Advances in Intelligent Systems and Computing 898

Jiacun Wang
G. Ram Mohana Reddy
V. Kamakshi Prasad
V. Sivakumar Reddy *Editors*

Soft Computing and Signal Processing

Proceedings of ICSCSP 2018, Volume 2

Springer

Advances in Intelligent Systems and Computing

Volume 898

Series editor

Janusz Kacprzyk, Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

The series "Advances in Intelligent Systems and Computing" contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing such as: computational intelligence, soft computing including neural networks, fuzzy systems, evolutionary computing and the fusion of these paradigms, social intelligence, ambient intelligence, computational neuroscience, artificial life, virtual worlds and society, cognitive science and systems, Perception and Vision, DNA and immune based systems, self-organizing and adaptive systems, e-Learning and teaching, human-centered and human-centric computing, recommender systems, intelligent control, robotics and mechatronics including human-machine teaming, knowledge-based paradigms, learning paradigms, machine ethics, intelligent data analysis, knowledge management, intelligent agents, intelligent decision making and support, intelligent network security, trust management, interactive entertainment, Web intelligence and multimedia.

The publications within "Advances in Intelligent Systems and Computing" are primarily proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

More information about this series at http://www.springer.com/series/11156

Jiacun Wang · G. Ram Mohana Reddy
V. Kamakshi Prasad · V. Sivakumar Reddy
Editors

Soft Computing and Signal Processing

Proceedings of ICSCSP 2018, Volume 2

Springer

Editors
Jiacun Wang
Department of Computer Science
and Software Engineering
Monmouth University
West Long Branch, NJ, USA

V. Kamakshi Prasad
Department of Computer Science
and Engineering
JNTUH College of Engineering Hyderabad
Hyderabad, Telangana, India

G. Ram Mohana Reddy
Department of Information Technology
National Institute of Technology Karnataka
Surathkal, Mangaluru, Karnataka, India

V. Sivakumar Reddy
Department of Electronics and
Communication Engineering
Malla Reddy College of Engineering &
Technology
Secunderabad, Telangana, India

ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-981-13-3392-7 ISBN 978-981-13-3393-4 (eBook)
https://doi.org/10.1007/978-981-13-3393-4

Library of Congress Control Number: 2018962132

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Organizing Committee

Chief Patron

Sri. Ch. Malla Reddy
Hon'ble MP, Government of India
Founder Chairman, MRGI

Patrons

Sri. Ch. Mahendar Reddy, Secretary, MRGI
Sri. Ch. Bhadra Reddy, President, MRGI

Conference Chair

Dr. V. S. K. Reddy, Principal

Publication Chair

Dr. Suresh Chandra Satapathy, Professor, KIIT, Bhubaneswar

Convener

Prof. P. Sanjeeva Reddy, Director, ECE and EEE

Organizing Chair

Dr. M. Murali Krishna, Dean, Academics

Organizing Secretaries

Dr. S. Srinivasa Rao, HOD, ECE
Dr. D. Sujatha, HOD, CSE
Dr. G. Sharada, HOD, IT

Session Chairs

Dr. C. Suchismita, Professor, NIT Rourkela
Dr. Ram Murthy Garimella, Professor, IIIT Hyderabad
Dr. Chandra Sekhar, Professor, Osmania University
Dr. Mohammed Arifuddin Sohel, Professor, Muffakham Jah CET
Dr. Samrat Lagnajeet Sabat, Professor, HCU
Dr. Malla Rama Krishna Murty, Professor, ANITS, Visakhapatnam
Dr. Mohana Sundaram, Professor, VIT, Vellore
Dr. Suresh Kumar Nagarajan, Professor, VIT, Vellore

Coordinators

Dr. S. Shanthi, Professor, CSE
Dr. N. S. Gowri Ganesh, Professor, IT
Dr. V. Chandrasekar, Professor, CSE
Mr. G. S. Naveen Kumar, Associate Professor, ECE
Mr. K. Mallikarjuna Lingam, Associate Professor, ECE
Mr. M. Vazralu, Associate Professor, IT

Organizing Committee

Prof. K. Kailasa Rao, Director, CSE and IT
Prof. K. Subhas, Professor and Head, EEE
Dr. B. Jyothi, Associate Professor, ECE
Dr. Pujari Lakshmi Devi, Professor, ECE

Dr. C. Ravishankar Reddy, Professor, ECE
Dr. Ajeet Kumar Pandey, Professor, CSE
Dr. A. Mummoorthy, Professor, IT
Dr. V. M. Senthil Kumar, Professor, ECE
Dr. Murugeshan Rajamanickam, Professor, ECE
Sri. B. Rajeswar Reddy, Administrative Officer

Web Developer

Mr. K. Sudhakar Reddy, Assistant Professor, IT

Proceedings Committee

Dr. Sucharitha Manikandan, Associate Professor, ECE
Ms. P. Anitha, Associate Professor, ECE
Ms. M. Gayatri, Associate Professor, CSE
Ms. D. Asha, Assistant Professor, ECE
Mr. T. Vinay Simha Reddy, Assistant Professor, ECE
Mr. N. Sivakumar, Assistant Professor, CSE

Technical Program Committee

Dr. E. Venkateshwar Reddy, Professor, CSE
Dr. R. Roopa Chandrika, Professor, IT
Dr. A. Mummoorthy, Professor, IT
Mr. M. Sandeep, Associate Professor, CSE
Mr. M. Ramanjaneyulu, Associate Professor, ECE
Mr. K. Murali Krishna, Associate Professor, ECE
Mr. N. Ramesh, Associate Professor, EEE
Mr. K. Srikanth, Associate Professor, CSE
Mr. P. Bikshapathy, Associate Professor, CSE
Mr. D. Chandrasekhar Reddy, Associate Professor, CSE
Mr. M. Sambasivudu, Associate Professor, CSE
Mr. M. Jaypal, Associate Professor, CSE
Ms. J. Suneetha, Associate Professor, IT

Publicity Committee

Ms. D. Radha, Associate Professor, CSE
Mr. Ch. Kiran Kumar, Assistant Professor, ECE
Ms. P. Swetha, Associate Professor, ECE
Mr. R. Chinna Rao, Assistant Professor, ECE
Ms. Arthi Jeyakumari, Assistant Professor, CSE
Mr. P. Raji Reddy, Assistant Professor, EEE
Mr. K. D. K. Ajay, Assistant Professor, ECE
Ms. Renju Panicker, Assistant Professor, ECE
Mr. K. L. N. Prasad, Assistant Professor, ECE
Mr. T. Srinivas, Assistant Professor, ECE
Ms. R. Sujatha, Assistant Professor, CSE
Mr. A. Yogananda, Assistant Professor, IT

Registration Committee

Ms. M. Anusha, Assistant Professor, ECE
Mr. K. Suresh, Assistant Professor, ECE
Mr. V. Shiva Raja Kumar, Assistant Professor, ECE
Ms. B. Srujana, Assistant Professor, ECE
Ms. D. Kalpana, Assistant Professor, CSE
Mr. S. Vishwanath Reddy, Assistant Professor, CSE
Mr. Naresh, Assistant Professor, CSE

Hospitality Committee

Mr. A. Syam Prasad, Associate Professor, CSE
Mr. G. Ravi, Associate Professor, CSE
Mr. P. Srinivas Rao, Associate Professor, IT
Mr. M. Venu, Assistant Professor, CSE
Ms. Novy Jacob, Assistant Professor, IT
Mr. M. Anantha Gupta, Assistant Professor, ECE
Mr. G. Sekhar Babu, Assistant Professor, EEE
Mr. S. Rakesh, Assistant Professor, EEE
Mr. B. Mahendar, Assistant Professor, IT
Mr. P. Harikrishna, Assistant Professor, IT
Ms. W. Nirmala, Assistant Professor, CSE
Ms. Shruthi Rani Yadav, Assistant Professor, CSE
Ms. V. Alekya, Assistant Professor, CSE

Ms. G. Shamini, Assistant Professor, CSE
Mr. Naveen, Assistant Professor, CSE

Certificate Committee

Mr. M. Sreedhar Reddy, Associate Professor, ECE
Ms. S. Rajani, Assistant Professor, ECE
Ms. M. Hima Bindu, Assistant Professor, ECE
Mr. Manoj Kumar, Assistant Professor, CSE
Mr. K. Srinivas, Assistant Professor, CSE
Ms. Srilakshmi, Assistant Professor, IT

Decoration Committee

Mr. M. Anantha Gupta, Assistant Professor, ECE
Ms. N. Saritha, Assistant Professor, ECE
Mr. O. Saidulu Reddy, Assistant Professor, EEE
Mr. B. Srinivasa Rao, Assistant Professor, EEE
Ms. M. Nagma, Assistant Professor, ECE
Ms. D. Kavitha, Assistant Professor, ECE
Mr. Maheswari, Assistant Professor, ECE
Ms. Honey Diana, Assistant Professor, CSE
Ms. K. Swetha, Assistant Professor, IT
Ms. Sireesha, Assistant Professor, CSE
Mr. Y. Dileep Babu, Assistant Professor, CSE

Transportation Committee

Mr. V. Kamal, Associate Professor, CSE
Mr. P. Dileep, Associate Professor, CSE
Mr. G. Ravi, Associate Professor, CSE
Mr. M. Arun Kumar, Assistant Professor, ECE
Mr. E. Mahender Reddy, Assistant Professor, ECE
Mr. Saleem, Assistant Professor, CSE

International and National Advisory Committee

Dr. Heggere Ranganath, Chair of CS, The University of Alabama in Huntsville, USA
Dr. Someswar Kesh, Professor, Department of CISA, University of Central Missouri, USA
Mr. Alex Wong, Senior Technical Analyst, Diligent Inc., USA
Dr. Bhaskar Kura, Professor, University of New Orleans, USA
Dr. Ch. Narayana Rao, Scientist, Denver, Colorado, USA
Dr. Arun Kulkarni, Professor, University of Texas at Tyler, USA
Dr. Sam Ramanujan, Professor, Department of CIS and IT, University of Central Missouri, USA
Dr. Richard H. Nader, Associate Vice President, Mississippi State University, USA
Prof. Peter Walsh, Head of the Department, Vancouver Film School, Canada
Dr. Ram Balalachandar, Professor, University of Windsor, Canada
Dr. Asoke K. Nandi, Professor, Department of EEE, University of Liverpool, UK
Dr. Vinod Chandran, Professor, Queensland University of Technology, Australia
Dr. Amiya Bhaumik, Vice Chancellor, Lincoln University College, Malaysia
Prof. Soubarethinasamy, UNIMAS International, Malaysia
Dr. Sinin Hamdan, Professor, UNIMAS
Dr. Hushairi bin Zen, Professor, ECE, UNIMAS
Dr. Bhanu Bhaskara, Professor, Majmaah University, Saudi Arabia
Dr. Narayanan, Director, ISITI, CSE, UNIMAS
Dr. Koteswararao Kondepu, Research Fellow, Scuola Superiore Sant' Anna, Pisa, Italy
Shri B. H. V. S. Narayana Murthy, Director, RCI, Hyderabad
Prof. P. K. Biswas, Head, Department of E & ECE, IIT Kharagpur
Dr. M. Ramasubba Reddy, Professor, IIT Madras
Prof. N. C. Shiva Prakash, Professor, IISc, Bangalore
Dr. B. Lakshmi, Professor, Department of ECE, NIT Warangal
Dr. Y. Madhavee Latha, Professor, Department of ECE, MRECW, Hyderabad

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 — Jiacun Wang
Surathkal, India — G. Ram Mohana Reddy
Hyderabad, India — V. Kamakshi Prasad
Hyderabad, India — V. Sivakumar Reddy

Contents

About the Editors

Dr. Jiacun Wang received his Ph.D. in computer engineering from Nanjing University of Science and Technology (NJUST), China, in 1991. He is currently Professor in the Department of Computer Science and Software Engineering at Monmouth University, West Long Branch, New Jersey. From 2001 to 2004, he was a member of scientific staff with Nortel Networks in Richardson, Texas. Prior to joining Nortel, he was Research Associate of the School of Computer Science, Florida International University (FIU), Miami. Prior to joining FIU, he was Associate Professor at NJUST.

He has published two books and about 80 papers. He is Secretary of the Organizing and Planning Committee of the IEEE SMC Society. He is an associate editor of several international journals and has served as program chair, program co-chair, special session chair, or program committee member for many international conferences. He has been a senior member of IEEE since 2000.

His research interests include software engineering, discrete event systems, formal methods, wireless networking, and real-time distributed systems. Most recently, he has been focusing his research on workflow modeling and analysis for emergency management systems.

Dr. G. Ram Mohana Reddy is Professor and Head in the Department of IT at NITK Surathkal, Mangalore. He completed his B.Tech. (1987) in electronics and communication engineering from Sri Venkateswara University, Tirupati, Andhra Pradesh, India, and M.Tech. (1993) in telecommunication systems engineering from Indian Institute of Technology Kharagpur, India. He received his Ph.D. (2005) in cognitive hearing science from the University of Edinburgh, Edinburgh, UK. His areas of interests include affective human-centered computing, big data and cognitive analytics, cognitive hearing and speech science, cloud/edge/fog computing and QoS-aware green datacenters, Internet of things and smart city/home/office applications, social multimedia, and social network analysis. He has 75 publications in various reputed international/national journals and conferences. To his credit, he has authored many textbooks and chapters and he has worked on many significant funded projects and received many awards and honors.

Dr. V. Kamakshi Prasad is currently working as Professor in the Department of Computer Science and Engineering at Jawaharlal Nehru Technological University, Hyderabad. He completed his B.Tech. in civil engineering from K.L. College of Engineering during 1985–1989 and his M.Tech. in computer science and technology from Andhra University, Visakhapatnam, during 1990–1992. He received his Ph.D. in speech recognition from IIT Madras, Chennai, during 1998–2002. His areas of interest include speech recognition and processing, image processing, pattern recognition, data mining, ad hoc networks, and computer graphics. He has guided 11 Ph.D. students and is having a vast experience of 21 years in the teaching field. His research interests include speech recognition and processing, image processing, neural networks, data mining, and ad hoc networks. To his credit, he authored many textbooks and 95 publications in various reputed international/national journals and conferences. He is acting as the TEQIP coordinator and a member in various academic bodies.

Dr. V. Sivakumar Reddy is working as Principal and Professor in the Department of Electronics and Communication Engineering at Malla Reddy College of Engineering & Technology (Autonomous). He completed his B.Tech. in electronics and communication engineering from S.V. University, Tirupati, India, and M.Tech. (first class) in digital systems from JNTU, Hyderabad, India. He received his Ph.D. in electronics and communication engineering from IIT Kharagpur, India. His areas of research interest include computer networks and communications, video processing, multimedia system design, operating systems, TCP/IP networks and protocols, system architecture, and advanced microprocessors. He is having a total of 21 years of experience at various levels of academic and administrative positions. To his credit, he is having 105 publications in various reputed international/national journals and conferences and received many awards and honors and he is the reviewer for many international journals.

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

Ayush Goyal, Disha Bathla, Sai Durga Prasad Matla Leela Venkata Manikanta, Gahangir Hossain, Rajab Challoo, Ashwani K. Dubey, Anupama Bhan and Priya Ranjan

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

A. Goyal (✉) · S. D. P. M. L. V. Manikanta · G. Hossain · R. Challoo
Texas A&M University - Kingsville, Kingsville, TX, USA
e-mail: ayush.goyal@tamuk.edu

S. D. P. M. L. V. Manikanta
e-mail: sai_durga_prasad.matla_leela_venkata_manikanta@students.tamuk.edu

G. Hossain
e-mail: gahangir.hossain@tamuk.edu

R. Challoo
e-mail: rajab.challoo@tamuk.edu

D. Bathla · A. K. Dubey · A. Bhan · P. Ranjan
Amity University Uttar Pradesh, Noida, UP, India
e-mail: dishabathla@gmail.com

A. K. Dubey
e-mail: akdubey@amity.edu

A. Bhan
e-mail: abhan@amity.edu

P. Ranjan
e-mail: pranjan@amity.edu

J. Wang et al. (eds.), *Soft Computing and Signal Processing* ,
Advances in Intelligent Systems and Computing 898,
https://doi.org/10.1007/978-981-13-3393-4_1

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

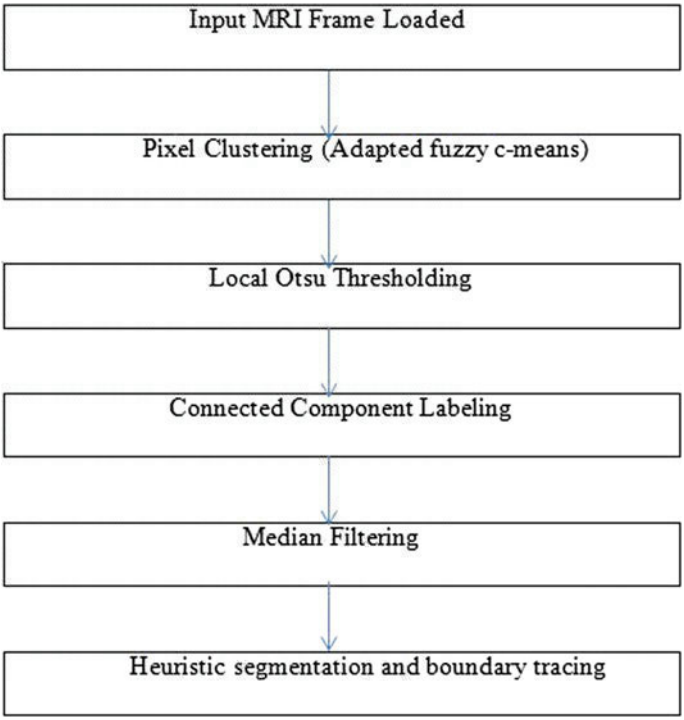

Fig. 1 Methodology for segmenting both the ventricles (left and right ventricles)

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):

$$w_k = \sum_j \frac{d(center_k, x)}{d\left(center_j, x\right)}^{\frac{2}{m-1}}. \quad (1)$$

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):

$$Stroke\ Volume = End\ Diastolic\ Volume - End\ Systolic\ Volume. \quad (3)$$

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).

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

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.

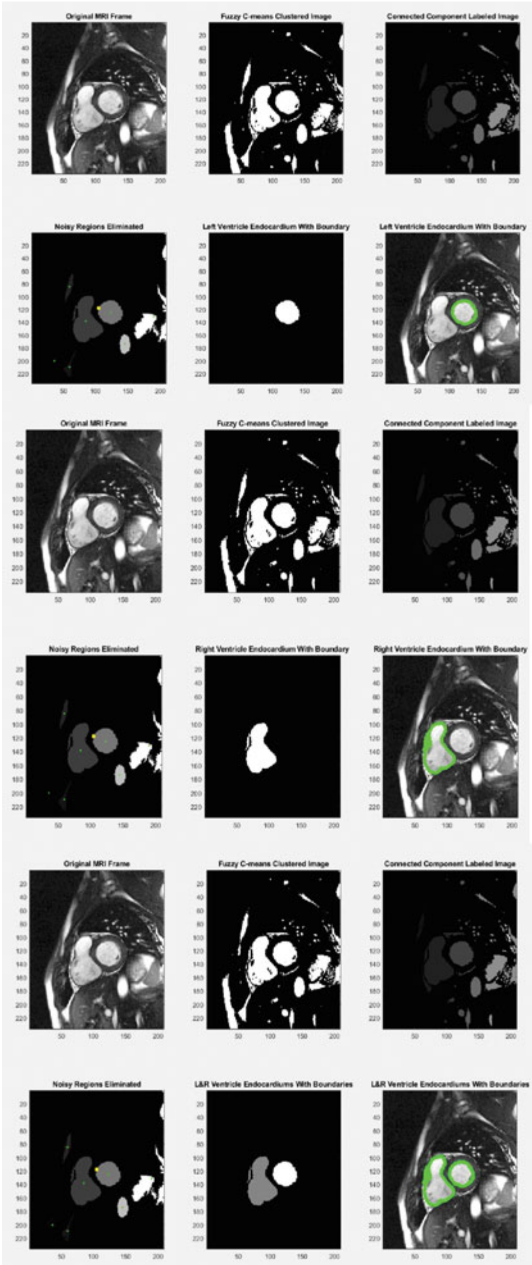

Fig. 2 Stepwise procedure for segmenting left and right ventricles

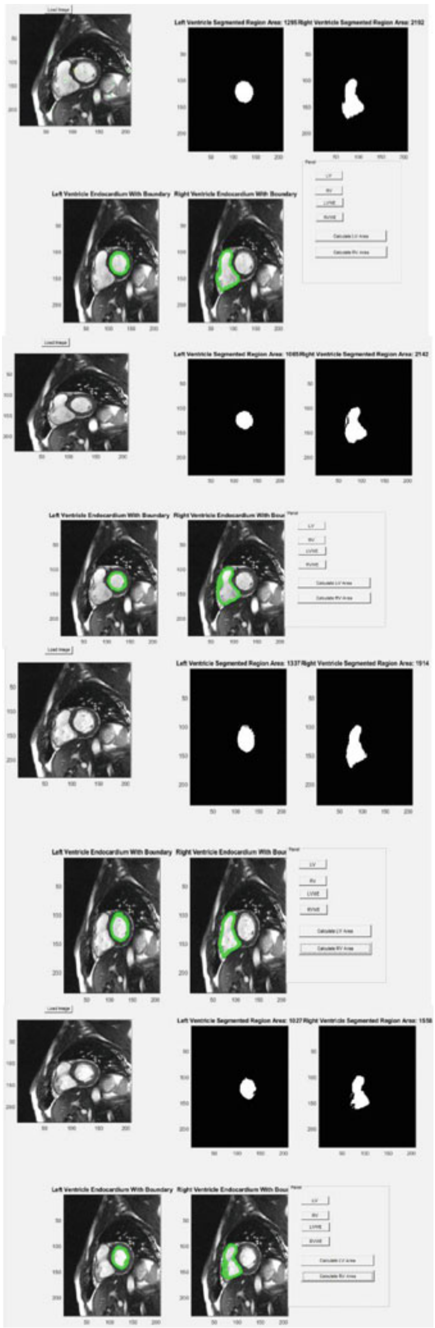

Fig. 3 Screenshots of the stand-alone computational software GUI for cardiac disease prognosis and analysis. This tool (developed in this work) segments both ventricles (left and right) in MRI images (cardiac MRI) along with calculating the areas of these regions of interest