PANIMALAR
ENGINEERING COLLEGE
An Autonomous Institution, Affiliated to Anna University, Chennai
A Christian Minority Institution
(JAISAKTHI EDUCATIONAL TRUST)
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PROGRESS THROUGH KNOWLEDGE

Department of Computer Science and Engineering

DEVELOPING A MACHINE LEARNING DRIVEN CARDIO ACOUSTIC ANALYZER FOR CARDIAC CONDITION DETECTION

Batch: A9

Ananyaa R R [211421104019]
Gayathri V [211421104074]
Likitha R [211421104142]

Guide: Dr. Jackulin C
(Assistant Professor)

Coordinator: Dr. Kavitha Subramani
(Professor)

Abstract

Cardiovascular diseases remain a major global health challenge, requiring early detection for effective treatment and prevention. This project presents an ML-driven heartbeat sound analysis system that utilizes machine learning models (RNN, LSTM, and GRU) to predict heart disease from heartbeat audio recordings. Users are also provided with a user-friendly web interface made of Django framework which helps them easily view, upload the heartbeat audio recordings and a detailed medical insights. A centralized database allows users to store and view their past records, ensuring accessibility and historical tracking.

Introduction

This project leverages machine learning to develop a Django-based web application for heartbeat sound analysis, utilizing RNN, LSTM, and GRU models to classify heart sounds and detect potential cardiac conditions. The model with the highest accuracy is selected and integrated into the frontend for real-time predictions. Users can log in, upload heartbeat audio files, and access their past records through a centralized database. Once an audio file is uploaded, the system processes it and provides detailed medical insights, including disease descriptions, symptoms, effects, dietary recommendations.

Objective of the Project

This project aims to ease the cardiac condition detection by analyzing heartbeat audios using RNN when compared with GRU and LSTM . It extracts key acoustic features, classifies heart sounds, and provides instant diagnostic insights to aid early detection. A Django-based web platform enables seamless audio uploads, real-time classification, and access to past records, ensuring efficient, scalable, and accessible heart health monitoring. By reducing dependence on specialized expertise, this system enhances diagnostic accuracy, speeds up medical assessments, and supports proactive healthcare management.

Literature Survey

S .NO	YEAR	PAPER DETAILS	JOURNAL DETAILS	APPROACH	OUTCOME
1	2024	Z. Ren, Y. Chang, et al. "A Comprehensive Survey on Heart Sound Analysis in the Deep Learning Era"	IEEE Computational Intelligence Magazine Volume: 19 Issue: 3 2024	The paper reviews deep learning techniques for analyzing heart sounds, focusing on signal processing, classification, and addressing data challenges.	Deep learning improves heart sound analysis accuracy but requires better datasets and standardized, interpretable models for broader use.
2	2024	M. F. A. B. Haza, et al. "A Comprehensive Overview of Heart Sound Analysis Using Machine Learning Methods"	IEEE Access Volume: 12	The paper reviews machine learning methods for processing and classifying heart sounds, emphasizing feature extraction and classification algorithms for cardiovascular diagnosis.	Machine learning improves accuracy in heart sound classification, but better datasets and advanced techniquesare needed for more reliable results.

Literature Survey

S .NO	YEAR	PAPER DETAILS	JOURNAL DETAILS	APPROACH	OUTCOME
3	2023	Haobo Zhang et al. "Multi- Feature Decision Fusion Network for Heart Sound Abnormality Detection and Classification"	IEEE journal of biomedical and health informatics volume: 28 Issue: 3 march 2024	A Multi-Feature Decision Fusion Network that integrates various features extracted from heart sound recordings. This network combines multiple decision-making processes to enhance the accuracy and reliability.	The proposed framework demonstrated improved performance in identifying and classifying abnormal heart sounds, contributing to more effective early diagnosis of cardiovascular conditions.
4	2023	Chen, Junxin ,et al. "A Robust Deep Learning Framework Based on Spectrograms for Heart Sound Classification"	Ieee/acm Transactions on computational biology and bioinformatics volume: 21 Issue: 4, july-Aug. 2024	The authors employ a deep learning model that processes heart sound signals transformed into spectrograms, enabling the model to effectively capture temporal and frequency domain features.	The proposed framework demonstrates improved performance in classifying heart sounds, suggesting its potential as a reliable tool for early detection of cardiac conditions.

Literature Survey

S .NO	YEAR	PAPER DETAILS	JOURNAL DETAILS	APPROACH	OUTCOME
5	2024	David susic, et al. "PCGmix: A Data-Augmentation Method for Heart-Sound Classification"	IEEE Journal of Biomedical and Health Informatics Volume: 28 Issue:11 November 2024	A data augmentation technique that generates synthetic heart sound samples by combining segments of existing phonocardiograms to improve training diversity for classification models.	The method enhances the accuracy and robustness of heart sound classification models, enabling better detection of cardiac abnormalities.
6	2021	Xinlin J. Chen, et al."Heart Sound Analysis in Individuals Supported With Left Ventricular Assist Devices"	IEEE Transactions on Biomedical Engineering Volume: 68 Issue: 10 October 2021	The paper analyzes heart sounds of patients with Left Ventricular Assist Devices (LVADs) using advanced signal processing to identify unique acoustic patterns influenced by the device.	The study uncovers distinct acoustic signatures, aiding in non- invasive monitoring of LVAD function and detecting potential complications.

Problem Statement

Early and accurate detection of cardiac conditions is vital for better patient outcomes. Traditional methods rely on clinician expertise, leading to errors, delays, and inefficiencies. To overcome these challenges, this project develops an AI-driven cardiac acoustic analyzer using deep learning and audio signal processing. By leveraging Recurrent Neural Networks (RNNs), the system extracts key features and classifies heart sounds as normal or abnormal, ensuring precise detection. This approach enhances diagnostic accuracy and enables scalable, efficient cardiac health monitoring.

Proposed System

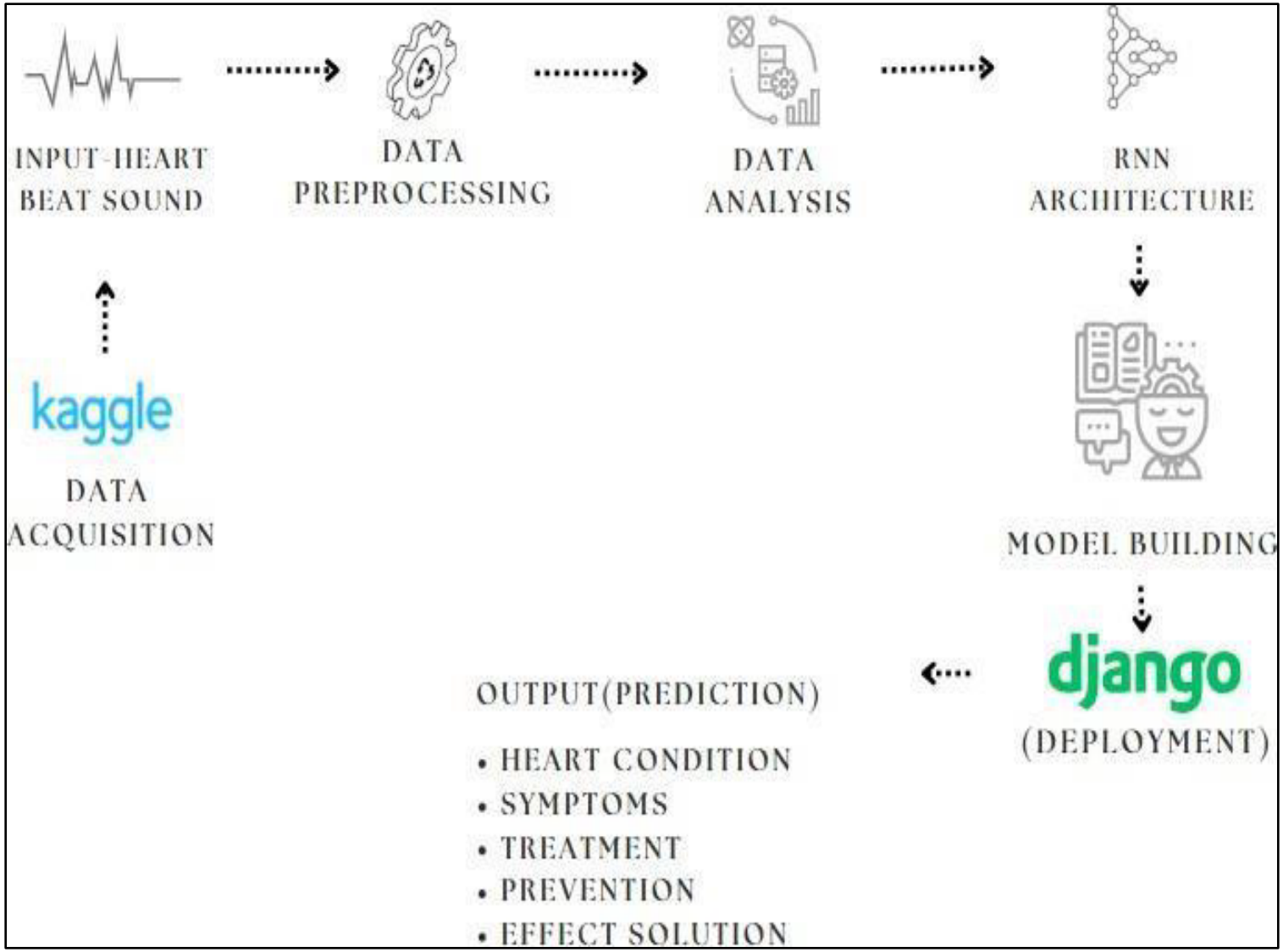
•Utilizes Recurrent Neural Network (RNN) architectures to analyze and classify heartbeat audio signals for medical diagnostics. Processes recorded heartbeat sounds by extracting relevant audio features. Employs a trained RNN model to categorize heartbeat audio signals as normal or abnormal.

•Provides a Django-based interface for users to: seamlessly upload audio recordings , receive instant classification feedback, access a comprehensive database of recorded results. Aims to enhance early detection of heart conditions, improving diagnostic accuracy and patient outcomes.

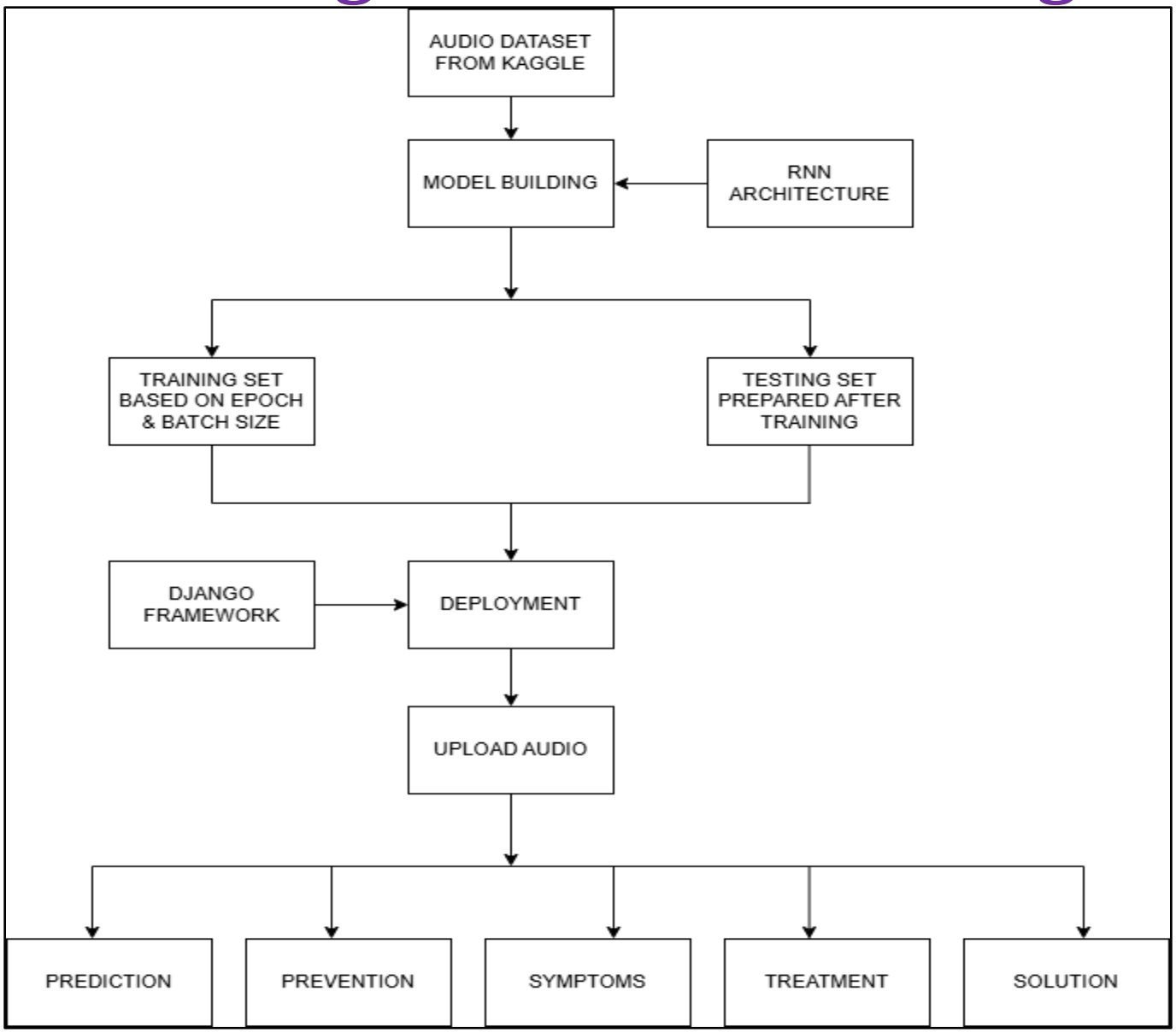
Software / Hardware used

Operating System	Windows
Tool	Anaconda with Jupyter Notebook
Front-End	HTML,CSS,JS
Back-End	Python, Django Framework
Database	SQLite
Core Technology	Machine Learning

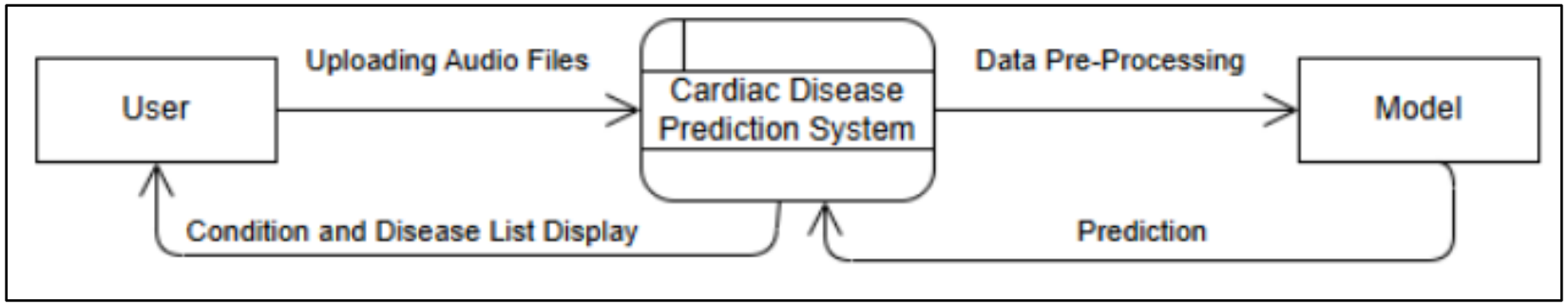
Architecture Diagram



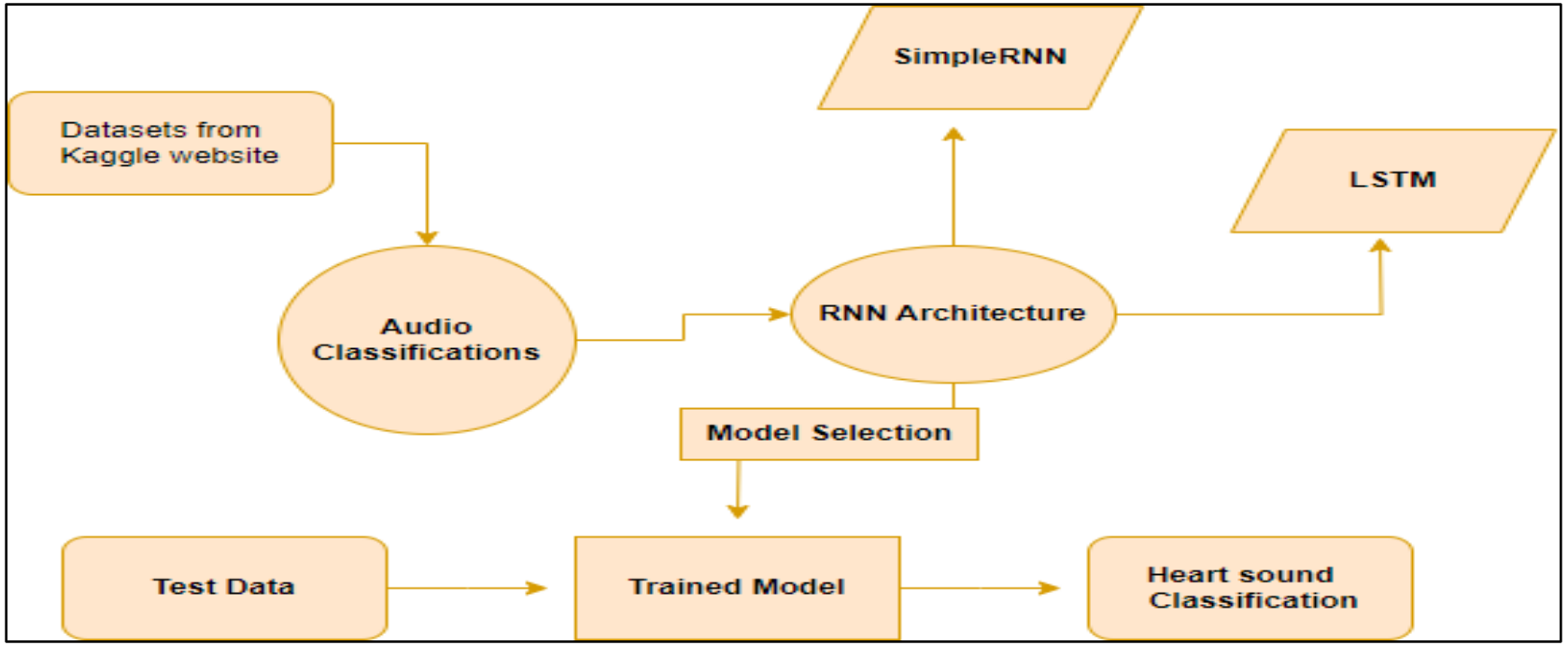
System Design - Flow Chart Diagram



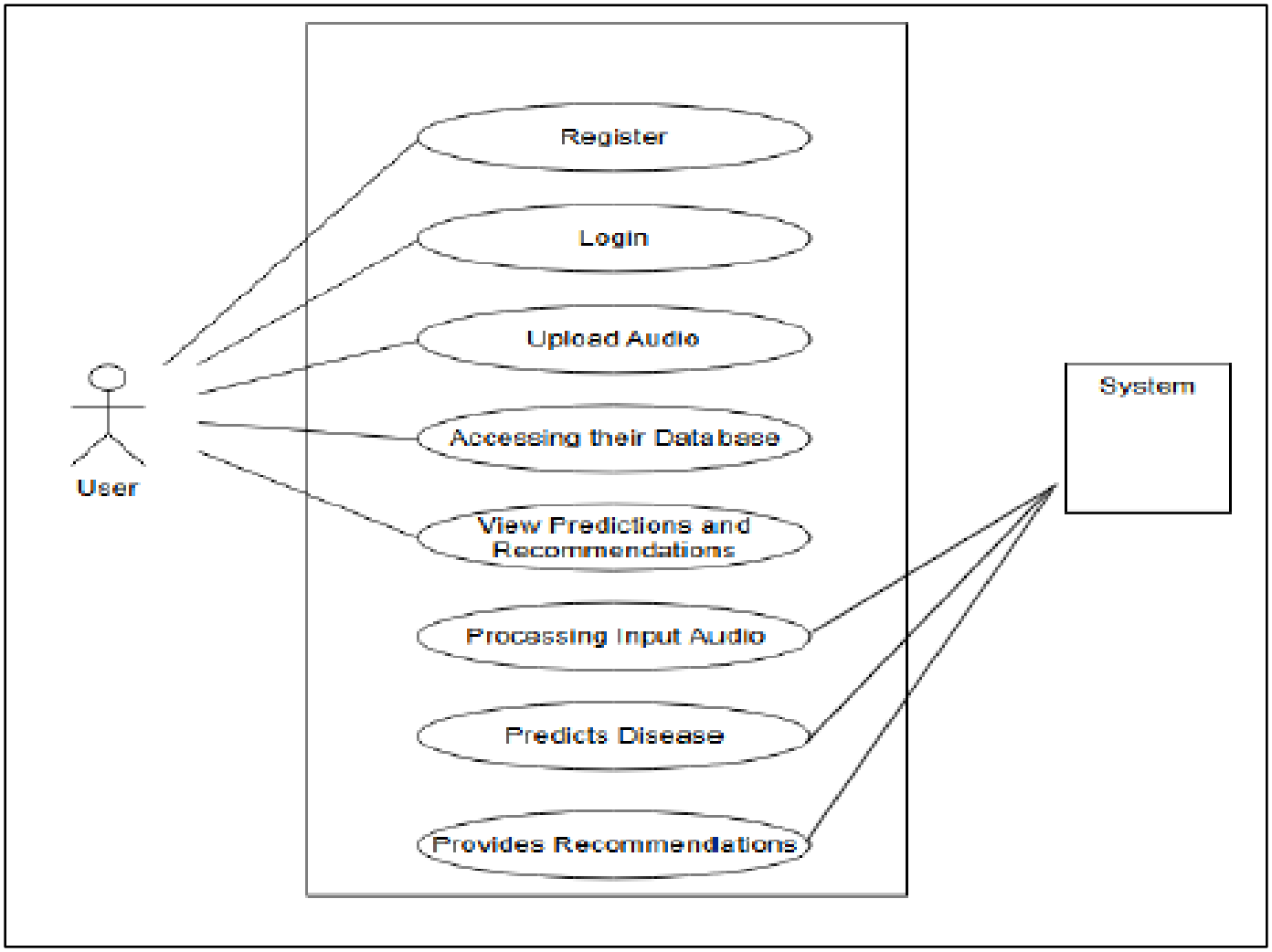
System Design – DFD Level 1 Diagram



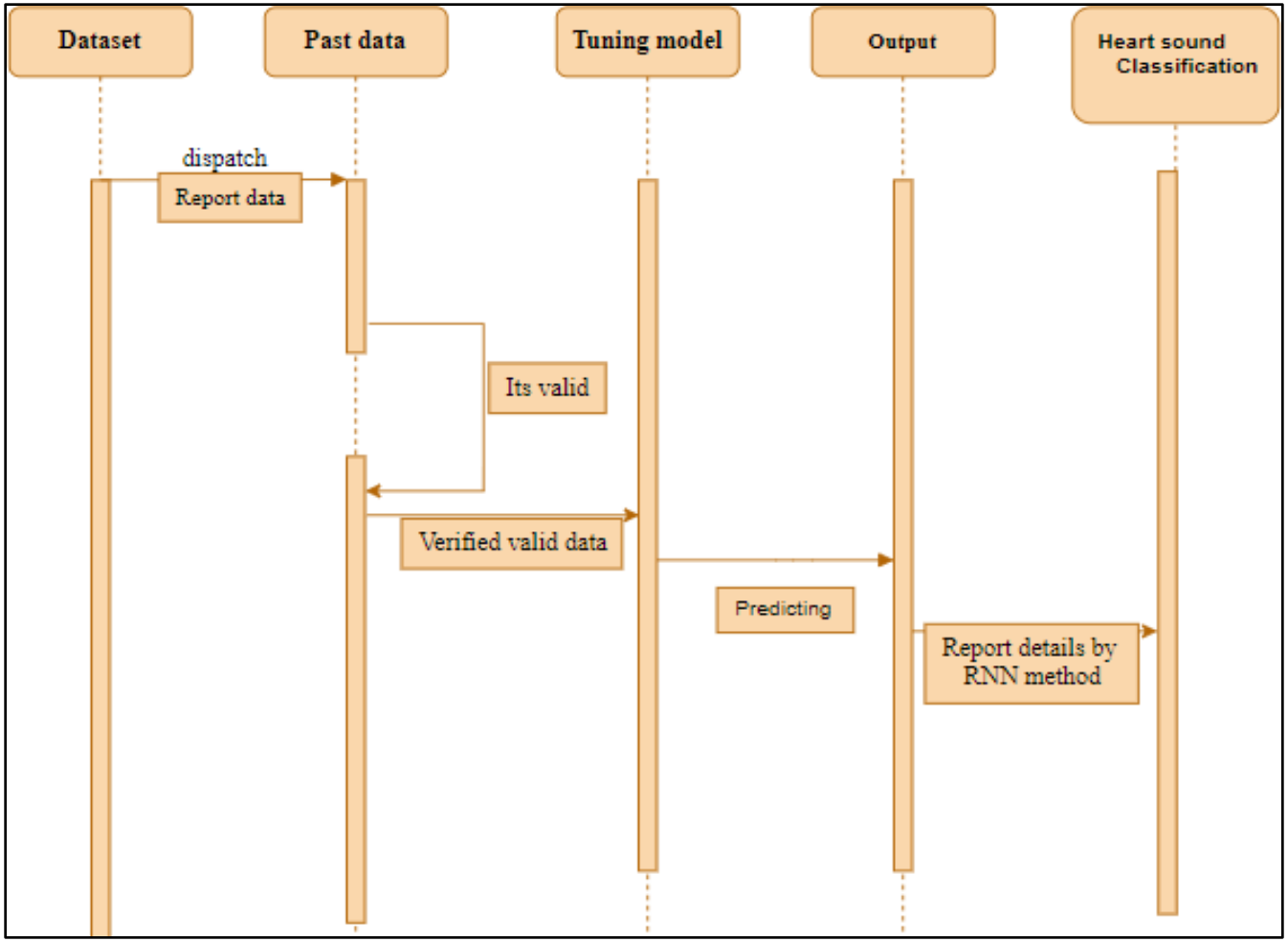
System Design - ER Diagram



System Design – Use Case Diagram



System Design – Sequence Diagram



Module Description-Data Analysis

Data from individuals across different age groups is collected for analysis. The raw audio data is carefully examined to isolate heartbeats while filtering out noise and unwanted signals. Following this, a preprocessing stage enhances the audio quality to ensure clarity and consistency. The refined data is then categorized into different types of heart sounds based on predefined criteria. This training process enhances the model's accuracy in detecting potential cardiac conditions, ultimately contributing to early diagnosis and better medical insights.

Module Description-Simple RNN

RNNs are a type of neural network designed to process sequential data, such as time series, speech, or text. Unlike traditional neural networks, which treat each input independently, RNNs have a memory that allows them to remember previous inputs while processing the current one. This makes them useful for tasks where past information matters, like predicting the next word in a sentence. RNNs can handle variable-length input sequences, making them versatile for real-world data.

Module Description-LSTM

LSTMs are an improved version of RNNs designed to remember important information for a longer time. They achieve this by using gates that control what information should be stored, updated, or forgotten. The forget gate decides which past information should be discarded based on its importance. The input gate determines what new information should be added to the memory. The cell state acts as a long-term storage unit that carries important information across time steps. The output gate regulates what part of the stored information should be passed to the next step.

Module Description-GRU

A Gated Recurrent Unit (GRU) is a type of RNN built to handle sequential data while overcoming the vanishing gradient issue. The GRU process begins with an input sequence, where the reset gate controls how much past information should be discarded. Next, the candidate hidden state is generated using the reset gate's filtered memory and the new input. The update gate then decides the balance between the new candidate state and the previous hidden state, ensuring that only relevant information is retained.

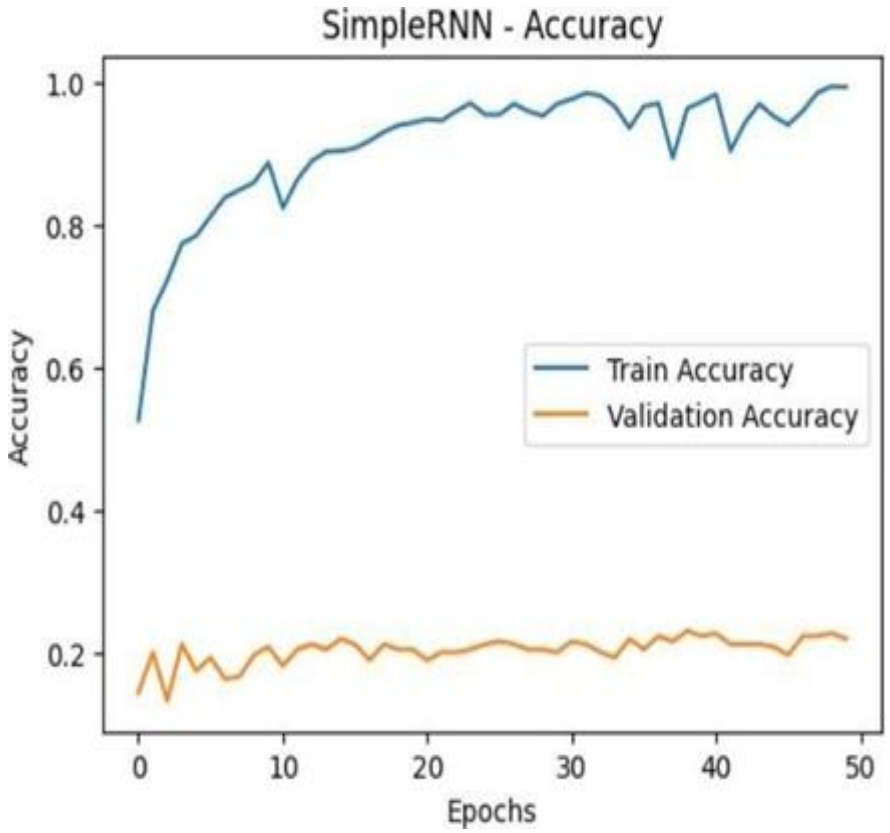
Testing

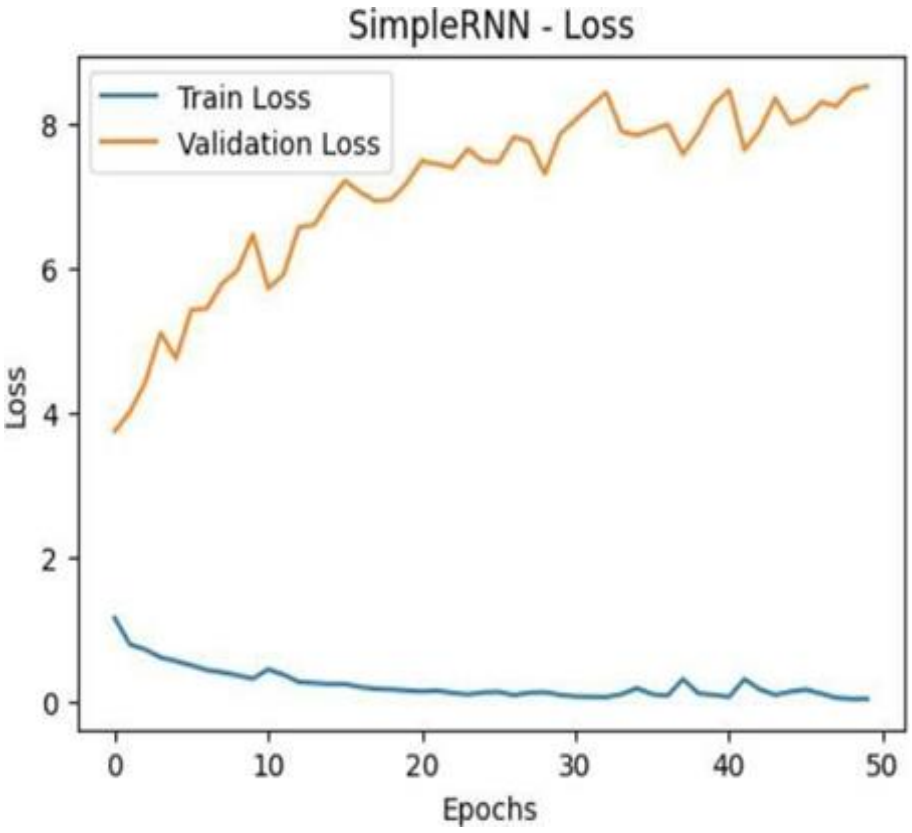
TEST CASE ID	TEST CASE ACTION TO BE PERFORMED	EXPECTED RESULT	ACTUAL RESULT	PASS/FAIL
1	User navigates to the register page and enters valid credentials to register.	User should be successfully registered.	User registred successfully.	Pass
2	User navigates to the login page and enters valid credentials to log in.	User should be successfully logged in and redirected to the home page.	User logged in successfully and redirected to the home page.	Pass
3	On the home page, user clicks the Database button.	User should be redirected to a page displaying their uploaded heartbeat sound files.	User redirected to the database page with uploaded heartbeat sound files.	Pass
4	On the home page, user clicks the Input button.	User should be redirected to a file upload page.	User successfully navigated to the file upload page.	Pass
5	User uploads a valid heartbeat sound file (.wav, .mp3).	File should be uploaded successfully	File uploaded successfully,	Pass

Testing

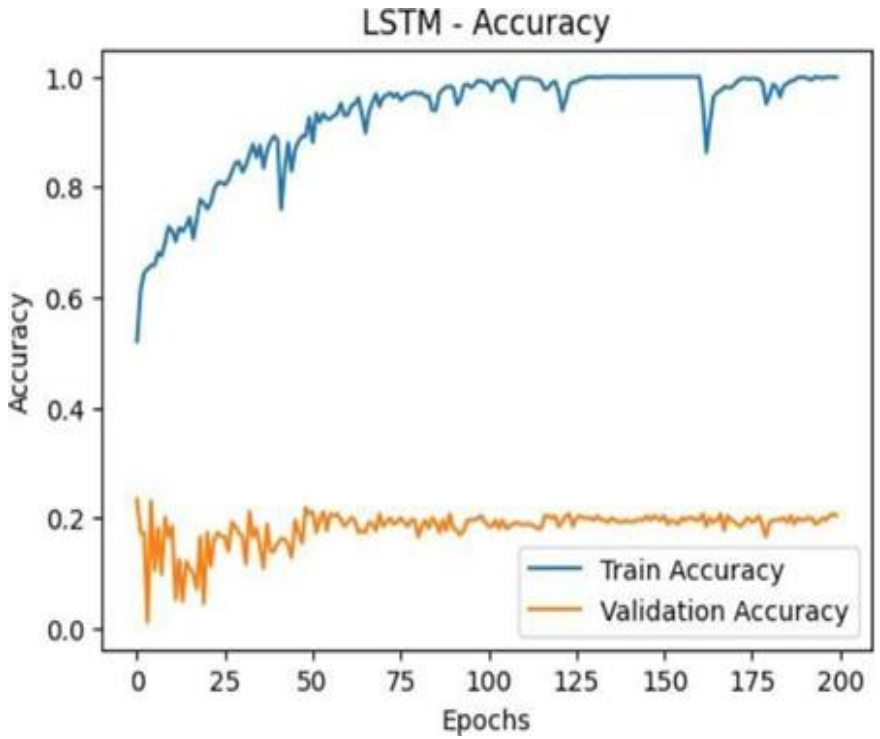
5	After uploading, the system processes the file using highest accuracy model connected to the frontend.	The audio file should be processed by the highest accuracy model.	The file is processed successfully using the highest accuracy model.	Pass
6	System predicts the heart disease based on the given audio file.	Accurate prediction result should be displayed.	Prediction displayed successfully.	Pass
7	System displays disease description, symptoms, effects, dietary recommendations, and physical activity recommendations.	Relevant information based on the prediction should be displayed clearly.	Disease information displayed correctly.	Pass
8	User logs out from the system.	User should be successfully logged out and redirected to the login page.	User logged out successfully and redirected to the login page.	Pass

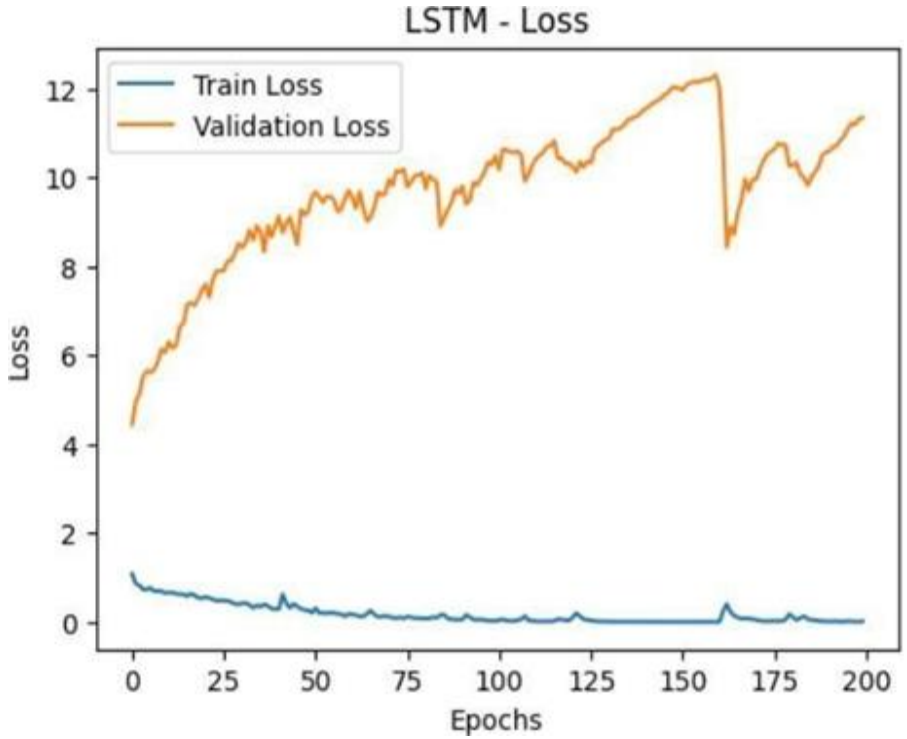
Performance Metrices



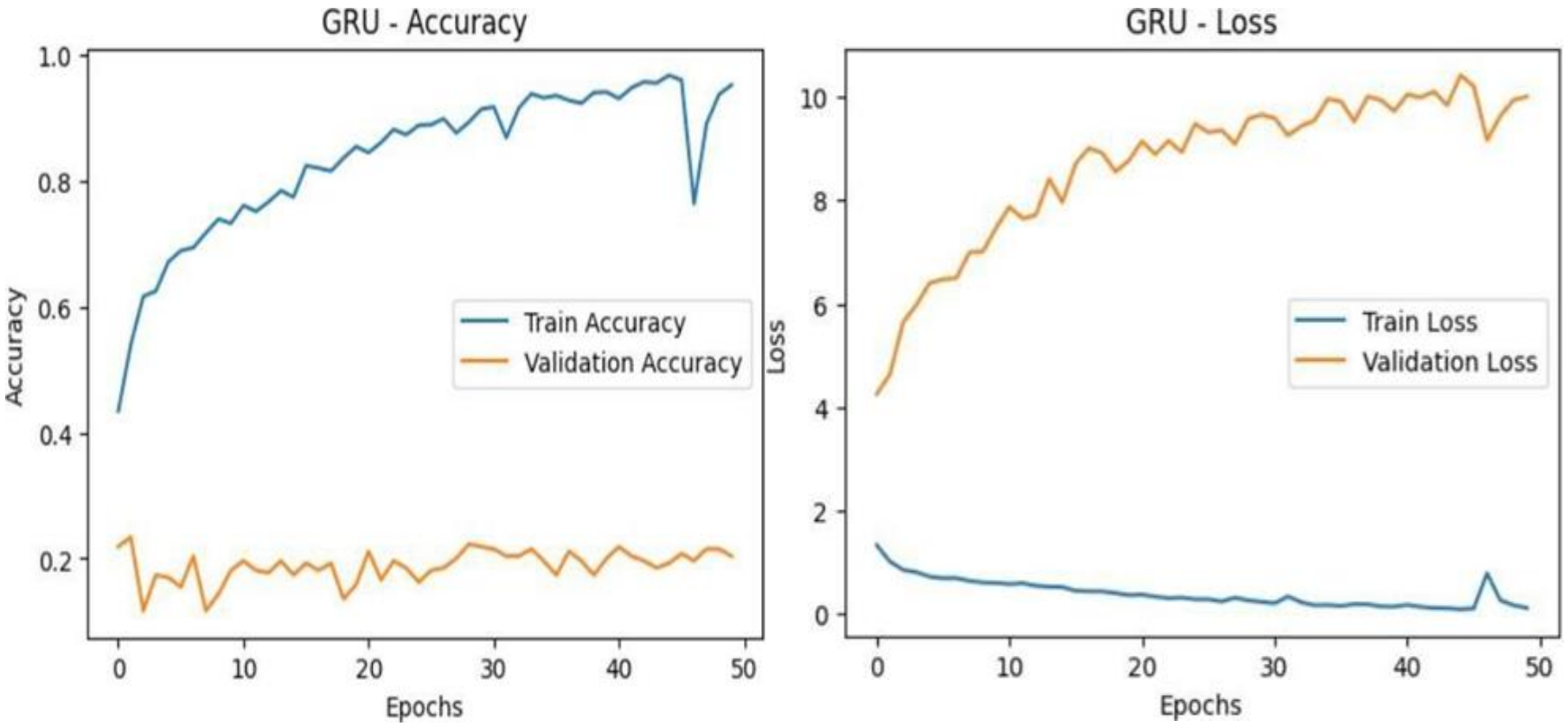


Performance Metrices

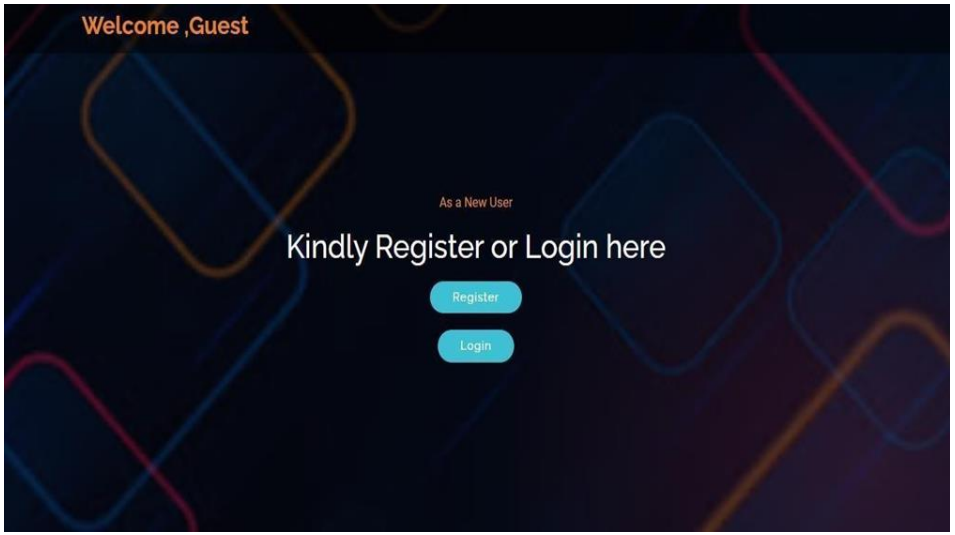


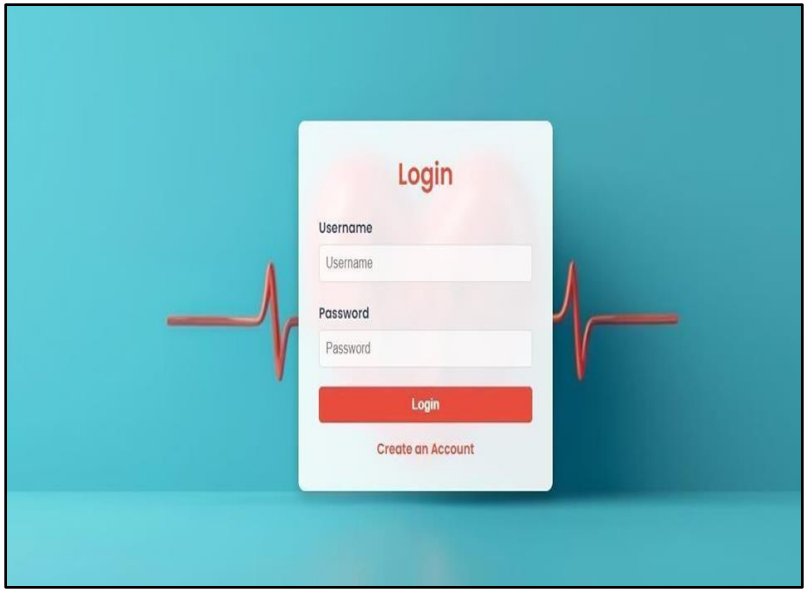


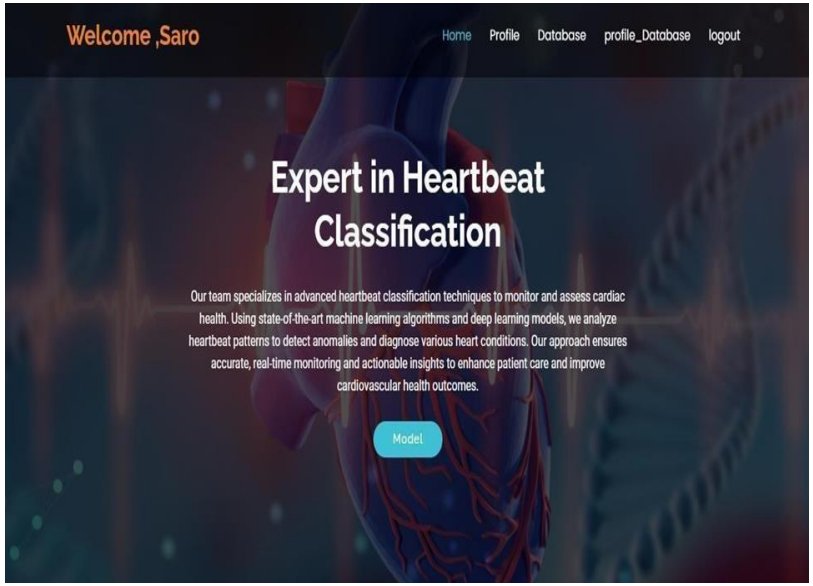
Performance Metrices



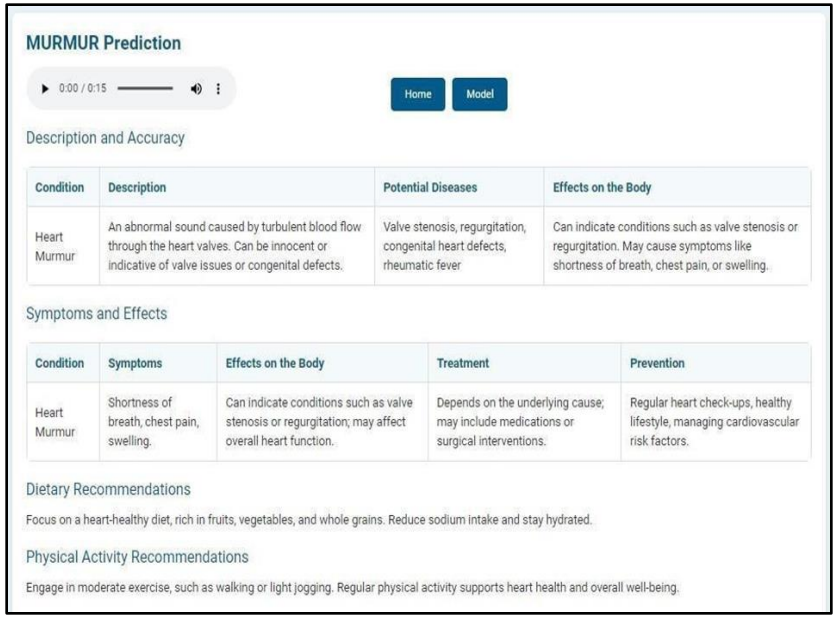
Screen Shots







Screen Shots



MURMUR Prediction

0:00 / 0:15

Home Model

Description and Accuracy

Condition	Description	Potential Diseases	Effects on the Body
Heart Murmur	An abnormal sound caused by turbulent blood flow through the heart valves. Can be innocent or indicative of valve issues or congenital defects.	Valve stenosis, regurgitation, congenital heart defects, rheumatic fever	Can indicate conditions such as valve stenosis or regurgitation. May cause symptoms like shortness of breath, chest pain, or swelling.

Symptoms and Effects

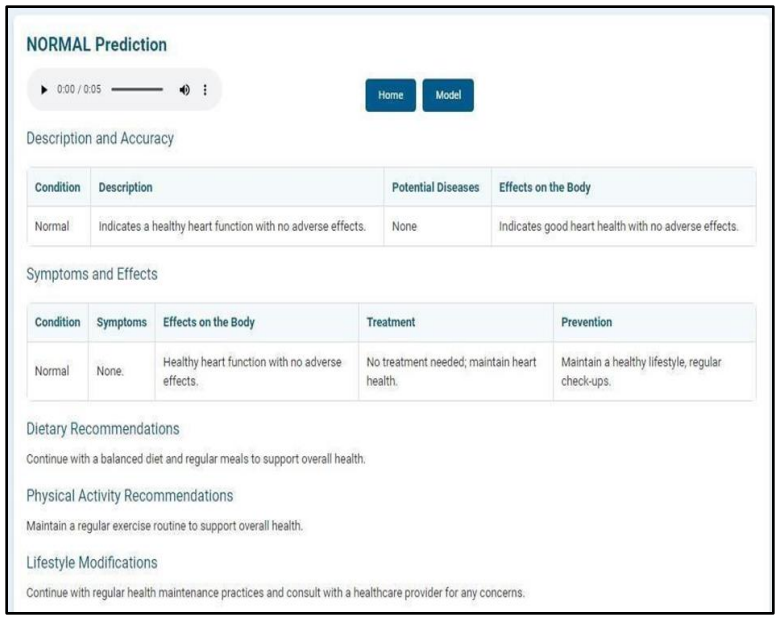
Condition	Symptoms	Effects on the Body	Treatment	Prevention
Heart Murmur	Shortness of breath, chest pain, swelling.	Can indicate conditions such as valve stenosis or regurgitation; may affect overall heart function.	Depends on the underlying cause; may include medications or surgical interventions.	Regular heart check-ups, healthy lifestyle, managing cardiovascular risk factors.

Dietary Recommendations

Focus on a heart-healthy diet, rich in fruits, vegetables, and whole grains. Reduce sodium intake and stay hydrated.

Physical Activity Recommendations

Engage in moderate exercise, such as walking or light jogging. Regular physical activity supports heart health and overall well-being.



NORMAL Prediction

0:00 / 0:05

Home Model

Description and Accuracy

Condition	Description	Potential Diseases	Effects on the Body
Normal	Indicates a healthy heart function with no adverse effects.	None	Indicates good heart health with no adverse effects.

Symptoms and Effects

Condition	Symptoms	Effects on the Body	Treatment	Prevention
Normal	None.	Healthy heart function with no adverse effects.	No treatment needed; maintain heart health.	Maintain a healthy lifestyle, regular check-ups.

Dietary Recommendations

Continue with a balanced diet and regular meals to support overall health.

Physical Activity Recommendations

Maintain a regular exercise routine to support overall health.

Lifestyle Modifications

Continue with regular health maintenance practices and consult with a healthcare provider for any concerns.

Conclusion / Feature Enhancement

CONCLUSION

On comparing LSTM,GRU and RNN architectures for analyzing heartbeat sounds using the Librosa library, RNN demonstrated higher efficiency, leading to its selection for our implementation. The model effectively classified various heartbeat types based on extracted audio features, showcasing the potential of deep learning in biomedical signal processing. Integration with Django provided a seamless interface for users to upload audio files and receive real-time predictions, emphasizing the practical applicability of this research in clinical settings.

Conclusion / Feature Enhancement

FUTURE WORKS

- Develop a hybrid model combining RNN with advanced techniques like attention mechanisms.
- Expand the dataset with diverse heartbeat sounds for better generalization.
- Integrate visualizations for improved interpretability of results.
- Explore wearable device integration for real-time monitoring.

Reference Paper/ URL

[1] Ren, Zhao et al. (2023). ***A Comprehensive Survey on Heart Sound Analysis in the Deep Learning Era***. arXiv preprint. doi: 10.48550/arXiv.2301.09362.

[2] Hamza, M. F. A. B. & Sjarif, N. N. A. (2024). ***A Comprehensive Overview of Heart Sound Analysis Using Machine Learning Methods.*** IEEE Access, vol. 12, pp. 117203. doi: 10.1109/ACCESS.2024.3432309.

[3] Zhang, Haobo & Peng, Zhang & Wang, Zhiwei & Chao, Lianying & Chen, Yuting & Li, Qiang. (2023). ***Multi-Feature Decision Fusion Network for Heart Sound Abnormality Detection and Classification.*** IEEE journal of biomedical and health informatics. PP. 10.1109/JBHI.2023.3307870.

[4]Chen, Jun-xin et al. (2023). ***A Robust Deep Learning Framework Based on Spectrograms for Heart Sound Classification.*** IEEE/ACM Transactions on Computational Biology and Bioinformatics, PP. 1-12. doi: 10.1109/TCBB.2023.3247433.

[5] Susic, D. et al. (2024). *PCGmix: **A Data-Augmentation Method for Heart-Sound Classification***. IEEE Journal of Biomedical and Health Informatics, vol. 28, no. 11, pp. 6874-6885. doi: 10.1109/JBHI.2024.3458430.

[6]Chen, X. J. et al. (2021). ***Heart Sound Analysis in Individuals Supported With Left Ventricular Assist Devices.*** IEEE Transactions on Biomedical Engineering, vol. 68, no. 10, pp. 3009-3018. doi: 10.1109/TBME.2021.3060718.

Conference / Publication / Patent Certificate/ Project Contest Winner Certificates

- Conference Name: International Conference on Computer, Communication and Signal Processing 2025

  Paper ID: 358
- Conference Name: 2025 2nd International Conference on Computing and Data Science (ICCDS)

  Paper ID: 207
- Conference Name: 2025 11th International Conference on Communication and Signal Processing (ICCSP)

  Paper ID: 880