Human Cardiac Abnormality Detection Using Deep Learning with Heart Sound in Newborn Children

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Abstract

In pediatric healthcare, early detection of cardiovascular diseases in newborns is crucial. Analyzing heart sounds using stethoscopes can be subjective and reliant on physician expertise, potentially leading to delayed diagnosis. There is a need for a simple method that can help even inexperienced doctors detect heart abnormalities without an electrocardiogram or ultrasound. Automated heart sound diagnosis systems can aid clinicians by providing accurate and early detection of abnormal heartbeats. To address this, we developed an intelligent deep-learning model incorporating CNN and LSTM to detect heart abnormalities based on artificial intelligence using heart sound data from stethoscope recordings. Our research achieved a high accuracy rate of 97.8%. Using audio data to introduce advanced models for cardiac abnormalities in children is essential for enhancing early detection and intervention in pediatric cardiovascular healthcare.

Keywords: Heart sound · Deep learning · Artificial Intelligence in cardiology · AI in Diagnosis ·Audio classification.

1. Introduction

Diagnosing heart abnormalities via auscultation, or listening to heart sounds, is a widely adopted non-invasive method by medical professionals [1]. Recent advancements in robust machine learning techniques have displayed potential in automating this process, enhancing its accuracy and reliability. This research endeavor delves into utilizing a convolutional neural network (CNN) and long short-term memory (LSTM) model for detecting heart conditions in children based on recordings of their heart sounds. The model is further fortified by applying Mel Frequency Cepstral Coefficients (MFCC) as a method for feature extraction, enabling the representation of heart sounds.

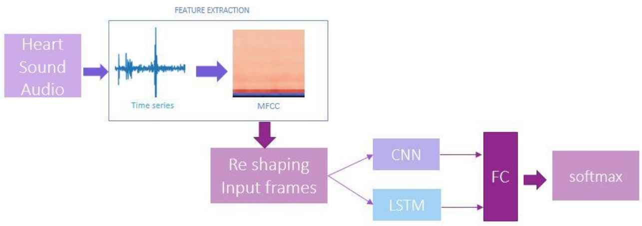
2. Related work

Extensive research on heart sounds often uses PCG signals and deep-learning models like CNN and LSTM. Some studies have used FFT, MFCC, DWT, and STFT as feature extractors. Future work will expand datasets, include additional features, and reference existing research. Most existing papers focus on ECG and PCG signals, but we propose a new approach using raw audio files of heart sounds.

Although adult heart sound models have been introduced briefly, advanced deep-learning models still need to be found in children.

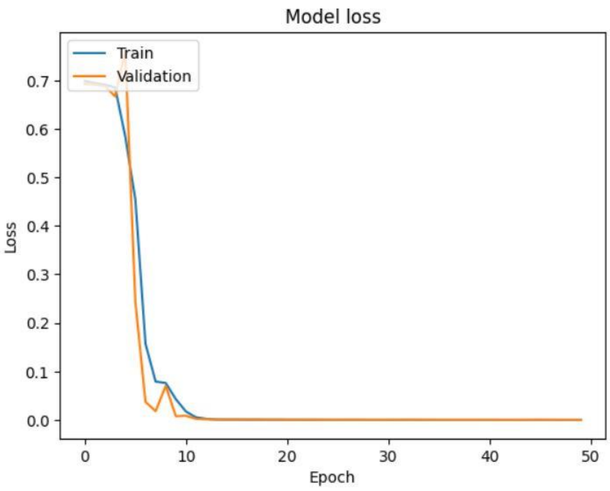
3. Method

Figure 1 shows the architecture to detect the abnormal heart sound based on the artificial intelligence (AI) model. The study utilized publicly available heart sound datasets for research. The process involved collecting all publicly



(Figure 1) Model Diagram.

available datasets related to heart sounds and developing a comprehensive framework. Preprocessing and feature extraction techniques were applied to raw audio files to convert them into time series signals. Mel-frequency cepstral coefficients (MFCC) were used for feature extraction by analyzing the audio's time and frequency data. Subsequently, sound-to-spectrogram images were generated. A deep-learning model was employed, requiring the reshaping of input data into a specific frame size. The model architecture included Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) layers. The initial 2D convolutional layer included 32 filters with a kernel size of 3 and used Rectified Linear Unit (ReLU) activation functions. A max-pooling layer with a pool size of 2 and stride of 2, along with batch normalization, was employed. A subsequent convolutional layer with 64 filters, a kernel size of 3, and a stride of 1 was introduced, along with another max-pooling layer and batch normalization. The subsequent layer was flattened, adding two LSTM layers with 64 and 128 units, respectively, and a dropout layer with a rate of 0.2 to prevent overfitting. Fully connected layers were then incorporated.



(Figure 2) Model loss over 50 epochs.

(Table 1) Result comparison with existing and proposed model.

References	Model	Accuracy(%)
[2]	SVM	94.1%
[3]	ResNet 50	56.8%
Ours	CNN,LSTM	**97.8%**

The model utilized the Adam optimizer for optimization, while the categorical cross-entropy loss function was employed during training. Finally, the model implemented the Softmax activation function with two units for the corresponding classes' output.

4. Results

Figure 2 shows the training and validation loss of our new model plotted over 50 epochs. We noticed a substantial decrease in loss over this period, reaching an optimal range. Our top-performing model achieved a remarkable accuracy of 97.8%, surpassing the performance of existing models, which is presented in Table 1.

5. Conclusion

In this research, we introduced a hybrid CNN-LSTM model for diagnosing heart conditions in children based on heart sound recordings. The model, which uses MFCC as a feature extractor, offers a robust representation of the heart sound signal. By capturing local spatial patterns in the MFCC features, CNN layers, and LSTM layers that capture temporal dependencies, the model proves highly effective at detecting abnormalities in heart sounds. This approach has the potential to revolutionize the accuracy and efficiency of heart disease diagnosis in children, providing a reliable, automated solution for early detection of cardiac conditions.

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