جامعة الإسكندرية
ALEXANDRIA
UNIVERSITY

Faculty of Engineering
Department of Electrical Engineering

Reconstruction of depolarization pattern for normal heart and myocardial infarction using two cascaded stages of artificial neural networks

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

In

Electrical Engineering

Presented by

Nihal Ahmed Mahmoud Mabrouk

B.Sc. in Electrical Engineering, Faculty of Engineering, Alexandria University 2006

M.Sc. in Electrical Engineering, Faculty of Engineering, Alexandria University 2011

2019

CamScanner

ABSTRACT

The inverse problem of electrocardiogram (ECG) is an ill-posed problem (does not fulfill Hadamard conditions). Several methods for this problem have been suggested long ago as the regularization technique, with its different types. Artificial neural network (ANN) technique is one of the most important techniques used to solve this problem as it allows a real time solution with minimal processing time.

A simple example illustrating the inverse problem of well-posed (which fulfill Hadamard conditions) and ill-posed types is presented. The model is tested with noisy data of random additive noise having a signal to noise ratio of about 10 dB. The back propagation ANN method is used to solve the inverse problem. The solution obtained using the inverse matrix technique for the well-posed problem and the Tikhonov regularization technique for the ill-posed problem are compared with the ANN results. Results show that the ANN method gives the best results with least mean squared error compared to other techniques.

A three-dimensional (3D) model of torso-embedded whole heart is presented, with spontaneous initiation of activation in the sinoatrial node, showing the electrical activity conduction system throughout the heart. The forward model is solved using the finite element method (FEM). The transmembrane potentials (TMPs) and the body surface potentials (BSPs) obtained in the forward simulation are used to train the ANN. This study successfully proves that ANN is able to retrieve the depolarization pattern of normal heart at different time intervals. The depolarization pattern of normal heart reconstructed using ANN is compared with the simulated depolarization pattern from the forward model at different time intervals.

Myocardial infarction (MI) is a main leading cause of death, so early detection of MI size and location is very important. Solving the inverse problem of ECG provides a noninvasive

CamScanner

method for imaging the MI regions without requirement of great experience in the visual analysis of ECG.

In this thesis, a proposed configuration of two cascaded stages of ANNs is used to solve the inverse problem of ECG for different MI cases. Eight different cases of MI regions of different sizes and locations in the heart are simulated in the forward model. The TMPs and the BSPs obtained from the forward simulation are used to train the ANN in the primary stage and each ANN for each MI case in the secondary stage. The primary stage selects one MI case from the eight different cases and the secondary stage reconstructs the depolarization pattern for the selected MI case. This configuration shows a significant improvement over the reconstructed patterns using one ANN. This approach also succeeded to detect the more difficult overlapped MI regions.

CS CamScanner