# GR-406

# Federated Learning in Cardiac Diagnostics: Balancing Predictive Accuracy with Data Privacy in Heart Sound Classification

## Abstract

In the pursuit of advancing heart disease diagnostics, our study presents a deep learning model leveraging Federated Learning (FL) for heart sound analysis, with a strong emphasis on data privacy. Training on the Physionet 2016 dataset with 3,240 heart sound recordings, our FL model notably enhances diagnostic accuracy using Federated Averaging (FedAvg), achieving a 69.1% accuracy rate. This approach outstrips traditional methods by ensuring patient data remains decentralized, thereby upholding stringent privacy standards. The FedAvg model's superior recall and specificity further confirm the viability of FL as a privacy-preserving, yet effective, tool for medical diagnostics in cardiovascular care.

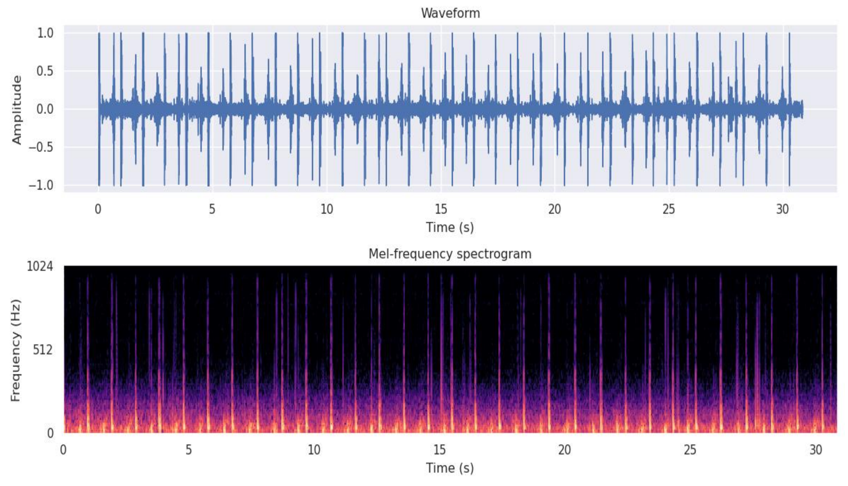


Fig.1(a) Normal PCG

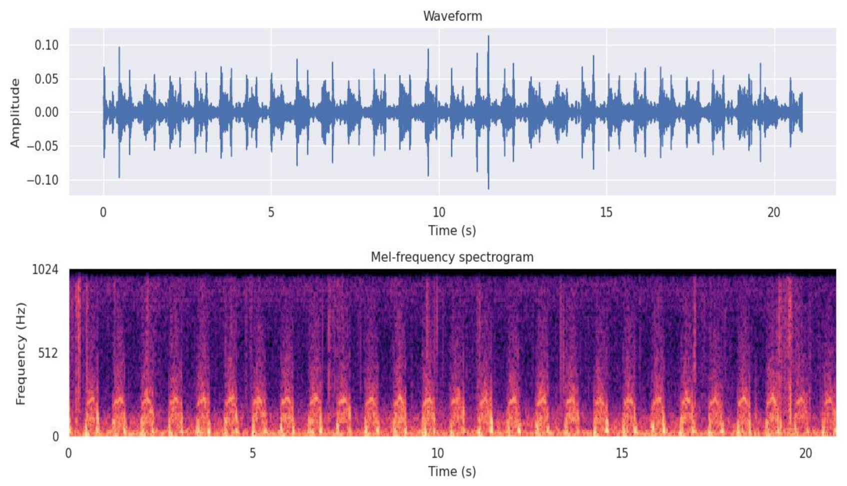


Fig.1(b) Abnormal PCG

## Introduction

Cardiovascular diseases, the leading cause of global mortality with 17.9 million deaths annually, necessitate improved diagnostic tools[1]. Our project employs FL within a deep learning framework, enhancing heart disease detection while adhering to HIPAA and GDPR privacy standards[2]. FL's decentralized analysis of heart sound data ensures patient confidentiality, and our deep learning model capitalizes on this to achieve a notable 69.1% accuracy with FedAvg[5]. This approach mitigates the subjectivity associated with traditional stethoscope examinations, providing a more objective and reliable diagnostic method. The use of FL represents a significant leap in medical diagnostics, combining enhanced accuracy with rigorous privacy protection, and setting a new benchmark for heart disease detection technologies.

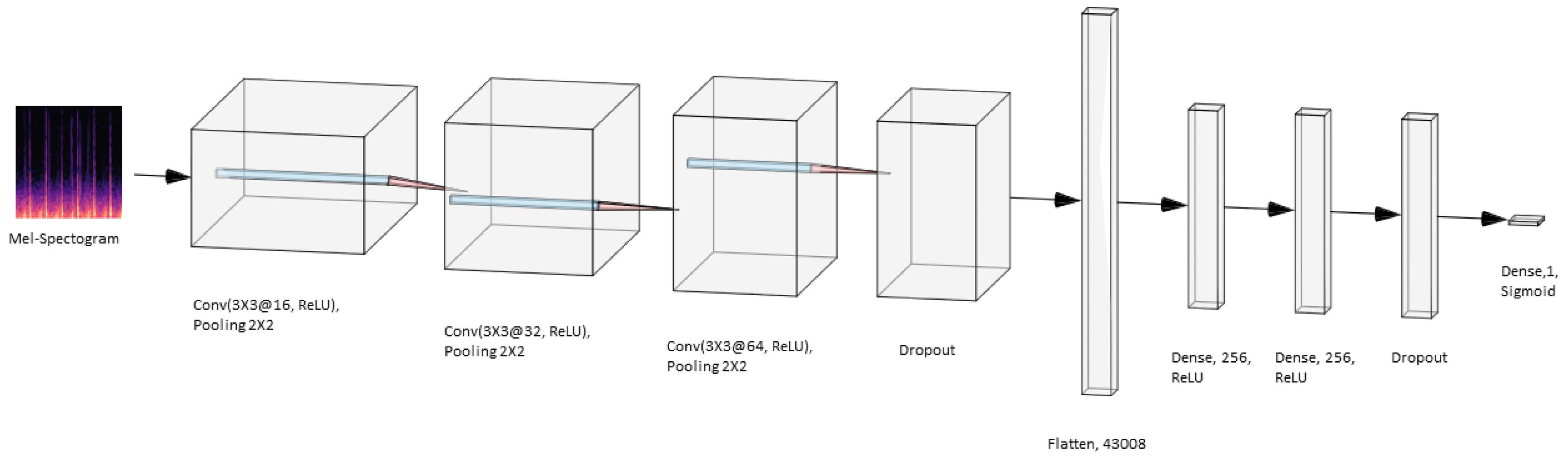


Fig.2 Architecture

## Research Methodology

The deep learning model's architecture consists of a sequential arrangement of layers. The architecture can be seen in Fig.2. It includes –

- Three Conv2D layers with increasing filter counts (16, 32, and 64).
- Three MaxPooling2D layers employed to downsample feature maps.
- Two Dropout layers (0.3 and 0.2 rates) utilized to prevent overfitting.
- A Flatten layer to convert multidimensional feature maps into a 1D vector.
- Two Dense layers with 256 units and ReLU activations.
- The final Dense layer has one unit and a sigmoid activation function.

In our research, federated learning was strategically implemented across five clients to process the Physionet 2016 challenge dataset, containing 3,240 heart sound recordings. Each client was allocated 625 audio files, and through rigorous preprocessing—downsampling to 16 kHz, normalizing, and length standardization—we prepared the data for analysis. Subsequently, we converted these signals into Mel-spectrograms, which then served as inputs to our neural network as shown in Fig. 1. Utilizing FedAvg and Stochastic Gradient Descent (FedSGD) within our federated architecture allowed for localized model training with central updates, ensuring data privacy. This methodology aligns with HIPAA and GDPR, bolstering the security of patient data while achieving enhanced diagnostic accuracy.

## Results

In this study, applying federated learning to heart sound classification yielded varied results as shown in Fig. 3. The FedAvg method outperformed the baseline model with a 69.1% accuracy, a significant improvement over the baseline's 65.4% and FedSGD's 63.4%. This demonstrates the efficacy of FedAvg in handling complex medical datasets. Additionally, the FedAvg model showed better precision (0.695) and recall (0.634), with an F1 Score of 0.663, indicating a balanced and enhanced performance in classification. These results underline the potential of federated learning in improving accuracy and reliability in medical diagnostics.

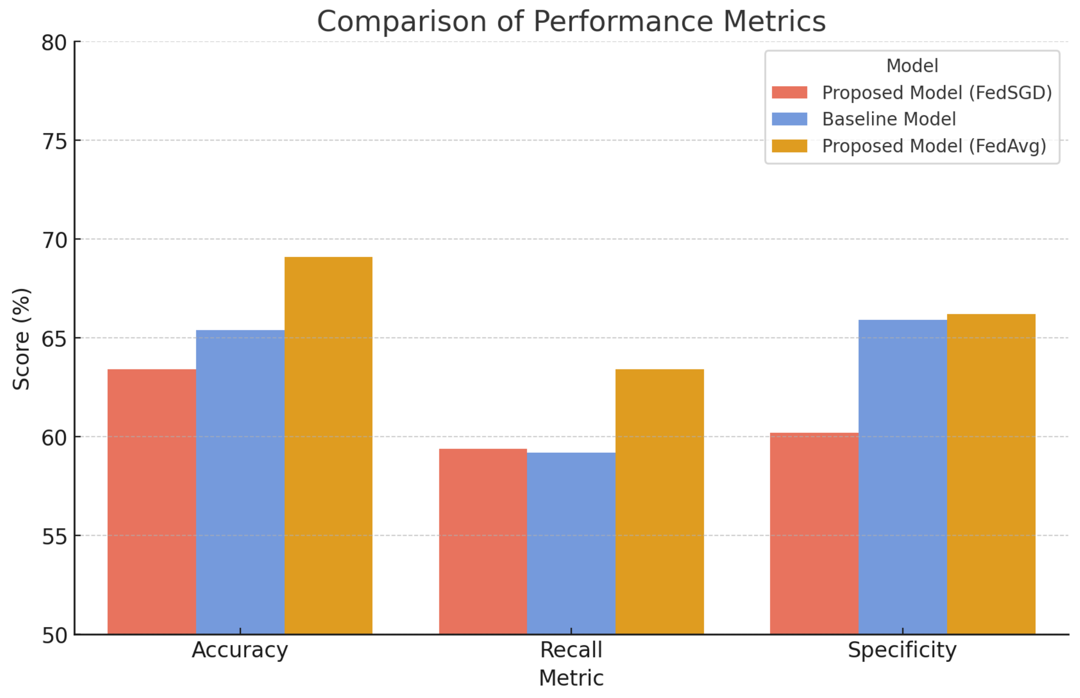


Fig.3 Performance metrics of baseline model vs our model

## Conclusion

This study highlights the potential of FL in addressing cardiovascular diseases through heart sound classification, emphasizing its ability to enhance diagnostic accuracy while maintaining data privacy and security. FL's decentralized training approach aligns with healthcare data regulations like HIPAA and GDPR, mitigating data breach risks. The model demonstrated improved diagnostic accuracy, precision, recall, and F1 Score, marking a step towards more precise and reliable tools for early intervention in cardiovascular care. However, the study also suggests room for further improvement through advanced techniques like feature extraction, data augmentation, or ensemble methods. This research sets a precedent for using machine learning responsibly in healthcare and paves the way for future advancements that combine technology and medical expertise to combat cardiovascular diseases more effectively.

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