Study of ECG Heartbeat Categorization using Convolutional Neural Networks

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1 Introduction

This report presents the results of my study on ECG heartbeat categorization taken from Kaggle. The data used in this study is from the MIT-BIH Arrhythmia Database. I apply a Convolutional Neural Network (CNN) to classify five types of heartbeats.

2 Data Analysis

The data used in this study is the MIT-BIH Arrhythmia Database. The dataset consists of 5 types of heartbeats: Normal (N), Supraventricular ectopic beats (S), Ventricular ectopic beats (V), Fusion beats (F), and Unknown beats (Q), which are encoded to 0, 1, 2, 3, and 4, respectively. Each sample contains 187 values representing the heartbeat signal.

3 Model Architecture

A Convolutional Neural Network (CNN) model was created to categorize ECG heartbeats. The model incorporates convolutional layers that are especially intended to identify patterns in ECG data. These layers are followed by maximum pooling layers, which minimize dimensionality while increasing the receptive field. Following the convolutional layers, a flattening layer turns the 2D feature maps into a 1D feature vector, followed by dense layers for classification. Dropout layers are used to avoid overfitting.

4 Training

The CNN model was trained using a batch size of 32 for 50 epochs. An Adam optimizer was used with a learning rate of 0.001. To prevent overfitting, early stopping was implemented with a patience of 5 epochs on the validation loss.

5 Evaluation

The performance of the model was assessed using metrics such as loss and accuracy for both the training and validation datasets. Below are the corresponding figures that illustrate the model's learning behavior over the epochs and its classification capabilities as represented by the confusion matrix.

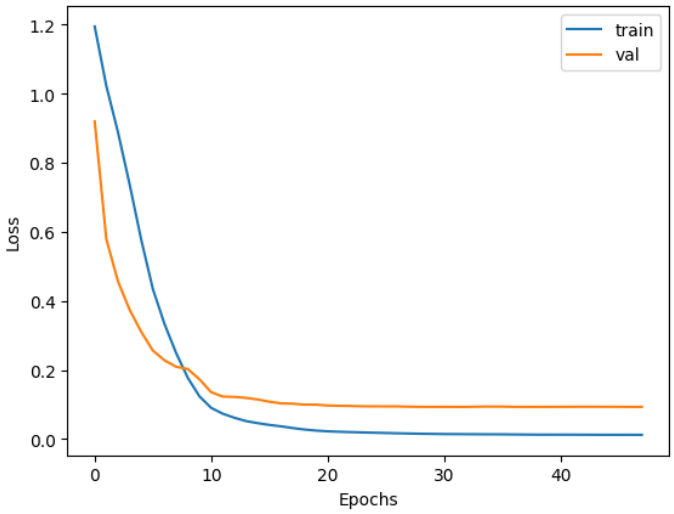

Figure 1: Training and Validation Loss Over Epochs

The confusion matrix demonstrates a high degree of accuracy in the classification of Normal (N) and Unknown (Q) beats, with respective precision and recall values close to 0.99. The matrix reveals some challenges in distinguishing between Supraventricular (S) and Ventricular (V) beats, evidenced by lower recall for S beats. This is indicative of the intrinsic difficulty in differentiating between these types due to their similar ECG signal shapes.

In summary, the model achieved an overall accuracy of 0.99, which is a testament to its effectiveness. The precision-recall balance, as shown by the F1-score, was particularly high for Normal and Unknown beats. Here are the detailed metrics:

The metrics underscore the model's robustness, with high precision and recall across all categories, which indicates reliable performance not only on the most common class but also on less represented classes.

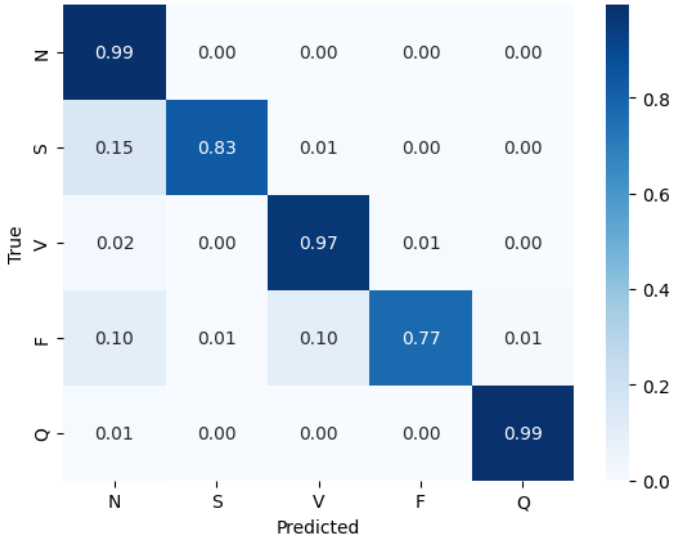

Figure 2: Confusion Matrix for ECG Heartbeat Categorization

Class	Precision	Recall	F1-score	Support
N	0.99	0.99	0.99	14506
S	0.92	0.83	0.88	459
V	0.96	0.97	0.96	1132
F	0.85	0.77	0.81	137
Q	0.99	0.99	0.99	1277
Accuracy			**0.99**	17511
Macro avg	0.94	0.91	0.93	17511
Weighted avg	0.99	0.99	0.99	17511

Table 1: Classification metrics