Non-Invasive Fetal Cardiac Arrhythmia Detection

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1. INTRODUCTION

Fetal cardiac arrhythmias are any irregular fetal cardiac rhythm or regular rhythm at a rate outside the reference range of 100 to 200 beats per minute (bpm). Arrhythmias discovered in about 1% of fetuses, with about 10% of these considered as potential sources of morbidity. Although most fetal arrhythmias are benign, some can cause fetal hydrops and fetal death [1].

The invasive direct fetal electrocardiogram monitors the fetal heart rate variability. This method involves inserting scalp electrode into the woman's cervical opening and attaching it to the baby's head. The direct application of an electrode to the fetal scalp would require adequate cervical dilation and may lead to rupturing of amniotic membranes, which poses a risk of injury to the fetal scalp [2]. Conversely, non-invasive fetal electrocardiography (NI-FECG) performed by placing surface electrodes on the women's abdomen to obtain FECG signals. This approach also offers clinical information to assist in detecting fetal distress, and thus it provides safe and novel diagnostic possibilities for prenatal treatment to arrhythmic fetuses.

1.1 Literature Review

The studies on fetal cardiac arrhythmia detection using NI-FECG as listed in Table 1.

2. MATERIALS AND METHODS

The following are the materials used:

- Non-Invasive Fetal ECG Arrhythmia Database [1]
- 12 arrhythmias and 14 normal rhythm datasets

The following are the methods used:

- Noise and baseline wander removal
- Segmentation
- Multi-Layer Perceptron (MLP)
- 1-Dimensional Convolutional Neural Network (1D CNN)

3. RESULTS

The preprocessed (noise and baseline wander removed) arrhythmias and normal rhythm datasets are segmented into lengths of four FECG beats. In total, 2376-segmented FECGs for each class. The segmented FECG are used to trained and test the baseline MLP and 1D CNN models of various layers. Further, the models experimented on model improvement methods, such as the callbacks, dropout and weight regularization, together with K-fold cross validation and confusion matrix. Overall, 1D CNN model of five layers (with callbacks of patience=30) yielded the best validation accuracy of 94.99% and training accuracy of 94.03% at epoch 35 as shown in Figure 1.

Table 1. The studies on fetal cardiac arrhythmia detection using NI-FECG.

Author/Year	Method	Best Result
Sharma et al., 2021 [3]	2D CNN	96.31 accuracy
Zhong et al., 2018 [4]	1D CNN	91.33% accuracy
Lee et al., 2018 [5]	1D CNN	93.27 % accuracy

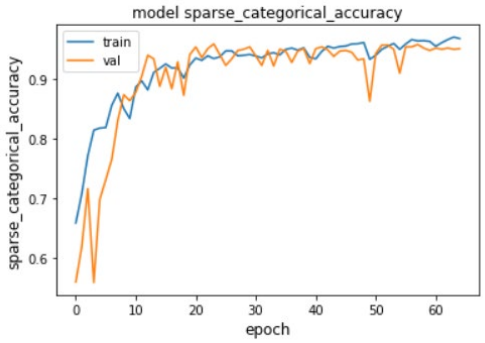

Figure 1. The classification performance of 1D CNN five layers model with callbacks.

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