A composite visualization method for electrophysiology-morphous merging of human heart

Fei Yang, Lei Zhang, Weigang Lu, Yue Zhang, Wangmeng Zuo, Kuanquan Wang, and Henggui Zhang

Abstract—Background: Electrophysiological behavior is of great importance for analyzing the cardiac functional mechanism under cardiac physiological and pathological condition. Due to the complexity of cardiac structure and biophysiological function, visualization of a cardiac electrophysiological model compositively is still a challenge. The lack of either modality of the whole organ structure or cardiac electrophysiological behaviors makes analysis of the intricate mechanisms of cardiac dynamic function a difficult task. This study aims at exploring 3D conduction of stimulus and electrical excitation reactivity on the level of organ with the authentic fine cardiac anatomy structure.

Methods: In this paper, a cardiac electrical excitation propagation model is established based on the human cardiac cross-sectional data to explore detailed cardiac electrical activities. A novel biophysical merging visualization method is then presented for biophysical integration of cardiac anatomy and electrophysiological properties in the form of the merging optical model, which provides the corresponding position, spatial relationship and the whole process in 3D space with the context of anatomical structure for representing the biophysical detailed electrophysiological activity.

Results: The visualization result present the action potential propagation of the left ventricle within the excitation cycle with the authentic fine cardiac organ anatomy. In the visualized images, all vital organs are identified and distinguished without ambiguity. The three dimensional spatial position, relation and the process of cardiac excitation conduction and re-entry propagation in the anatomical structure during the phase of depolarization and repolarization is also shown in the result images, which exhibits the performance of a more detailed biophysical understanding of the electrophysiological kinetics of human heart in vivo.

Conclusions: Results suggest that the proposed merging optical model can merge cardiac electrophysiological activity with the anatomy structure. By specifying the respective opacity for the cardiac anatomy structure and the electrophysiological model in the merging attenuation function, the visualized images can provide an in-depth insight into the biophysical detailed cardiac functioning phenomena and the corresponding electrophysiological behavior mechanism, which is helpful for further speculating cardiac physiological and pathological responses and is fundamental to the cardiac research and clinical diagnoses.

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Keywords: Computational cardiology, Morphous Biophysical merging, Cardiac biophysiological function, Merging attenuation model

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1 BACKGROUND

The cardiac disease, e.g., atrioventricular block, ventricular fibrillation and cardiomyopathy, is one of the most common causes of mortality in the world. It has been proven that cardiac functional abnormity may produce the serious problem of heart disability and are generally life-threatening [1]. Although there are considerable progresses have been achieved on conventional open-heart research and acquirement of experimental and clinical data, the cardiac mechanisms aren't well understood. Increasing mo-

mentum is tending to study the cardiac biophysiological function noninvasively [2], [3], [4]. Serpooshan et al. [5] analyzed the structure and function of the failing heart to enhance cardiac healing after injury. Zhang et al. [6] visualized cardiac microvessels embolization in 3D space with X-ray phase contrast images. This method was beneficial to diagnoses and predicting and judging the prognosis in myocardial infarction (MI). Based on the surface shape space Taimouri and Hua [7] et al. defined two novel shape descriptors by the geodesic distance connecting two points in the two cardiac medial surfaces, which quantitatively analyzed the similarity and disparity of the 3D heart motions between the healthy and myopathic subjects and accurately detected myopathic regions on the left ventricle. Spicher et al. [8] proposed a new cardiac triggering method to estimate the cardiac cycle phase in real-time from videos captured with an in-bore camera. However, the function mechanisms and the underlying genesis of human heart still remain unclear.

Electrophysiological behavior is of great importance for analyzing the functional mechanism under cardiac physiological and pathological condition. Noble [9] first applied the cell mathematical model-HH model to the purkinje fibre and pace-maker cells and started the research on

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and conference proceedings The book also includes Prof Or owska s autobiography bibliography and a trialogue between her and the editors of the volume as well as contributors biographical notes and is suitable for scholars and students of logic who are interested in understanding more about Prof Or owska s work   Natural Computing for Simulation and Knowledge Discovery Nunes de Castro, Leandro,2013-07-31 Nature has long provided the inspiration for a variety of scientific discoveries in engineering biomedicine and computing though only recently have these elements of nature been used directly in computational systems Natural Computing for Simulation and Knowledge Discovery investigates the latest developments in nature influenced technologies Within its pages readers will find an in depth analysis of such advances as cryptographic solutions based on cell division the creation and manipulation of biological computers and particle swarm optimization techniques Scientists practitioners and students in fields such as computing mathematics and molecular science will make use of this essential reference to explore current trends in natural computation and advance nature inspired technologies to the next generation   **Supporting Learning Flow Through Integrative Technologies** Tsukasa Hirashima,Ulrich Hoppe,Shelley Shwu-Ching Young,2007 Contains a range of issues related to using information technology for learning This book indicates a move from local support of specific learning activities towards supporting learning and teaching processes in a broader context beyond single tools and individuals users considering user learner groups on different levels of granularity   *Large-Scale Distributed Computing and Applications: Models and Trends* Cristea, Valentin,Dobre, Ciprian,Stratan, Corina,Pop, Florin,Costan, Alexandru,2010-05-31 Many applications follow the distributed computing paradigm in which parts of the application are executed on different network interconnected computers The extension of these applications in terms of number of users or size has led to an unprecedented increase in the scale of the infrastructure that supports them Large Scale Distributed Computing and Applications Models and Trends offers a coherent and realistic image of today s research results in large scale distributed systems explains state of the art technological solutions for the main issues regarding large scale distributed systems and presents the benefits of using large scale distributed systems and the development process of scientific and commercial distributed applications   *Putting Research to Work in Quality Improvement and Quality Assurance* ,1993 This document has the background papers from the 1992 AHCPR conference held to formulate a research agenda for quality assurance and improvement Contents Executive summary A perspective on quality assurance research Quality improvement quality assurance taxonomy a framework Organisational issues and perspectives on quality assurance Quality assurance and quality improvement in the information age Using information in quality improvement and quality assurance What is quality improvement a report from the field Quality improvement a patient s perspective Closing quality improvement assurance information gaps AHCPR s role Closing quality improvement assurance information gaps public and private sector roles Workshop recommendations Appendices   *Fundamentals of Computation Theory* Erzsébet Csuhaj-Varjú,Zoltán Ésik,2007-08-28 This book features the refereed proceedings of the 16th International

Symposium on Fundamentals of Computation Theory Thirty nine full papers are presented along with four invited papers The papers address all current topics in computation theory including automata and formal languages design and analysis of algorithms computational and structural complexity semantics logic circuits and networks learning theory and more

Handbook of Research on User Interface Design and Evaluation for Mobile Technology Lumsden, Joanna,2008-02-28 This book compiles authoritative research from scholars worldwide covering the issues surrounding the influx of information technology to the office environment from choice and effective use of technologies to necessary participants in the virtual workplace Provided by publisher **The Oxford Handbook of Affective Computing** Rafael A. Calvo,Sidney D'Mello,Jonathan Gratch,Arvid Kappas,2015-01-15 Affective Computing is a growing multidisciplinary field encompassing computer science engineering psychology education neuroscience and many other disciplines It explores how affective factors influence interactions between humans and technology how affect sensing and affect generation techniques can inform our understanding of human affect and on the design implementation and evaluation of systems that intricately involve affect at their core The Oxford Handbook of Affective Computing will help both new and experienced researchers identify trends concepts methodologies and applications in this burgeouning field The volume features 41 chapters divided into five main sections history and theory detection generation methodologies and applications Section One begins with a look at the makings of AC and a historical review of the science of emotion Chapters discuss the theoretical underpinnings of AC from an interdisciplinary perspective involving the affective cognitive social media and brain sciences Section Two focuses on affect detection or affect recognition which is one of the most commonly investigated areas in AC Section Three examines aspects of affect generation including the synthesis of emotion and its expression via facial features speech postures and gestures Cultural issues in affect generation are also discussed Section Four features chapters on methodological issues in AC research including data collection techniques multimodal affect databases emotion representation formats crowdsourcing techniques machine learning approaches affect elicitation techniques useful AC tools and ethical issues in AC Finally Section Five highlights existing and future applications of AC in domains such as formal and informal learning games robotics virtual reality autism research healthcare cyberpsychology music deception reflective writing and cyberpsychology With chapters authored by world leaders in each area The Oxford Handbook of Affective Computing is suitable for use as a textbook in undergraduate or graduate courses in AC and will serve as a valuable resource for students researchers and practitioners across the globe **Cybersecurity for Critical Infrastructure Protection Via Reflection of Industrial Control Systems** O.B. Popov,L. Sukhostat,2022-11-23 Although cybersecurity is something of a latecomer on the computer science and engineering scene there are now inclinations to consider cybersecurity a meta discipline Unlike traditional information and communication systems the priority goal of the cybersecurity of cyber physical systems is the provision of stable and reliable operation for the critical infrastructures of all fundamental societal functions

and activities This book Cybersecurity for Critical Infrastructure Protection via Reflection of Industrial Control Systems presents the 28 papers delivered at the NATO Advanced Research Workshop ARW hosted in Baku Azerbaijan and held online from 27 29 October 2021 The inspiration and motivation behind the ARW stem from the growth in large scale cyber attacks the rising degree of complexity and sophistication of advanced threats and the need to protect critical infrastructure by promoting and building a resilient system to promote the well being of all citizens The workshop covered a wide range of cybersecurity topics permeating the main ideas concepts and paradigms behind ICS and blended with applications and practical exercises with overtones to IoT IIoT ICS artificial intelligence and machine learning Areas discussed during the ARW included the cybersecurity of critical infrastructures its educational and research aspects vulnerability analysis ICS PLC SCADA test beds and research intrusion detection mitigation and prevention cryptography digital forensics for ICS PLCs Industry 4 0 robustness and trustworthiness and Cyber Fortress concept infused with practical training Investigating theoretical and practical problems involving the security of critical and essential infrastructure of each segment of contemporary societies the book will be of interest to all those whose work involves cybersecurity **Cognitive Informatics for Revealing Human Cognition: Knowledge Manipulations in Natural Intelligence** Wang, Yingxu,2012-11-30 This book presents indepth research that builds a link between natural and life sciences with informatics and computer science for investigating cognitive mechanisms and the human information processes **Ecological Data** William K. Michener,James W. Brunt,2009-04-01 Ecologists are increasingly tackling difficult issues like global change loss of biodiversity and sustainability of ecosystem services These and related topics are enormously challenging requiring unprecedented multidisciplinary collaboration and rapid synthesis of large amounts of diverse data into information and ultimately knowledge New sensors computers data collection and storage devices and analytical and statistical methods provide a powerful tool kit to support analyses graphics and visualizations that were unthinkable even a few years ago New and increased emphasis on accessibility management processing and sharing of high quality well maintained and understandable data represents a significant change in how scientists view and treat data These issues are complex and despite their importance are typically not addressed in database ecological and statistical textbooks This book addresses these issues providing a much needed resource for those involved in designing and implementing ecological research as well as students who are entering the environmental sciences Chapters focus on the design of ecological studies data management principles scientific databases data quality assurance data documentation archiving ecological data and information and processing data into information and knowledge The book stops short of a detailed treatment of data analysis but does provide pointers to the relevant literature in graphics statistics and knowledge discovery The central thesis of the book is that high quality data management systems are critical for addressing future environmental challenges This requires a new approach to how we conduct ecological research that views data as a resource and promotes stewardship

recycling and sharing of data Ecological Data will be particularly useful to those ecologists and information specialists that actively design manage and analyze environmental databases However it will also benefit a wider audience of scientists and students in the ecological and environmental sciences   **Embedded Systems: Design, Analysis and Verification** Gunar Schirner,Marcelo Götz,Achim Rettberg,Mauro C. Zanella,Franz J. Rammig,2013-06-13 This book constitutes the refereed proceedings of the 4th IFIP TC 10 International Embedded Systems Symposium IESS 2013 held in Paderborn Germany in June 2013 The 22 full revised papers presented together with 8 short papers were carefully reviewed and selected from 42 submissions The papers have been organized in the following topical sections design methodologies non functional aspects of embedded systems verification performance analysis real time systems embedded system applications and real time aspects in distributed systems The book also includes a special chapter dedicated to the BMBF funded ARAMIS project on Automotive Railway and Avionics Multicore Systems

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