ECGNet: Deep Network for Arrhythmia Classification

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Abstract— Cardiac arrhythmias are presently diagnosed by manual interpretation of Electrocardiography (ECG) signals. Automated ECG interpretation is required to perform efficient screening of arrhythmia from long term ECG data. Existing automated ECG interpretation tools however require extensive preprocessing and knowledge to determine relevant features. Thus there is a need for a comprehensive feature extractor and classifier to analyze ECG signals. In this paper, we propose three robust deep neural network (DNN) architectures to perform feature extraction and classification of a given two second ECG signal. The first network is a Convolutional Neural Network (CNN) with multiple kernel sizes, the second network is a Long Short Term Memory (LSTM) network and the third network is a combination of CNN and LSTM based feature extractor, CLSTM network. The proposed networks are end to end networks which can be directly trained without any preprocessing. The networks were trained and tested with the MITDB ECG dataset on three classes Normal (N), Premature Ventricular Contraction (PVC) and Premature Atrial Contraction (PAC). The best model CLSTM gave an accuracy of 97.6%. Further, transfer learning is showcased on the best performing network for use with multiple ECG datasets requiring training only on the final three layers. The results showcase the potential of the network as feature extractor for ECG datasets. Our results outperform the state-of the art works on ECG classification on several metrics.

INTRODUCTION

- Automated detection and classification of arrhythmias would enable early diagnosis using continuous wireless ECG monitoring devices[1].

PRIOR WORKS

- QRS feature extraction based arrhythmia classifier.
- ECG spectrogram transformation and image classifier[2].
- 34-layer CNN network for ECG arrhythmia classifier[3].

PROPOSED MODEL

- Improved CNN to aid in better feature extraction and thus increase the accuracy significantly.
- A novel scheme having a combination of CNN and LSTM to aid in faster convergence and improved accuracy.

ARCHITECTURE

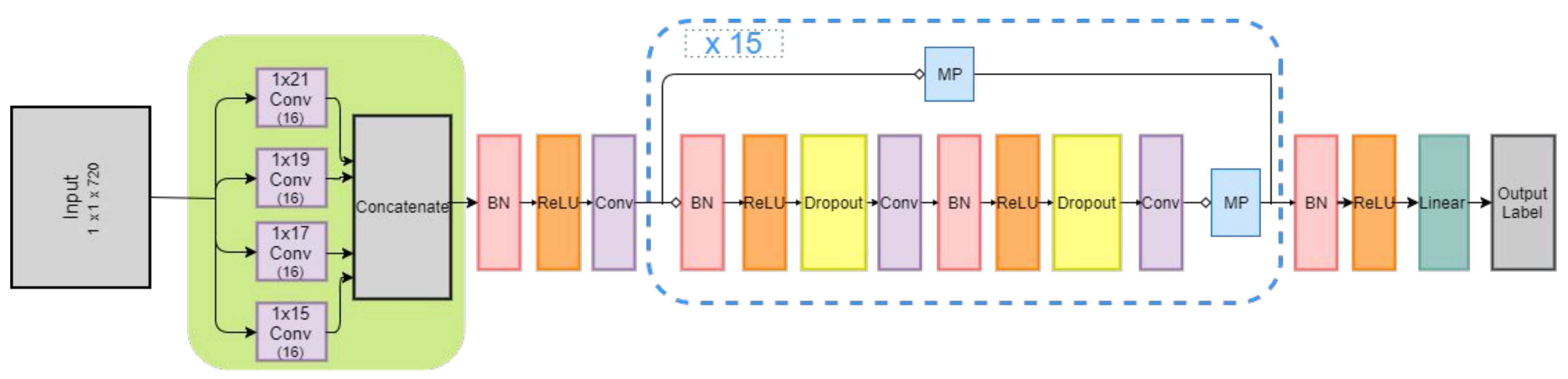

Fig 1: Architecture of the proposed CNN with inception & residual blocks

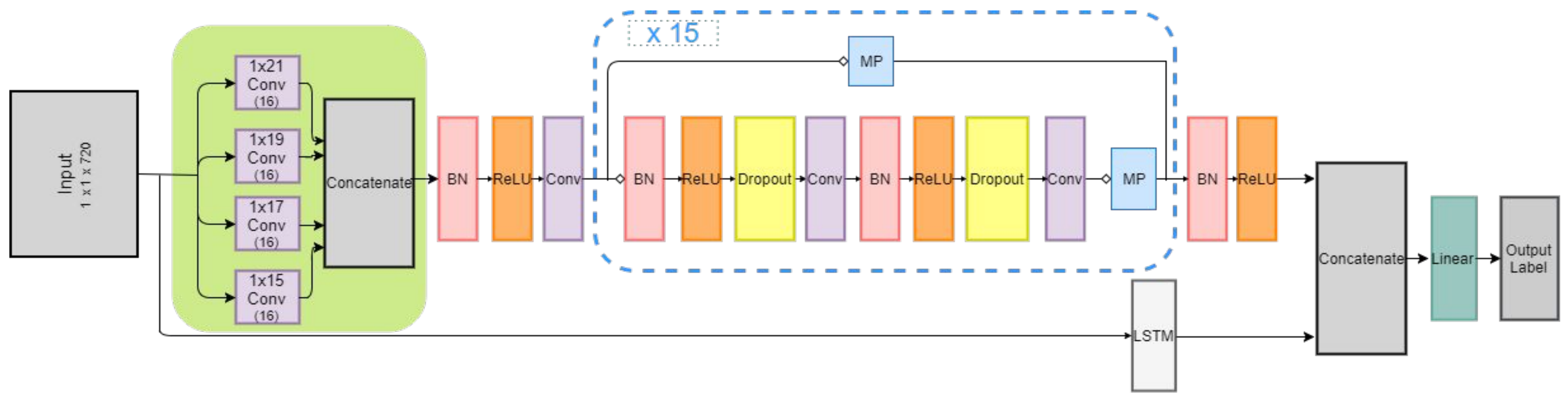

Fig 2: Architecture of the proposed CLSTM network

- Convolution filters of different sizes were used to learn diverse set of features.
- Residual blocks, which take advantage of residual mapping to preserve inputs and prevent vanishing gradient problem.
- LSTM network ensembled with the proposed CNN to increase network performance and enable faster convergence.

DATASET

- This study uses the PAC, PVC and Normal ECG rhythms from the physionet MITDB Arrhythmia database for developing the network.
- The corresponding rhythms in the Lead II ECG was extracted into sections of two second duration.
- Other annotated Lead II datasets such as the LTDB and LTAFDB from Physionet[4] were also used to train and test the model.

Dataset Name	N beats	V Beats	A beats	Total Beats
MITDB	60309	12034	2584	74927
LTDB	20001	5137	0	25138
LTAFDB	30000	1318	14914	46232

Table 1 : Distribution of the datasets used in the study

RESULT

Architecture	Accuracy
LSTM	89.4%
CNN without inception layer	93.4%
CNN with inception layer	95.7%
CLSTM	97.6%

Table 2 : Accuracies of models on MITDB

Class	Precision	Recall	F1-score	Total
Normal	99%	98%	99%	60309
PVC	97%	97%	97%	12034
PAC	75%	96%	84%	2584
Avg	98%	98%	98%	74927

Table 3 : Classification report of CLSTM model

Dataset	Accuracy	
	Pretrained weight	Transfer Learning
LTAFDB	67%	97%
LTDB	80%	98%

Table 4 : Accuracies of alternate datasets

The improved performance of the CLSTM network can be attributed to having features from both and CNN and LSTM.

CONCLUSION

- The model performance was validated with multiple datasets and out of the three proposed models the CLSTM network performed the best.
- In future, we would like to extend the network to classify additional classes of arrythmias.

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