INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Automated Diagnosis of Cardiac Disorders from Electrocardiogram Signals using Deep Learning

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SHORT ABSTRACT

Cardiac disorders are the leading cause of human mortality worldwide. Most disorders progressively worsen over time; as a result, if left untreated can lead to severe complications such as heart attack and stroke. Therefore, early diagnosis and a better understanding of the disease progression are crucial to timely initiating appropriate treatments that can help prevent further disease progression and severe cardiac events. Widely used by clinicians as a routine modality in hospitals, electrocardiogram (ECG) signals non-invasively capture the heart's electrical activity from the body surface. Therefore, many cardiac electrophysiological abnormalities have a signature on the ECG, and their identification can aid in the early diagnosis of cardiac disorders. In practice, an experienced cardiologist manually examines the morphological changes in ECG to diagnose disorders. Manual examination of enormous amounts of ECG data can be tedious, time-consuming, and prone to human errors. Hence, research on automated ECG interpretation methods is gaining popularity as they can aid in rapid and improved objective clinical decision-making, allowing clinicians to provide timely treatment. This thesis documents our investigations on developing efficient deep learning-based automated methods that can effectively handle the pathological variabilities of single- and 12-lead ECG signals for the reliable diagnosis of various cardiac disorders.

First, a new multi-lead diagnostic attention-based recurrent neural network (MLDA-RNN) architecture is proposed for classifying myocardial infarction (MI) severity stages such as early MI, acute MI, and chronic MI using 12-lead ECG signals. The method systematically processes input 12-lead ECG using lead-specific RNNs and intra- and inter-lead attention layers to effectively encode the clinically relevant 12-lead ECG information for improved MI severity staging. The second work presents an attention-based deep residual RNN (A-DRRNet) to diagnose congestive heart failure (CHF) from single-lead ECG beats. The method incorporates multi-layered RNNs with residual connections followed by an attention module to comprehend the complex pathological ECG changes associated with CHF syndrome. In the third work, a multi-task deep convolutional neural network (MT-DCNN) is investigated as a new robust framework

for accurately estimating the atrial fibrillation (AF) burden (the percentage of the time patient is in AF rhythm) from the long-term ambulatory ECG recordings. This method incorporates ECG reconstruction as an auxiliary task for the primary task of AF detection, which aided in robust AF burden estimation. The estimated daily AF burden demonstrates improved diagnosis and stroke risk assessment in AF patients. Lastly, a novel multi-scale deep temporal CNN ensemble (MS-DTCE) framework is investigated for the simultaneous classification of multiple cardiac disorders such as MI, bundle branch blocks, and hypertrophic cardiomyopathy using 12-lead ECGs. This method effectively handles the disease variabilities by combining diagnosis decisions from several scale-dependent expert classifiers designed using dilated and causal convolutional filters with different receptive fields. Evaluation of the proposed methods on the diverse clinical ECG datasets shows significant improvements over the existing approaches.