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(SHORT COMMUNICATION)

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Modeling of LBBB and RBBB Abnormal Activations of the Heart

Ihab ELAFF [1, 2, *]

[1] *Department of Computer Science and Engineering, College of Engineering, Qatar University, Qatar.*
[2] *Department of Computer Engineering, Faculty of Engineering and Natural Sciences, Üsküdar University, Türkiye.*

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Abstract

Accurate modeling of the heart's electrical activation is essential for simulating Body Surface Potential Maps (BSPMs) and understanding abnormal conduction patterns. This study investigates the simulation of two pathological conduction conditions—Left Bundle Branch Block (LBBB) and Right Bundle Branch Block (RBBB)—using a previously developed human heart model based on Diffusion Tensor Imaging (DTI). Two conduction network models were tested: a manually constructed network and a diffusion volume (DV)-based automated network. Pathological activation was simulated by applying conduction delays to the corresponding bundle branches. The manual model successfully reproduced electrograms consistent with reference vertical ECG leads, while the automated model failed to replicate realistic bundle splitting due to limitations in the region-growing method. These findings underscore the importance of accurate anatomical modeling in simulating abnormal cardiac activation and suggest areas for future improvement in automated conduction modeling.

Keywords: Cardiac conduction system; LBBB; RBBB; Electrocardiogram (ECG) modeling; Arrhythmia modeling

1. Introduction

Modeling of the normal heart electrical activation is the base point to generate the Body Surface Potential Map (BSPM) [1]. Based on the developed human torso [2], activation isochrones [3, 4] is generated for the heart model which has been developed in an earlier stage using DTI scans [5]. Activation inside that model has been simulated using two models of conduction network [4]. The first model of conduction network is built manually based on the Trabecular muscles locations and the other was extracted using Diffusion Volume quantity (DV) [6, 7].

This manuscript concern about modeling 2 abnormal cases of the heart activation; namely: Left Bundle Branch Block (LBBB) and Right Bundle Branch Block (RBBB) [8].

2. Results

The effect of arrhythmia was introduced by applying a delay to the defected branch in the model, in order to simulate the real situation. The manual conduction system responded with results visually near to the reference electrograms of vertical ECG leads [9] (Figure 1 and Figure 2)

* Corresponding author: Ihab ELAFF; ORCID: 0000-0002-0913-5476

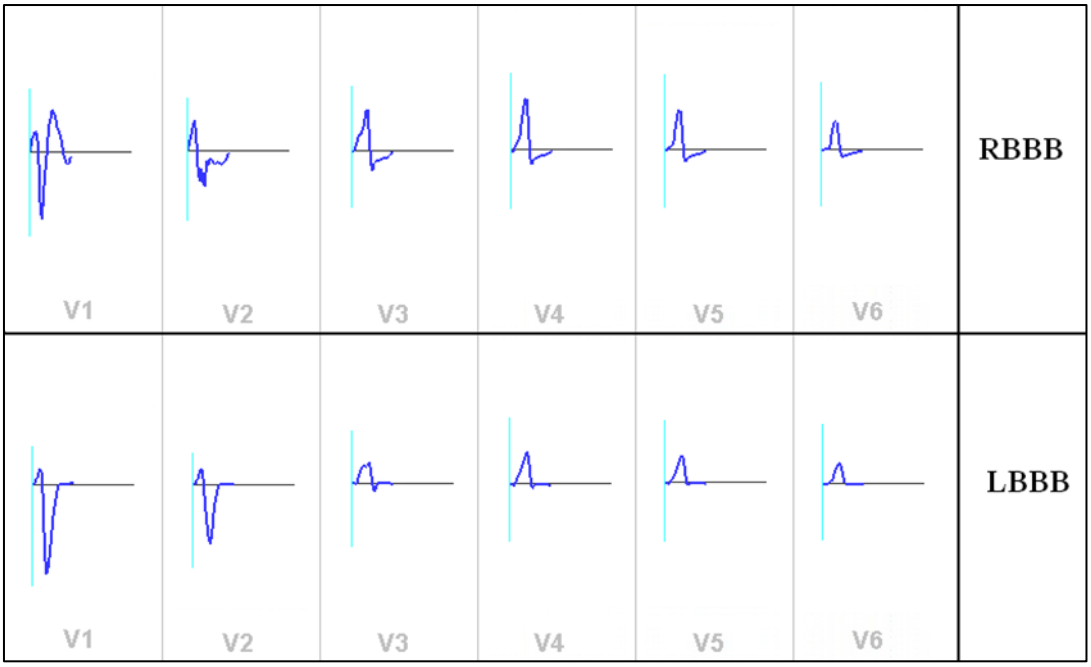

Figure 1 Simulated vertical ECG leads (V1 – V6) of LBBB and RBBB (QRS complex)

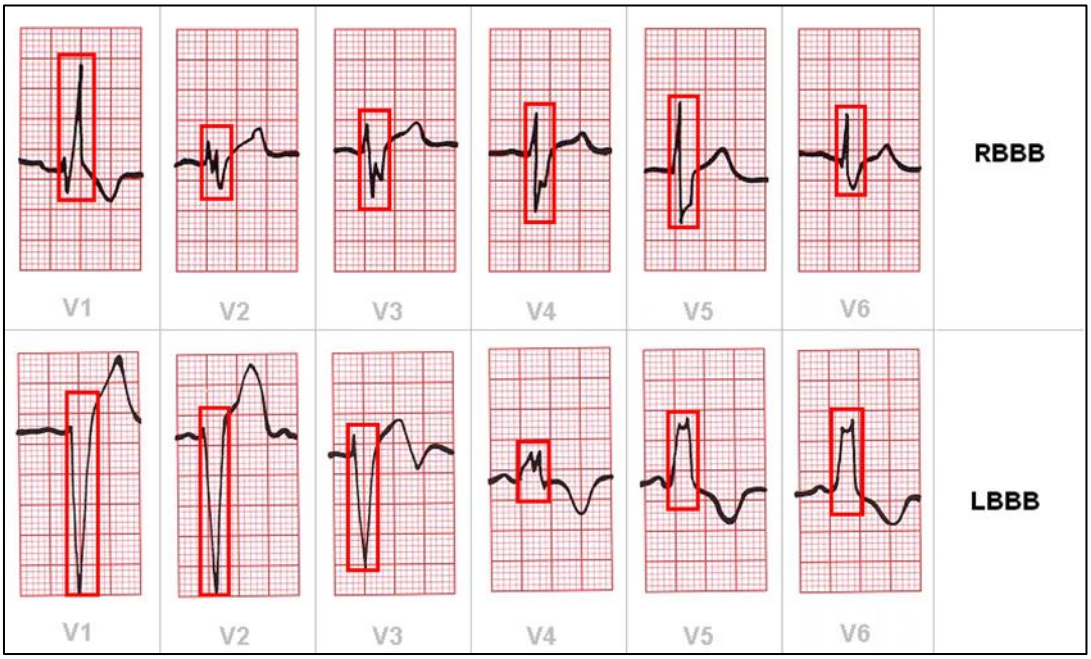

Figure 2 Reference electrograms of vertical ECG leads (V1 – V6) of LBBB and RBBB (QRS complex) [9]

Modeling of the LBBB and the RBBB fails using the 2nd model of the conduction system (model 2) because the splitting of bundles in the IV Septum using the region growing method was not accurate enough, and manual splitting or other method is required to do such a function. This part is left as a future work.

3. Conclusion

This study demonstrates the feasibility of modeling bundle branch blocks using a manually constructed conduction network within a DTI-based heart model. The simulation results closely align with reference ECG patterns for LBBB and RBBB, validating the effectiveness of manual conduction modeling in replicating pathological conditions. Conversely, the DV-based automated conduction system failed to accurately simulate these abnormalities due to insufficient bundle

separation in the interventricular septum. Future work will focus on enhancing the automated extraction methods to better represent anatomical bundle divisions and improve the reliability of conduction simulations for both normal and pathological heart states.

Compliance with ethical standards

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References

[1] Elaff, I. "Modeling of the Body Surface Potential Map for Anisotropic Human Heart Activation", Research Square, 2025. https://doi.org/10.21203/rs.3.rs-6840196/v1

[2] Elaff, I. "Modeling of 3D Inhomogeneous Human Body from Medical Images", World Journal of Advanced Engineering Technology and Sciences. 2025, 15(02): 2010-2017. https://doi.org/10.30574/wjaets.2025.15.2.0772

[3] Elaff, I. "Modeling of realistic heart electrical excitation based on DTI scans and modified reaction diffusion equation" Turkish Journal of Electrical Engineering and Computer Sciences: 2018, 26(3): Article 2. https://doi.org/10.3906/elk-1710-118J

[4] Elaff, I. "Modeling of The Excitation Propagation of The Human Heart", World Journal of Biology Pharmacy and Health Sciences, 2025, 22(02): 512–519. https://doi.org/10.30574/wjbphs.2025.22.2.0541

[5] Elaff, I. "Modeling of the Human Heart in 3D Using DTI Images", World Journal of Advanced Engineering Technology and Sciences, 2025, 15(02), 2450-2459. https://doi.org/10.30574/wjaets.2025.15.2.0812

[6] El-Aff, I.A.I. "Extraction of human heart conduction network from diffusion tensor MRI" The 7th IASTED International Conference on Biomedical Engineering, 217-22.

[7] Elaff, I. "Modeling the Human Heart Conduction Network in 3D using DTI Images", World Journal of Advanced Engineering Technology and Sciences, 2025, 15(02), 2565–2575. https://doi.org/10.30574/wjaets.2025.15.2.0838

[8] O. Berenfeld and J. Jalife "Purkinje-Muscle Reentry as a Mechanism of Polymorphic Ventricular, Arrhythmias in a 3-Dimensional Model of the Ventricles" Circ. Res., (1998);82;1063-1077

[9] J.R. Hampton "The ECG made easy" 5th Ed., Pearson Prof., (1997), ISBN: 0443-056811