Cardiovascular Diagnosis Using Federated Learning

Department of CSE
Jyothi Engineering College
Thrissur

June 9, 2021

Department Mission & Vision

Vision

- **Creating eminent and ethical leaders in the domain of computational sciences through quality professional education with a focus on holistic learning and excellence.**

Mission

- **To create technically competent and ethically conscious graduates in the field of Computer Science & Engineering by encouraging holistic learning and excellence.**
- **To prepare students for careers in Industry, Academia and the Government.**
- **To instill Entrepreneurial Orientation and research motivation among the students of the department**
- **To emerge as a leader in education in the region by encouraging teaching, learning, industry and societal connect.**

OUR TEAM

GROUP MEMBERS

1. **ANN MARIYA (JEC16CS026)**
2. **RAHUL M (JEC16CS092)**
3. **MANEESH MANOJ (JEC17CS063)**
4. **RASHI M (JEC17CS079)**

Guide

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Project Github Repository

github.com/mnshmnu/group18

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Contents

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Introduction

- **According to WHO, Cardiovascular diseases stand as the number one cause of death globally.**
- **Disease identification by Auscultation depends on the expertise of the Physician**
- **Conventional Machine Learning based technologies are not able to achieve the level of accuracy, comparable to a human counterpart due to data-privacy restrictions**
- **Project Abstract**
  - **Uses decentralized, privacy preserving Federated Learning to diagnose and detect abnormalities in cardiovascular system by observing heart sound.**

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Introduction [contd]

The System Aims to:

1. **Privacy oriented approach to conventional Machine Learning**
2. **Implementing Federated Learning in the healthcare sector**
3. **Discovering effective ways to implement Federated Learning technology**

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Literature Papers Reviewed

1. Classification of normal/abnormal heart sound recordings: The physionet-computing in cardiology challenge 2016, Gari D Clifford, Chengyu Liu et.al, 2016
2. Federated machine learning: Concept and applications Qiang Yang, Yang Liu, Tianjian Chen, and Yongxin Tong, 2019
3. Federated learning for healthcare informatics, Jie Xu, Benjamin S Glicksberg et.al, 2020
4. Introduction to federated learning and challenges,Kelvin, 2020
5. Classification of heart sounds using convolutional neural network, Fan Li, Hong Tang et.al, 2020
6. Spectral images based environmental sound classification using cnn with meaningful data augmentation, Zohaib Mushtaq, Shun-Feng Su, and Quoc-Viet Tran, 2020
7. Lung and heart sounds analysis: state-of-the-art and future trends, Ana L Padilla-Ortiz and David Ibarra. 2018

Existing System

- **Base Paper: Classification of Heart Sounds Using CNN**
- **Key Points:**
  1. **Uses CNN to classify PCG signals of heart sound samples**
  2. **Produced 86% validation accuracy in classifying normal vs abnormal heart sounds**
  3. **Single learning entity**

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Proposed system

1. **Federated Learning to diagnose heart conditions**
2. **System includes distributed, collaborative, privacy-preserving deep learning architecture that can perform local training on edge devices**
3. **Uses *labeled heart sound* collected by Electronic Stethoscopes as our training data**
4. **The local inference learned by each model are transferred, in a way they cannot be re-engineered to raw data, to a central server**

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Proposed System [Contd.]

1. **Server efficiently aggregate these inferences to form a globally improved model**
2. **This model is transferred to edge devices to create a personalized model using local data, keeping the local data secured at respective devices**
3. **The model architecture used is Convolutional Neural Network (CNN)**

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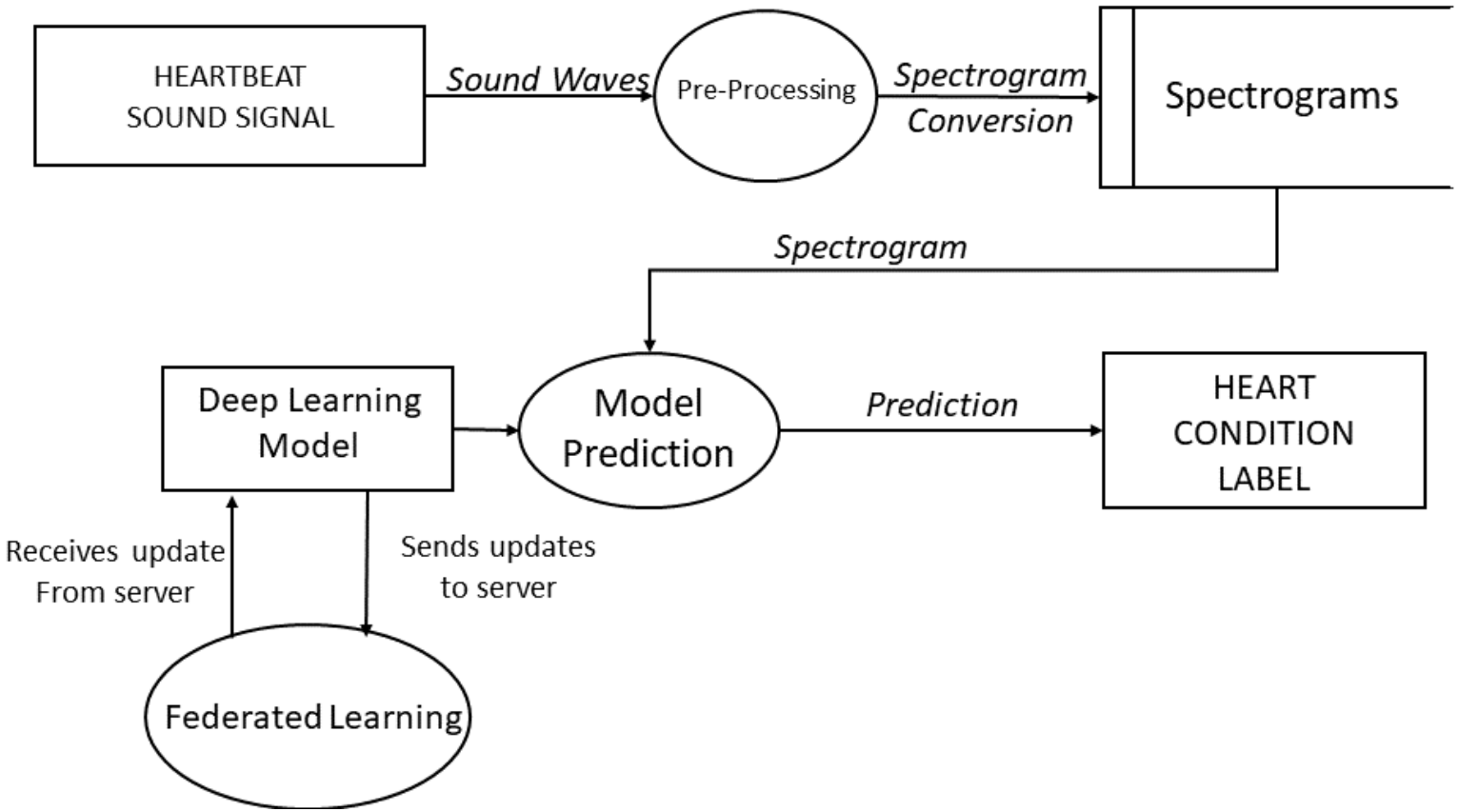
Overall Architecture



Modules

1. **Pre-Processing**
2. **Deep Learning Model**
3. **Federated Architecture**
4. **User Interface**

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Pre-processing

1. **Converting digital audio signal from electronic stethoscope to mel-spectrogram image**
2. **Covert image from RGB to Grayscale**
3. **Resizes the mel-spectrogram image**

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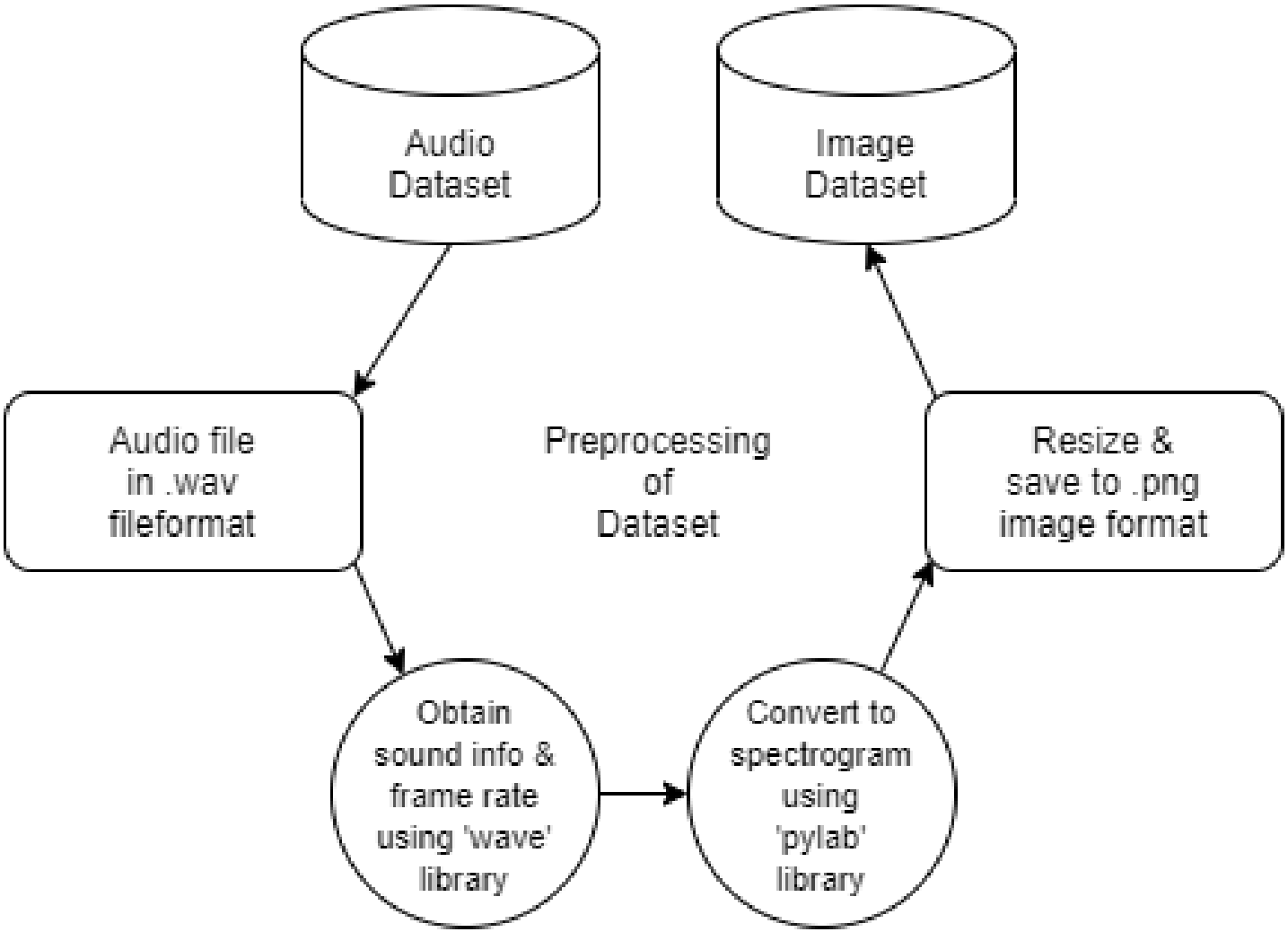
Workflow - Pre-processing



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Deep Learning Model

1. **Model analyses the spectrogram images to predict the heart conditions**
2. **Uses Convolutional Neural Network (CNN)**
3. **Uses PyTorch**

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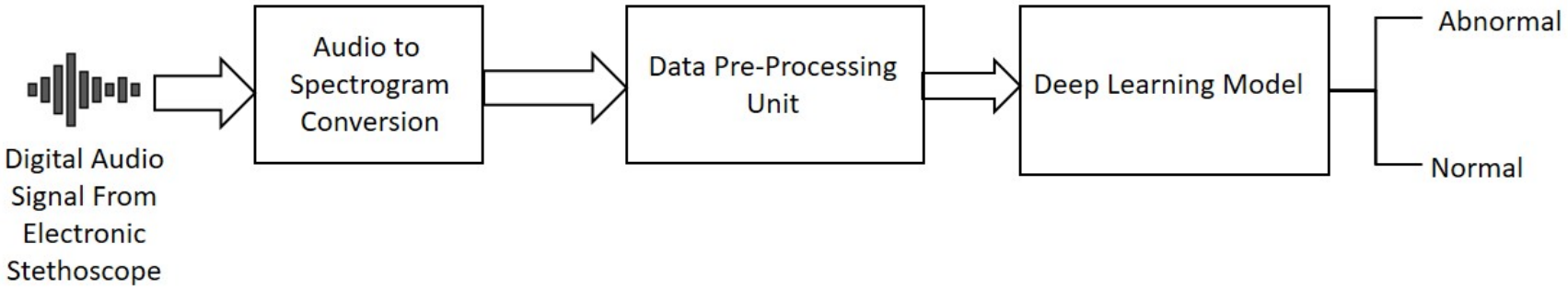
Workflow - Deep Learning model

Software Architecture



Distributed Architecture

Deep Learning Model Architecture

```
model_HeartCNN(
  (Conv2d_1): Conv2d(1, 20, kernel_size=(5, 5), stride=(2, 2))
  (ReLU_1): ReLU()
  (BatchNorm2d_1): BatchNorm2d(20, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (Conv2d_2): Conv2d(20, 20, kernel_size=(5, 5), stride=(2, 2))
  (ReLU_2): ReLU()
  (BatchNorm2d_2): BatchNorm2d(20, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (Flatten_1): Flatten(start_dim=1, end_dim=-1)
  (Linear_4): Linear(in_features=192640, out_features=2, bias=True)
)
```

Figure: **PyTorch Deep Learning Model**

Federated Learning

- **Federated learning is a machine learning technique that trains an algorithm across multiple decentralized edge devices or servers holding local data samples, without exchanging them**
- **Federated learning gives devices the power to learn collaboratively from a shared model**
- **Federated learning allows individual hospitals to benefit from the rich datasets of multiple non-affiliated hospitals without centralizing the data in one place**

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Federated Learning [Contd.]

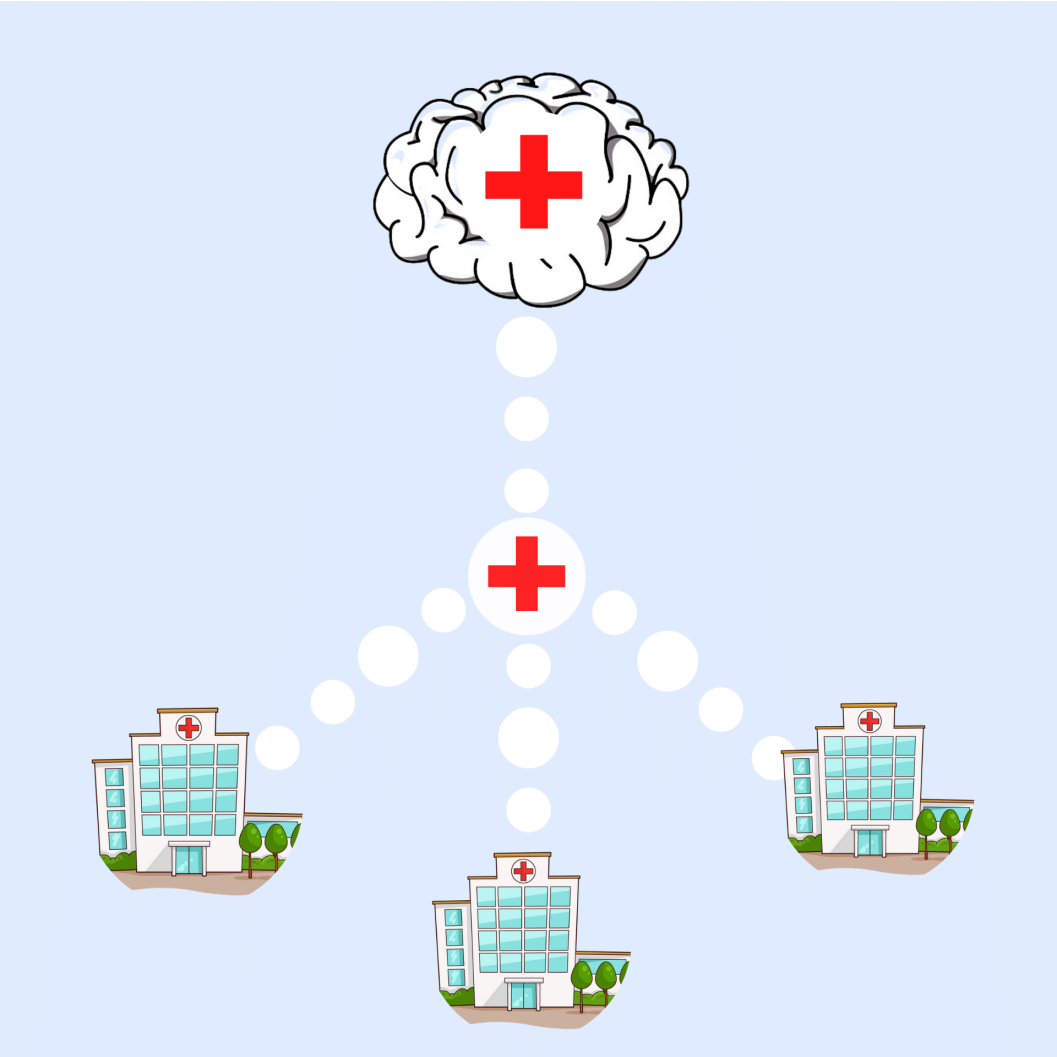

Figure: **Federated Learning**

Implementation - Federated Learning

- **Federated Learning requires a central server to host the central model, execute secure aggregation & register new client devices, for this we use OpenMined PyGrid environment**
- **OpenMined PySyft is an open-source framework for Machine Learning and other computations on decentralized data**
- **PySyft decouples private data from model training, using Federated Learning & Encrypted Computation within the main Deep Learning frameworks like PyTorch**

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Implementation - Federated Learning [Contd.]

- We used Docker to host PyGrid & deployed a PyTorch Deep Learning(DL) model in it
- PySyft was used for facilitating Federated Learning Paradigm such as Secure Aggregation & Client-Server Communication
- Clients train on local data and passes the updated parameters to the Central Server
- We used weighted averaging to aggregate parameter values in the Central Server
- Communication between Central Server and Client devices are secured using RS-256 which consist of RSA & SHA algorithms
- The updated parameters from Central Server is then sent back to Client Models to create a globally improved model

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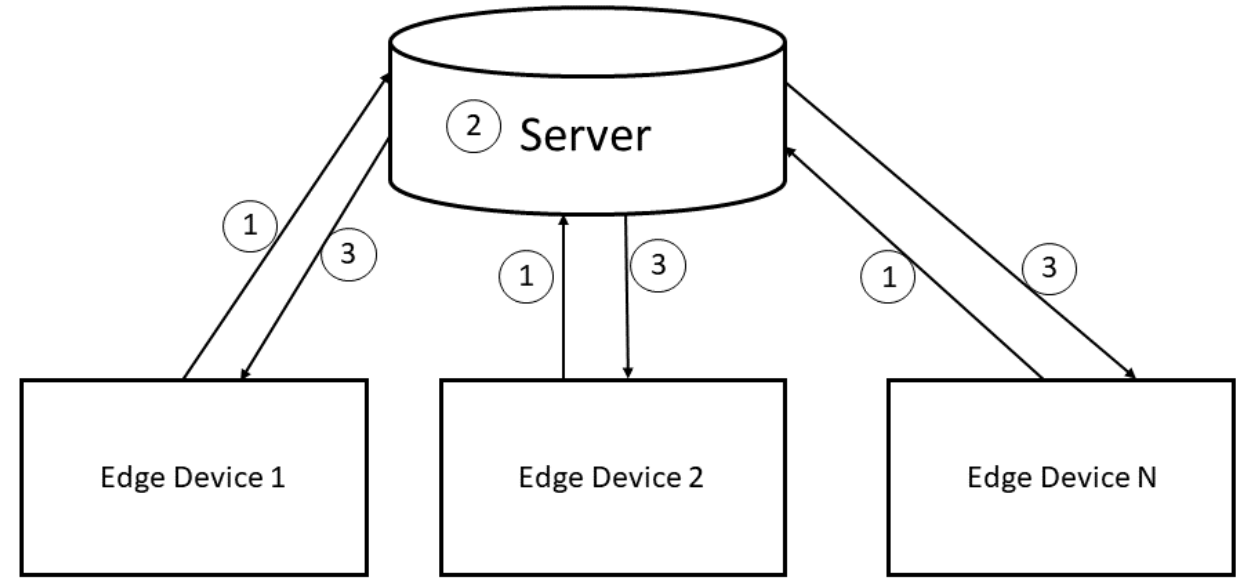
Workflow - Federated Learning



2. Federated Learning Architecture

Figure: **Federated Learning**

User Interface

Developed two User Interfaces:

1. **Web-Application for Doctors:**
   - Enables doctors to use ML model and report patient's condition
   - Flask Application with Web based UI
   - MySQL database
   - Uses Python3, HTML, CSS, JS, SQL
2. **Android Application for Patients:**
   - Enables patient's to view medical conditions, prescription etc.
   - Flutter Application for Android devices
   - Uses Dart

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Output - Pre-processing

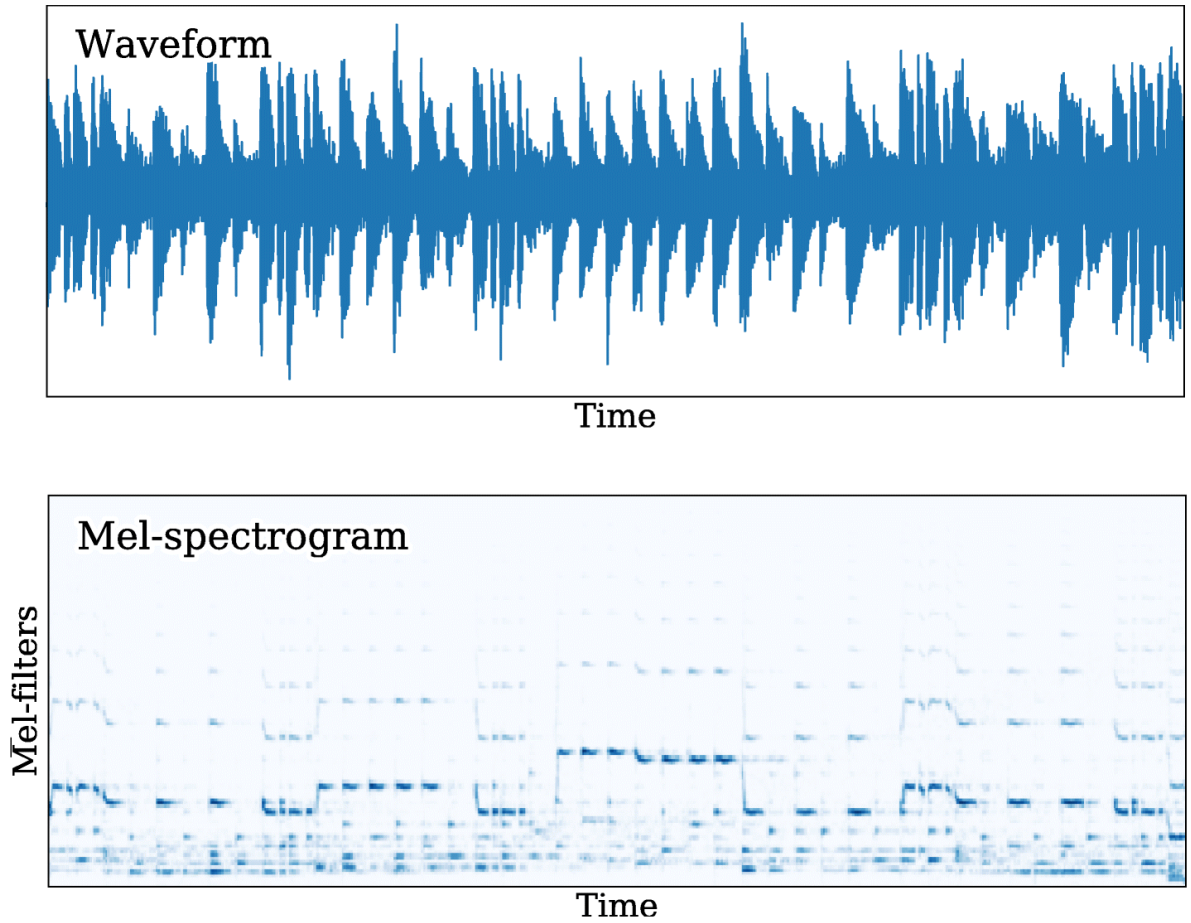

Figure: **Audio signal & generated mel-spectrogram**

Output - Deep Learning Model

```
[11]  1 model = model_HeartCNN()
      2 labels = torch.max(Prediction, 1)
      3
      4 class_list = {0:"Abnormal",1:"Normal"}
      5 output= [class_list[int(k)] for k in list(labels)]
      6 print(output)
```

```
['Abnormal', 'Normal', 'Abnormal', 'Normal', 'Normal', 'Abnormal', 'Normal', 'Abnormal']
```

Figure: **Model Predictions**

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Results & Screenshots

```
1 plotConfusion(model_HeartCNN)
```

```
total correct: 2142
accuracy: 0.5114613180515759
total correct - test: 891
accuracy - test: 0.8510028653295129
Confusion-Matrix: Train--------
 tensor([[1072, 1056],
         [ 990, 1070]], device='cuda:0')
Confusion-Matrix: Test--------
 tensor([[420, 112],
         [ 44, 471]], device='cuda:0')
```

Figure: **Model Metrics: Accuracy**

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Results & Screenshots[Contd.]

```
Test Metrics
Classes -  ['abnormal', 'normal']

Class 0
TP 420, TN 471, FP 112, FN 44
Sensitivity = 0.9051724076271057
Specificity = 0.807890236377716 1

Class 1
TP 471, TN 420, FP 44, FN 112
Sensitivity = 0.807890236377716 1
Specificity = 0.9051724076271057
```

Figure: **Model Metrics: Sensitivity, Specificity**

Results & Screenshots [Contd.]

```
1 plt.figure(figsize=(4,4))
2 plot_confusion_matrix(cm,classes)
```

Confusion matrix

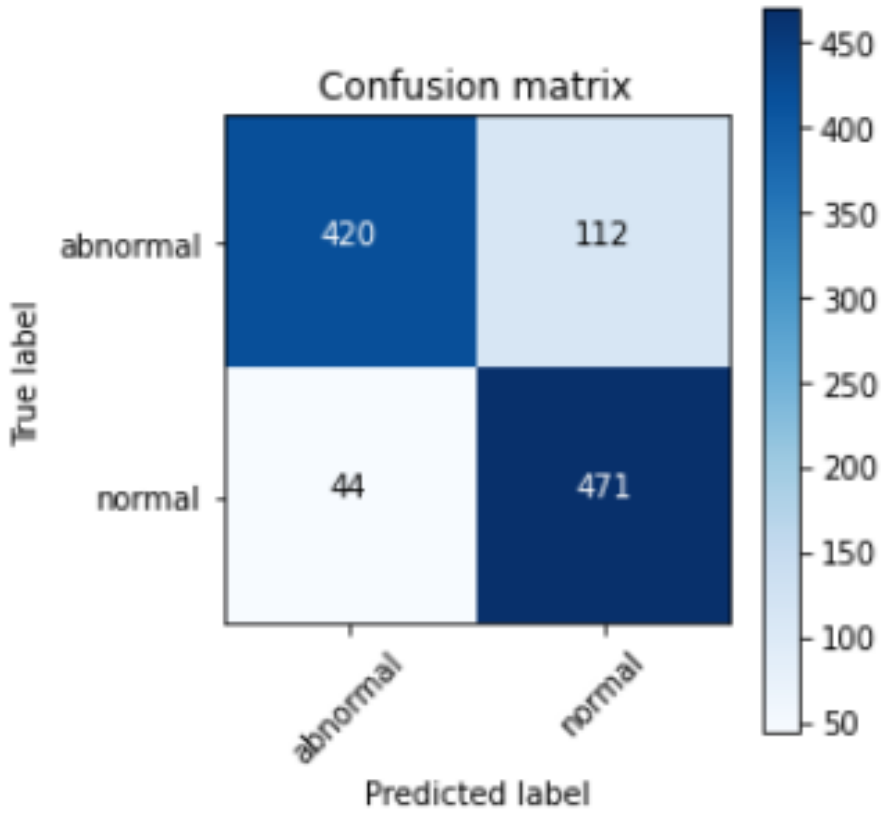

Figure: **Confusion Matrix - Test Dataset**

Results & Screenshots [Contd.]

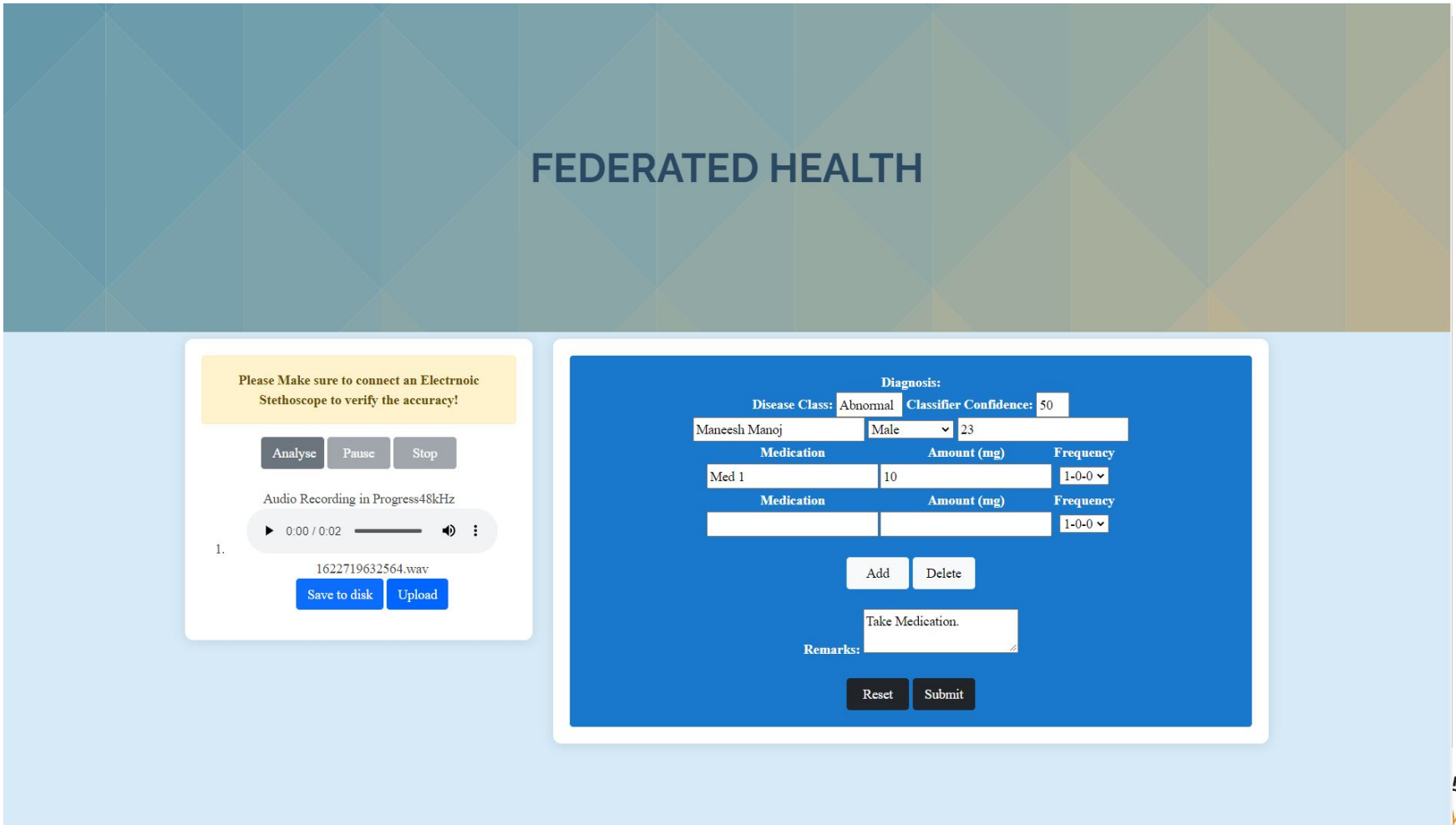

Figure: **Web Application - User Interface**

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Results & Screenshots [Contd.]

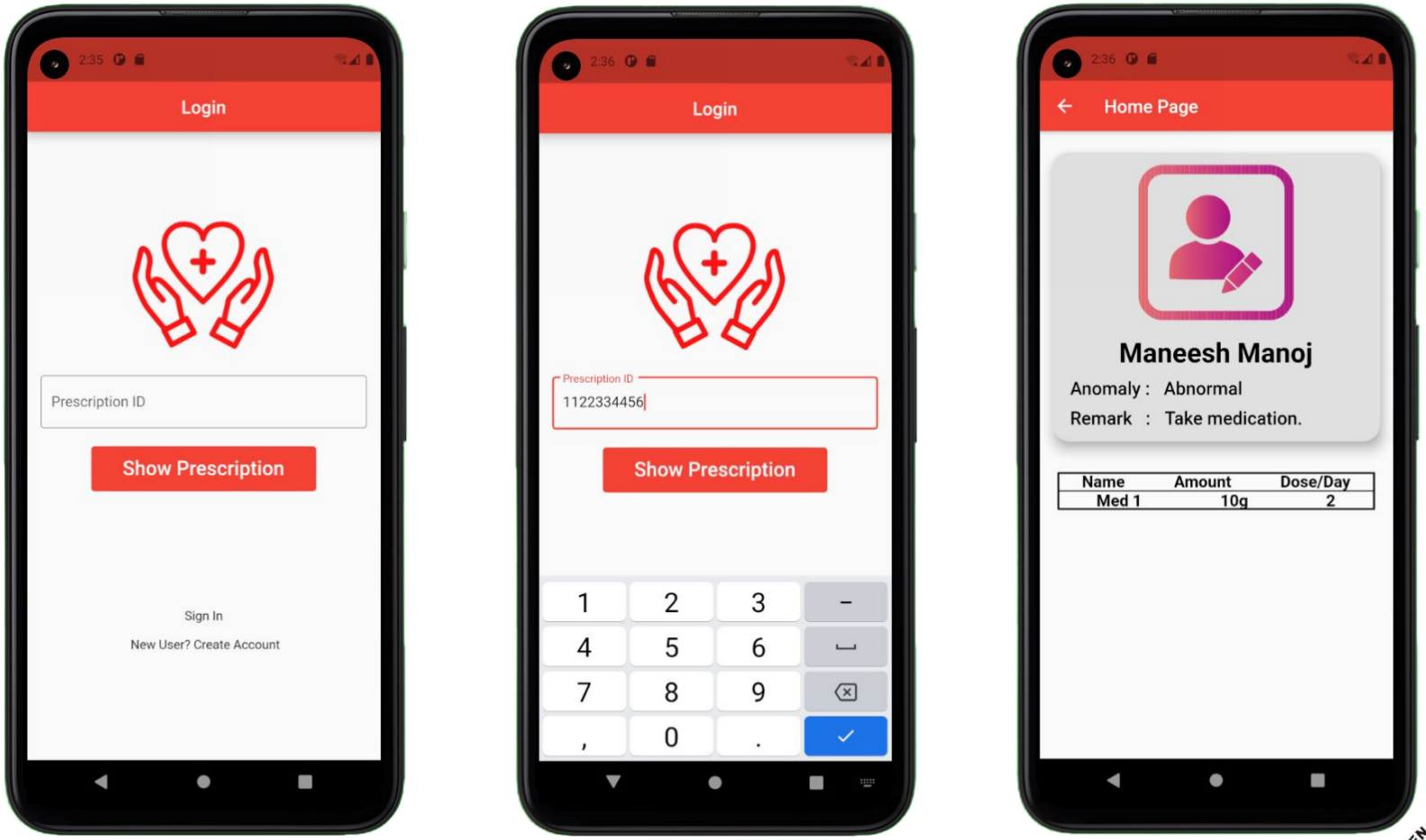

Figure: **Mobile Application - User Interface**

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Future Directions

1. **Improve the performance of the ML model**
2. **Implement a more secure method of saving medical record, like Blockchain**
3. **Deploy the Applications developed**

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CONCLUSION

1. **Created a privacy preserving, collaborative Machine Learning system for Heartbeat sound classification**
2. **Implemented Federated learning on Privacy sensitive Medical domain**
3. **Developed User Interfaces for Doctors & Patients**

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REFERENCES

- Gari D Clifford, Chengyu Liu, Benjamin Moody, David Springer, Ikaro Silva, Qiao Li, andRoger G Mark. `Classification of normal/abnormal heart sound recordings`
- Peter Kairouz, H. Brendan McMahan et. al `Advances and Open Problems in Federated Learning` CoRR, abs/1912.04977, 2019
- Yang, Qiang and Liu, Yang and Chen, Tianjian and Tong, Yongxin `Federated machine learning: Concept and applications`, ACM TIST, abs/1902.04885, 2019
- Li, Fan and Tang, Hong and Shang, Shang and Mathiak, et.al `Classification of Heart Sounds Using Convolutional Neural Network`, Applied Sciences, MDPI
- 2018. [Online]. Available`https://www.tensorflow.org/federated`

Thank You

Any Query?

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