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A Novel Automated Chf Prediction System Through Heartbeat Using Ml Techniques

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ABSTRACT

Detection of Chronic Heart Failure (CHF) is essential for effective intervention and improved patient outcomes. Traditional diagnostic methods, including ECGs and echocardiograms, require specialized equipment and expertise, making them less accessible in resource-limited environments. Modern approach is that an automated CHF detection system leveraging machine learning (ML) techniques, specifically the Random Forest classifier, to analyze heart sound recordings (phonocardiograms - PCG) for easy and simple approach for detecting the CHF risk. This helps the patient to take the required precautions and avoid the risk of the CHF. This project reviews the detection of the CHF risk and helps accurately analyze Heartbeat of a person.

Key Words: CHF, ECG, PCG, Random Forest, Web Interface.

INTRODUCTION

Chronic Heart Failure (CHF) represents a substantial global health concern, underscoring the critical need for prompt and precise identification to facilitate effective treatment strategies and enhance patient outcomes. Traditional diagnostic methods, including electrocardiograms (ECGs) and echocardiograms, are valuable clinical tools. However, their dependence on specialized equipment and skilled personnel can present limitations in terms of accessibility, particularly in environments with limited resources.To overcome these accessibility challenges, there is an increasing focus on harnessing the power of machine learning (ML) methodologies for automated CHF detection. This approach often utilizes readily obtainable physiological signals, such as heart sound recordings (phonocardiograms - PCG), as input data. The application of ML to PCG analysis offers the potential for a non-invasive, economically viable, and easily implementable technique for identifying individuals who may be at risk of developing CHF.The Flask application detailed herein exemplifies this trend, showcasing a system designed to analyze uploaded heart sound audio files using a pre-trained machine learning model. The system aims to categorize these recordings, with the potential to differentiate between normal heart sounds and those indicative of CHF-related anomalies. This endeavor aligns with the overarching objective of creating accessible and user-friendly tools for the early assessment of CHF risk, thereby empowering patients to adopt necessary preventive measures and reducing the likelihood of adverse health events. This project specifically investigates the use of machine learning in the accurate analysis of an individual's heartbeat to support the detection of potential CHF risk.

PROBLEM STATEMENT

The problem statement focuses on the challenges associated with traditional methods of detecting Chronic Heart Failure (CHF) and how machine learning can provide a solution. Traditional diagnostic methods like ECGs and echocardiograms require specialized equipment and expertise, making them inaccessible in resource-limited environments. Additionally, auscultation (listening to heart sounds) relies on a physician's expertise, which can lead to subjectivity and variability in diagnosis. Blood tests and imaging techniques further increase the time and cost associated with diagnosis, complicating early detection. To address these limitations, there is a need for automated and cost-effective CHF detection systems. Machine learning (ML) models offer a promising solution by enabling the analysis of heart sound recordings to accurately and efficiently detect CHF.

MOTIVATION

This project blends Machine learning, signal processing (maybe ECG or EHR data?), and medical domain knowledge. You'll flex your skills in data cleaning, feature extraction, model tuningKey. CHF disproportionately affects older adults and people in low-resource settings. ML can bridge gaps in diagnosis where doctors are scarce or overworked.

Features:

- **Feature Extraction & Preprocessing:** Extracting heart sound features such as MFCCs, RMS Energy, and Spectral Bandwidth to improve classification accuracy.
- **Comparative Model Analysis:** Provides performance evaluation of multiple AI techniques, allowing users to compare model accuracy and reliability for better investment strategies. Testing Random Forest, SVM, CNN, to identify the most accurate CHF detection system.
- **Real-World Applications:** Deploying the system on a web platform that allows users to upload heart sounds and receive CHF risk assessments.
- **Prediction System**: Hosting the trained model on ML for real-time and remote diagnostics.

LITERATURE REVIEW

1. [1]Kalpana Allani, [2]Arella Swamy Prasad, [3]Y Sandhya, [4]Yenamala Devi. Real Time machine learning and end-to-end deep learning for the detection of chronic heart failure from heart sounds. [1]

The study introduces a machine learning and end-to-end deep learning approach for detecting Chronic Heart Failure (CHF) using heart sound recordings. Data from 947 individuals across six public datasets and a newly collected CHF-specific dataset were used for training and evaluation. The system integrates classic machine learning techniques—relying on manually extracted expert features—with deep learning models that utilize spectrotemporal representations of the heart sounds. Notably, the deep learning model achieved an accuracy of 93%, outperforming traditional methods, which reached 90%. A further evaluation using a recording-based model reached an impressive 96% accuracy, showing superiority across key metrics like sensitivity and specificity. The study also identified 15 expert features effective in distinguishing between different CHF phases, with a classification accuracy of 93.2%. These results suggest the system's strong potential for early CHF detection and for future use in real-time, home-based monitoring tools that could help prevent hospitalizations.

2. Sk.Yasmeen, Puvvada Dorasanamma2, Pappu Gayathri2, Natakarani Syamala2, Peddisetty Vyshnavi2(2023). Detection of Chronic Heart Failure using Unified Machine Learning and Deep Learning. [2]

The study presents a comprehensive system for detecting Chronic Heart Failure (CHF) using phonocardiogram (PCG) data by integrating both machine learning (ML) and deep learning (DL) techniques. The approach involves preprocessing heart sound recordings to remove noise, segmenting them into individual heartbeats, and labeling them as normal or indicative of CHF. Mel-Frequency

Cepstral Coefficients (MFCCs) are then extracted from each heartbeat, providing a robust representation of the audio signals. These features are processed through a Convolutional Neural Network (CNN) for deep feature learning, followed by classification using a Random Forest model. The proposed system—referred to as the Average Aggregate Model—achieved a high accuracy of 96.3%, outperforming standalone ML and DL models, which reached 87.6% and 93.9% respectively. Sensitivity and specificity values were also significantly high, making the system effective for early CHF detection. This unified approach demonstrates strong potential for real-time, non-invasive diagnosis of heart failure, improving patient monitoring and outcomes.

3. Shreya Mahajan, Riya Parekh, Rashmi Mokashi (2021). Recognition of Chronic Heart failure using Heartbeat recordings. [3]

The study proposes a hybrid system for the early detection of Chronic Heart Failure (CHF) using heartbeat recordings by integrating machine learning (ML), deep learning (DL), and ensemble learning approaches. Data from the Kaggle and PhysioNet datasets were used, comprising heart sound recordings in .wav format. The ML component involves extracting 20 relevant features using Mel-frequency cepstral coefficients (MFCCs), selecting the most significant ones, and feeding them into classifiers like Random Forest, CatBoost, KNN, and Logistic Regression—achieving a peak accuracy of 98% during training. The DL model converts one-dimensional heart sounds into two-dimensional spectrograms and applies a CNN architecture consisting of multiple convolution, pooling, dropout, and dense layers, with the Adam optimizer and ReLU activation function, reaching up to 92% accuracy. To enhance prediction performance, an ensemble model combines the outputs of both ML and DL models, ultimately boosting the final system accuracy to 93%. The system can not only classify heart sounds as normal or abnormal but also distinguish between CHF phases, offering a valuable tool for early diagnosis and reducing hospitalization rates..

4. Martin Gjoresk, Anton Gradi ek, Borutbudna, Matja Gams (2019). Machine Learning and End-to-End Deep Learning for the Detection of Chronic Heart Failure From Heart Sounds. [4]

The study introduces a robust method for detecting Chronic Heart Failure (CHF) using heart sound recordings by combining classical machine learning (ML) and end-to-end deep learning (DL) techniques. Data were collected from seven datasets, including the authors' own dataset (UKC-JSI) and six from the PhysioNet 2016 Challenge, encompassing 947 recordings. The classic ML approach involved extracting over 3,800 features from each segment and recording using tools like OpenSMILE, followed by feature selection using mutual information, and classification with Random Forest models. In parallel, the deep learning model used a spectro-temporal ResNet architecture to process raw and spectrogram-transformed heart sound signals. Both models produced predictions that were then merged using a recording-based meta-classifier, also trained with Random Forest. The system achieved an overall accuracy of 92.9% and a score of 89.3, outperforming baseline models and most previous state-of-the-art methods. Additionally, the model was capable of distinguishing between compensated and decompensated CHF phases with an accuracy of 93.2% using a simple decision tree and a small set of statistically significant features. These results highlight the system's potential for personalized and early detection of CHF, aiding timely medical intervention and reducing hospitalizations.

5. **Myung-kyung Suh, Lorraine S. Evangelista, Chien-An Chen, Kyungsik Han, Jinha Kang, Michael Kai Tu, Victor Chen, Ani Nahapetian, Majid Sarrafzadeh (2010). An Automated Vital Sign Monitoring System for Congestive Heart Failure Patients. [5]**

The paper presents WANDA, a wireless health monitoring system designed for patients with Congestive Heart Failure (CHF). Recognizing the rising prevalence and high cost of CHF management, WANDA was developed to facilitate remote patient monitoring using sensor technologies and mobile communication. The system is built on a three-tier architecture: the first tier involves Bluetooth-enabled devices such as weight scales, blood pressure monitors, and activity trackers; the second tier comprises web servers that receive and store health data; and the third tier is a back-end database that handles data integrity, analysis, and recovery. Two versions—WANDA B and Mobile WANDA—were implemented. WANDA B targets elderly patients and transmits data through landlines, while Mobile WANDA employs smartphones for real-time data collection, visualization, and feedback. Daily SMS surveys assess symptoms based on the Heart Failure Somatic Awareness Scale. In a small study involving 16 elderly

CHF patients, the system led to improved self-monitoring behaviors, reduced instances of abnormal blood pressure and heart rate readings, and maintained healthier weight levels. Statistical analysis, including paired t-tests, supported the effectiveness of WANDA in enhancing early detection and management of CHF symptoms, thereby reducing hospital readmissions and improving quality of care.

6. William Hawkes, Geoffrey D. Huntley (2023). Automated Echocardiographic Detection of Heart Failure With Preserved Ejection Fraction Using Artificial Intelligence. [6]

This study presents an advanced artificial intelligence (AI) model for detecting Heart Failure with Preserved Ejection Fraction (HFpEF) using only a single apical 4-chamber (A4C) echocardiographic video clip. Researchers developed a 3D convolutional neural network trained on over 7,000 video clips from a dataset of 6,823 patients, including both HFpEF cases and matched controls. The model demonstrated high performance, achieving an AUROC of 0.95 in validation and maintaining sensitivity and specificity of 87.8% and 81.9% respectively in independent testing. Importantly, the model outperformed traditional clinical scoring systems such as HFA-PEFF and H2FPEF by successfully reclassifying over 73% of indeterminate cases. It also demonstrated strong repeatability and reproducibility. This approach has practical value for clinical settings lacking the expertise or time to perform complex diastolic assessments, offering a scalable, non-invasive tool for HFpEF screening. The AI model’s diagnostic accuracy, even with limited data inputs, suggests its potential to significantly enhance early diagnosis and patient management in heart failure care.

EXISTING SYSTEM:

1. Traditional Diagnostic Approaches

- **ECG & Echocardiograms**: Require specialized machines and trained professionals, making them inaccessible in remote areas.
- **Auscultation with a Stethoscope**: Relies on a physician’s expertise, leading to subjectivity and variability in diagnosis.
- **Blood Tests & Imaging**: Additional procedures that increase diagnosis time and cost, making early detection challenging.

2. Current Computational Approaches

- **Rule-Based Systems**: Utilize predefined heart rate thresholds but lack adaptability to individual variations.
- **Machine Learning Models (SVM, Decision Trees, etc.)**: Require feature engineering but may struggle with large-scale variability in heart sound patterns.
- **Deep Learning (CNN & LSTM)**: Have shown high accuracy but require large datasets, significant computational power, and may not generalize well to unseen data.

PROPOSED SYSTEM:

The proposed system presents an automated CHF detection system leveraging machine learning (ML) techniques, specifically the Random Forest classifier, to analyze heart sound recordings (phonocardiograms - PCG). The system extracts temporal and spectral features from heart sounds, such as Mel Frequency Cepstral Coefficients (MFCC), Spectral Contrast, and Zero-Crossing Rate, to distinguish between normal and CHF-affected heartbeats. A Random Forest model, trained on these extracted features, classifies whether a patient is at risk of CHF.The project is deployed as a Flask web application, enabling users to upload heart sound recordings for real-time diagnostic predictions. This approach offers a scalable, accessible, and cost-effective solution for early CHF detection, reducing reliance on expensive diagnostic tools while improving healthcare accessibility, particularly in remote or underprivileged regions. This project introduces an efficient machine learning-based approach using Random Forest for CHF detection. Unlike deep learning models, Random Forest is computationally efficient and performs well with structured features extracted from heart sounds.

METHADOLOGY: CHF prediction system using Machine Learning has 4 modules:

1. Data Preprocessing

- Convert heart sound recordings into **Mel-spectrograms** for feature extraction.
- Apply **noise reduction techniques** to remove background noise.
- Segment **S1 and S2 heartbeats** using signal processing techniques for better feature representation.

2. Feature Extraction

- Extract **MFCC (Mel Frequency Cepstral Coefficients)**, which capture key frequency-based patterns in heart sounds.
- Compute **Spectral Contrast & Zero-Crossing Rate** to analyze heartbeat irregularities.
- Use **Short-Time Fourier Transform (STFT)** for capturing frequency variations over time.

3. Model Training & Classification

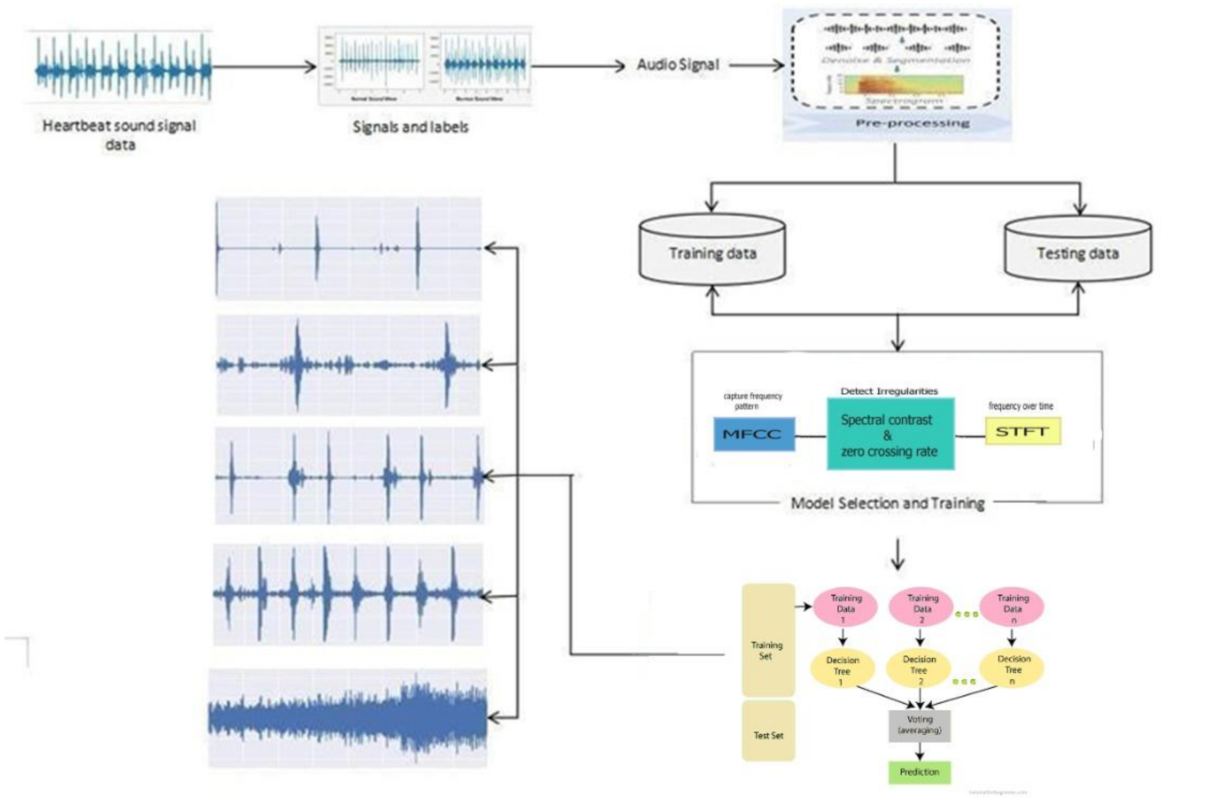
- Train a **Random Forest classifier** on extracted features.
- Random Forest combines multiple decision trees, reducing overfitting and improving accuracy for structured feature-based classification.
- The model predicts whether a given heart sound is **normal or indicative of CHF** based on extracted patterns.

4. Flask-Based Web Application

- Users can upload **heart sound recordings (.wav files)** for real-time analysis.
- The system extracts features, processes the input, and runs the prediction using the trained **Random Forest model**.

- The web interface displays **CHF risk assessment results** along with a probability score for better decision-making.

SYSTEM ARCHITECTURE



Evaluation of random forest algorithm

RESULTS & ANALYSIS

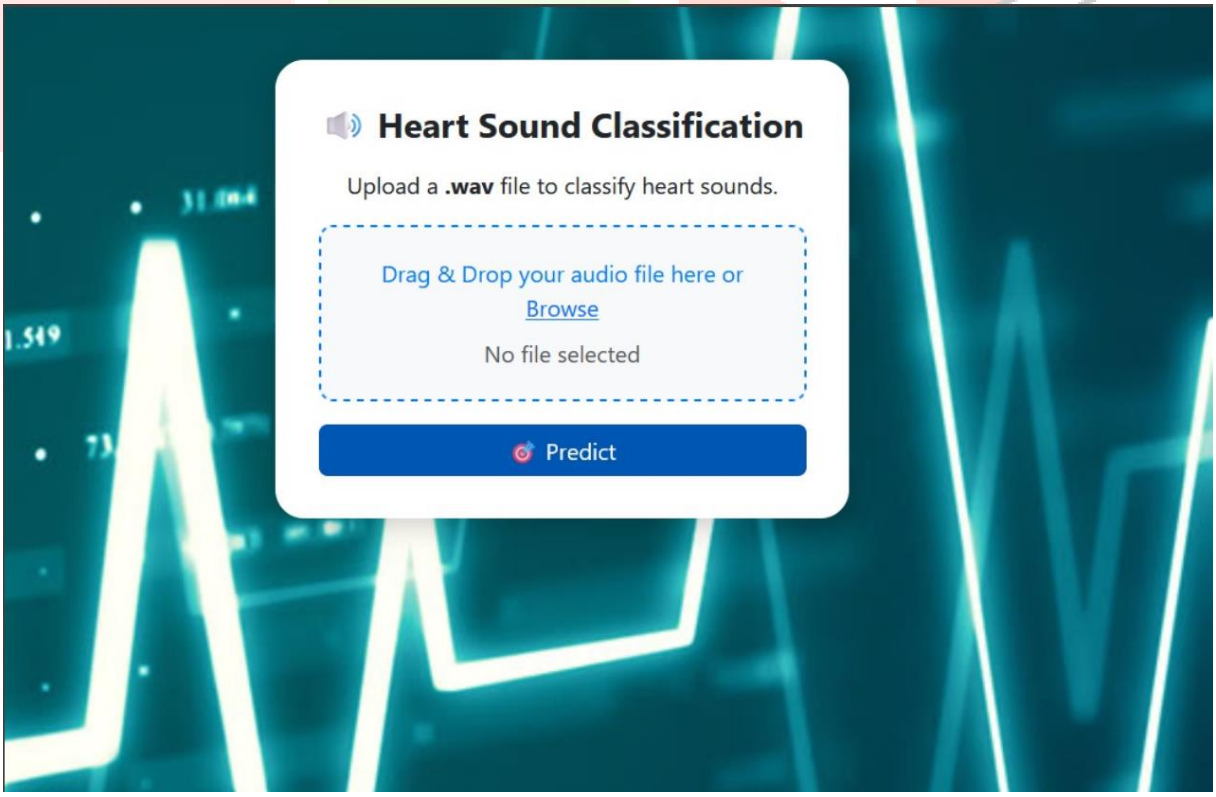


Figure1: Home page for Heartbeat upload Interface

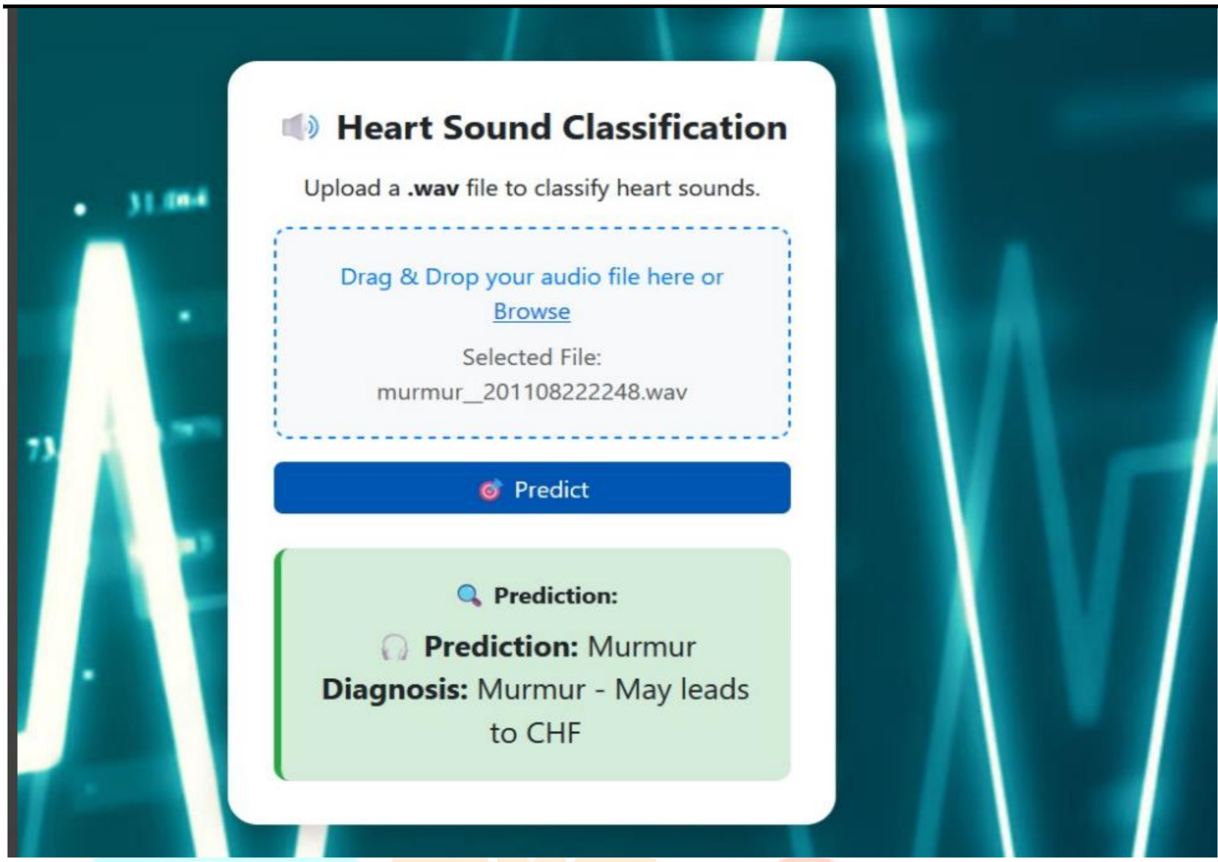


Figure2: Interface predicts the CHF risk

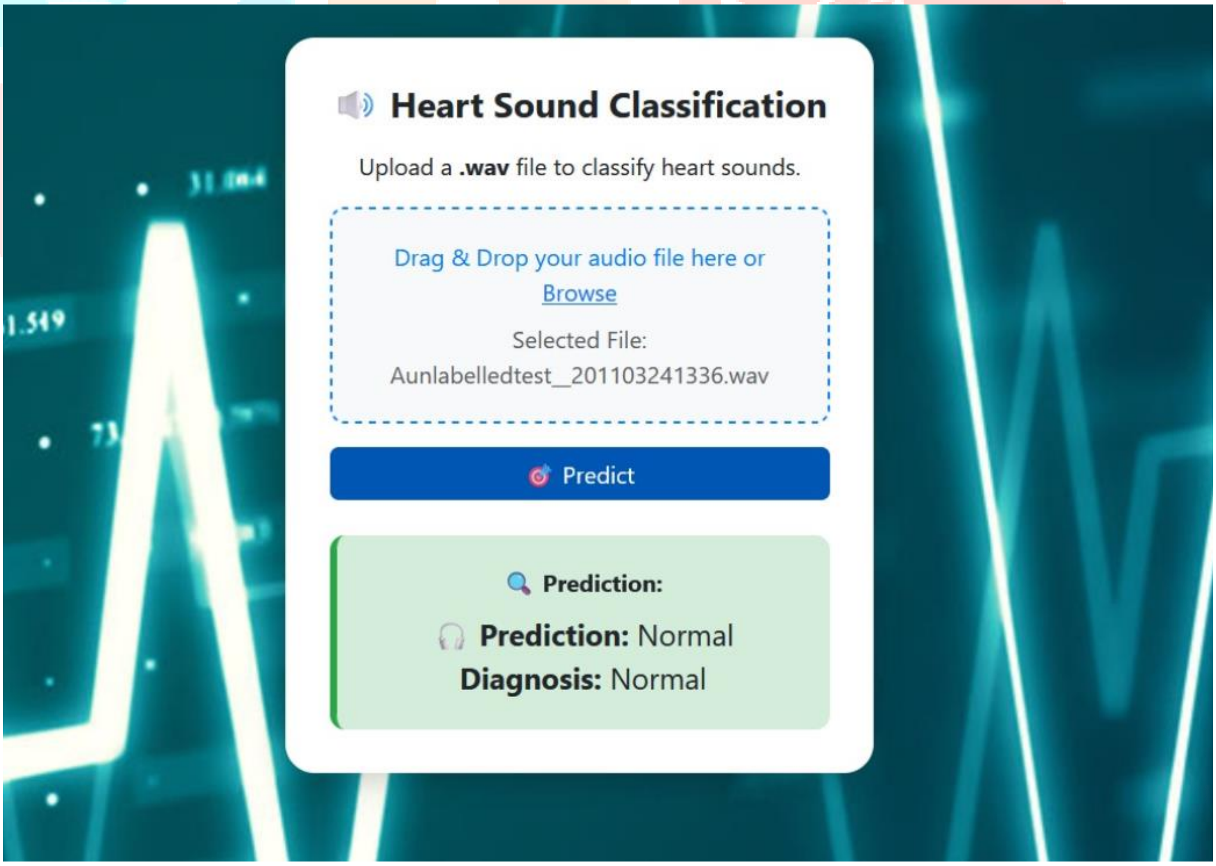


Figure3: Predicts the normal Heartbeat by using Flask interface

CONCLUSION:

Integrating a web interface into a machine learning-based CHF prediction system significantly enhances accessibility, usability, and real-time monitoring capabilities. By utilizing heartbeat data such as RR intervals or ECG signals, the system can remotely and automatically analyze heart function to detect early signs of congestive heart failure. A web-based platform allows healthcare providers, patients, and caregivers to interact with the prediction model from any location, facilitating continuous monitoring without the need for hospital visits. This is especially beneficial in telemedicine and home care environments.

The machine learning model processes uploaded or real-time heart data and delivers immediate diagnostic feedback through the interface. This enables prompt intervention, supports personalized treatment plans, and reduces the workload of medical professionals. Moreover, web interfaces can incorporate user-friendly dashboards, visualizations, and alerts, making complex data more interpretable for non-specialist users. Overall, combining a machine learning model with a web-based interface represents a promising step toward scalable, efficient, and proactive heart health management.

REFRENCES

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