster can be observed in Eq. (2):

$$c_k = \frac{\sum_x w_k(x^m)x}{\sum_x w_k(x^m)} \quad (2)$$

After the clustering, the obtained image is binarized by utilizing thresholding technique for automatic segmentation of foreground from background clusters. As soon as thresholding gets completed, connected component labeling is done [30]. Based on the connectivity of pixels, it is used for grouping of pixels to get components like background, left ventricle, right ventricle. Through the usage of median filtering, an image gets filtered in order to effectively eliminate the regions which are very minute and do not deserve to be called as noise. In this work, heuristics get utilized to choose which region belongs to right ventricle and which region belongs to left ventricle based on calculating the distance, which is exactly from the center of the image and least in eccentricity. Pixels that are present at left and right ventricle boundary regions are made to delineate for defining left and right ventricle boundary points. After the segmentation, the clinical cardiac parameters are measured. The parameters measured are described as follows: end-systolic volume—the amount of blood that is present inside the left ventricle during systole (end of contraction) and end-diastolic volume—the amount of blood which is present inside the left ventricle during diastole (during the beginning of expansion). Stroke volume can be obtained by taking the difference between the two. It can be found in Eq. (3):

$$\text{Stroke Volume} = \text{End Diastolic Volume} - \text{End Systolic Volume} \quad (3)$$

The measure of the ejection fraction parameter is calculated as the ratio between the parameters (stroke volume and end-diastolic volume). The formula for ejection fraction can be found defined below in Eq. (4).

$$\text{EjectionFraction} = \frac{\text{ED Volume} - \text{ES Volume}}{\text{ED Volume}} \quad (4)$$

3 Graphical Computational Tool

The entire process of the cardiac ventricle segmentation, which includes feature extraction, classification, and segmentation, was developed as a graphical computer interface (GUI) in this work. The objective was to develop a stand-alone graphical user application where the user can upload the cardiac MRI images upon the click of

a button. The generated GUI framework redraws the GUI by uploading the cardiac MRI image, drawing it, and grayscale and binary versions obtained with MATLAB functions. Medical specialists can use this graphical computational tool and segment images of heart patients generated from cardiac MRI. This would be helpful to segment the image and detect the ventricles automatically, which takes an ample amount of time manually. The following are the characteristics of the GUI:

1. It is easy to use and user-friendly.
2. It is accurate, and cardiac experts have verified its accuracy against manual segmentation.
3. Stand-alone software, especially useful for those who are in the biomedical imaging field, is made available to reduce the complexity of their work.
4. The MRI image that will get uploaded in this software will be automatically segmented, and this aids automated detection of the ventricles.
5. It will support all medical image data types (such as NIFTI, DICOM, PNG).
6. There is no need of manual segmentation, which eliminates human-made errors.

The computerized extraction of cardiac ventricles was done using the graphical user interface of a software platform that was developed in this work. While segmenting left ventricle, images generated from MRI are taken. MRI images are segmented in GUI, and both the ventricles (left and right ventricle endocardiums along with their boundaries) can be observed in Fig. 2.

For the ventricle segmentation and area calculation, in general, ventricular segmentation takes place through taking information of the entire cardiac cycle of each patient that gets generated from MRI [30]. In order to segment ventricles, a graphical user interface was developed. While segmenting ventricles, images generated from MRI were taken. MRI images are segmented in the GUI performing fuzzy c-means clustering, followed by connected component labeling and eliminating noisy regions. Figure 3 shows the extraction of the left and right ventricle endocardium regions and their calculated areas.

4 Validation

The validation gives a complete confirmation to show why the proposed cardiac image processing algorithm is more accurate when compared to previous methods. Automatic versus manual segmentation of both ventricles can be observed in Fig. 4, and accuracy results can be observed in Table 1.

Fig. 2 Stepwise procedure for segmenting left and right ventricles

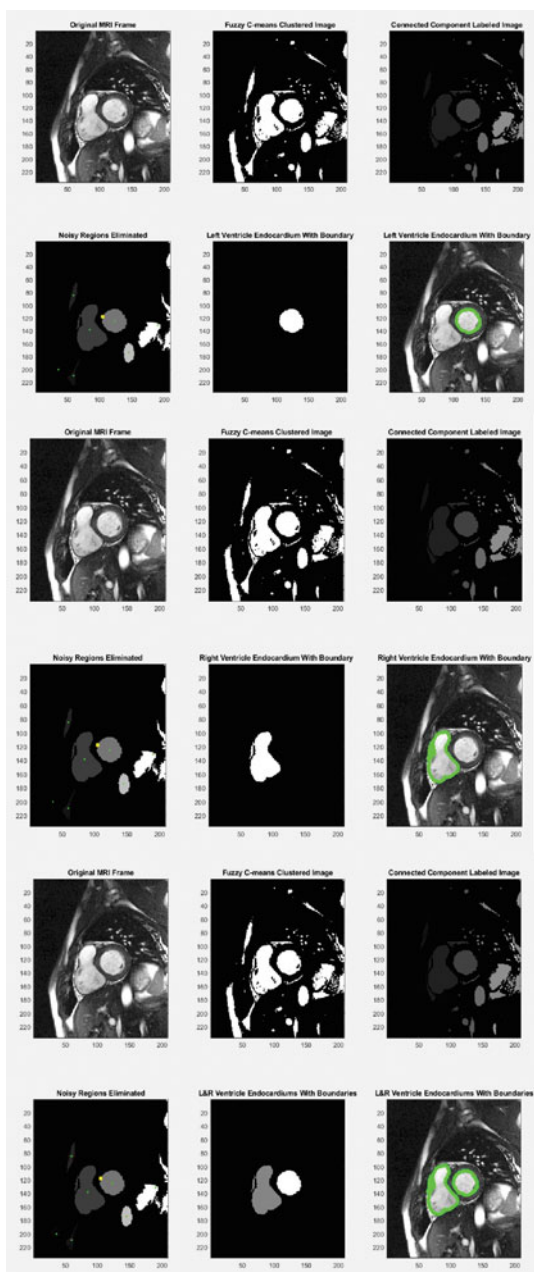


Fig. 3 Screenshots of the stand-alone computational software GUI for cardiac disease prognosis and analysis. This tool (developed in this work) segments both ventricles (left and right) in MRI images (cardiac MRI) along with calculating the areas of these regions of interest

