AI Implemented ECG-Based Cardiovascular Disease Diagnosis System

An end to end deep learning based pipeline that integrates multiple models through Ensembling technique to diagnose an ECG signal.

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The Devastating Reality of Cardiovascular Disease

WORLD HEART FEDERATION

DEATHS FROM CARDIOVASCULAR DISEASE SURGED 60% GLOBALLY OVER THE LAST 30 YEARS: REPORT

20 May 2023

CVD deaths have surged from 12.1 million in 1990 to 20.5 million in 2021—a staggering 69% increase

CVD continues to claim 20 million lives annually. In the India alone, Roughly 2.9 million Indians died from CVD in 2021—meaning the nation loses one life every 11 seconds to heart or blood-vessel disorders.

The Diagnostic Dilemma: Where Medicine Fails Its Patients

Diagnostic errors affect approximately 5-14% of patients in healthcare settings, with cardiovascular conditions representing one of the three leading categories of harmful misdiagnosis in primary care.

Case Study One: The Healthy Athlete's Silent Killer

AI system capable of analyzing ECG patterns, exercise responses, and genetic markers might have identified the risk factors

Case Study Two: The Misdiagnosed Emergency

An AI system trained of similar presentations could have immediately flagged the combination of symptoms as high-risk for acute coronary syndrome, recommended appropriate cardiac biomarkers and imaging, and prevented this tragic outcome

Approach For The Problem Statement

These cases illustrate the three fundamental vulnerabilities that make cardiovascular disease so devastating despite our advanced medical capabilities:

The Asymptomatic Presentation Challenge
The Diagnostic Accuracy Problem
The Time-Critical Nature of Cardiac Emergencies

The Promise of AI in Cardiovascular Medicine

AI-powered diagnostic systems can detect subtle ECG changes, genetic risk factors, and patterns beyond human observation, enabling early detection. Trained on diverse populations, they offer consistent, unbiased support and deliver instant analysis, significantly reducing delays.

Our Solution:

The Transformative Potential of Ensemble AI Solutions

Model`s Description

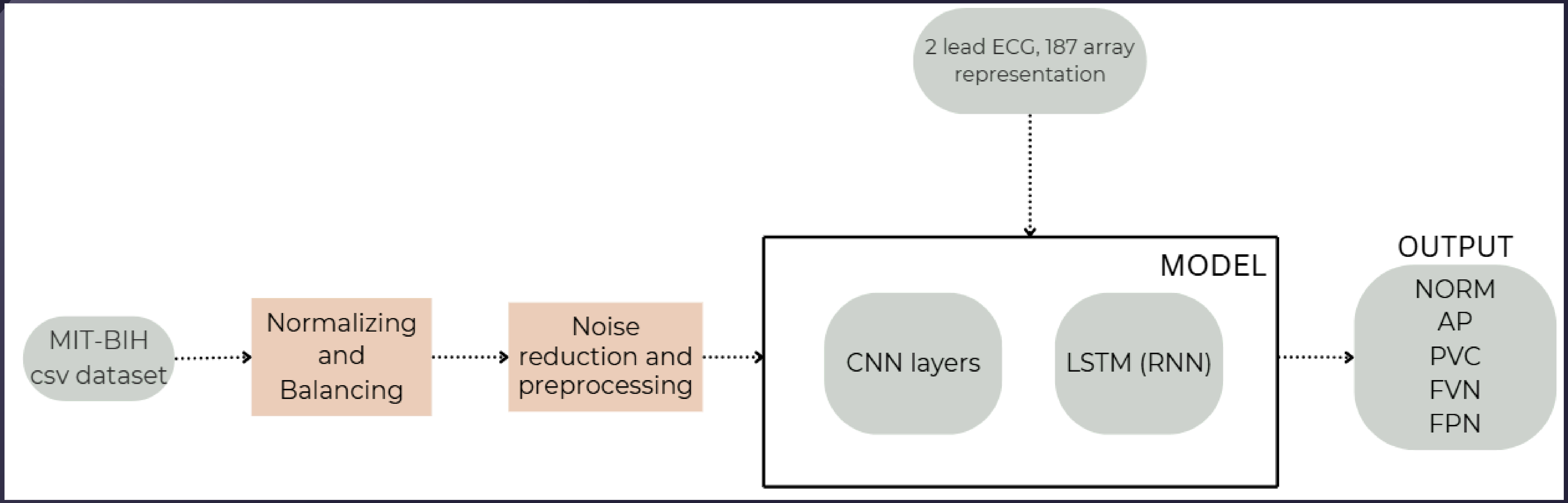
We have employed a pipeline that contains a stack of three ensembled models individually trained on different datasets and formats, this ensembling optimize and maximize diagnostic robustness. Pipeline is curated to take an image of a 12-lead ECG signal and is able to diagnose 13 different categories of CVD's.

The stack of models are curated to process an 187 array point representation of the ECG signals making the models maintain homogeneity.

Why Only ECG

- Universal Accessibility and Cost-Effectiveness
- Early Detection of Silent and Dynamic Cardiac Events
- Scalability and Integration With Wearables and Telemedicine

Model - 1 And Its Architecture

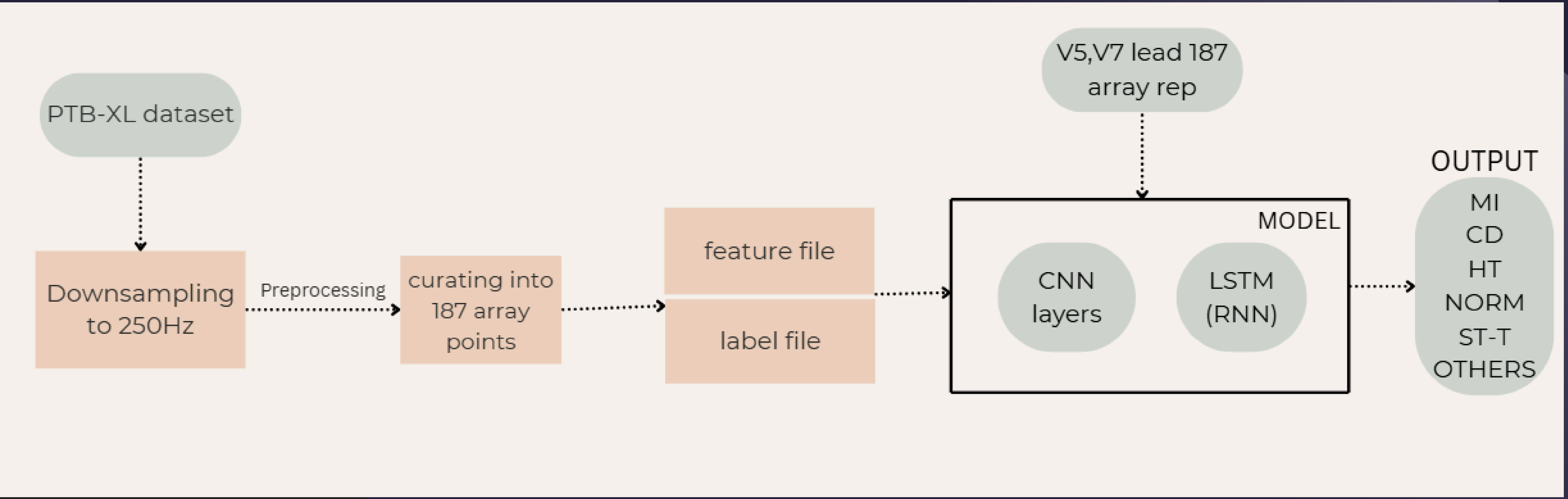


Model Accuracy: >95 %

Hybrid CNN-LSTM model for capturing spatial and temporal ECG features

- Two Conv1D layers (64 filters, kernel size 3) with BatchNorm and MaxPooling
- Two LSTM layers (64 units returning sequences, then 32 units)
- Fully connected layers: Flatten → Dense(64) → Dense(32) → Output Dense(5, softmax)

Model 2 And Its Architecture



Model Accuracy: 88.7 %

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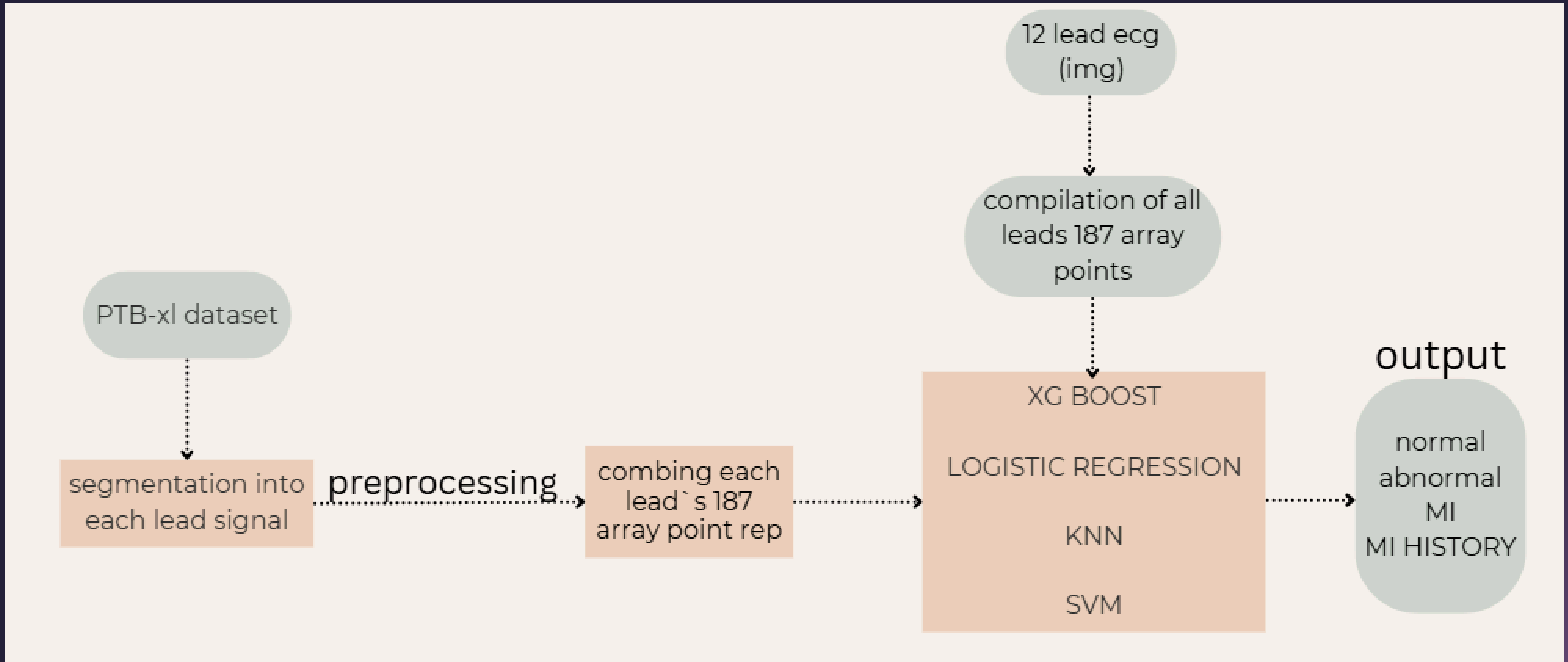
Model - 3 And Its Architecture

- An hybrid architecuture, ensembling multiple Machine Learning models like SVM, KNN, XGBoost, Logistic Regression an attempt to achieve higher combined accuracy.

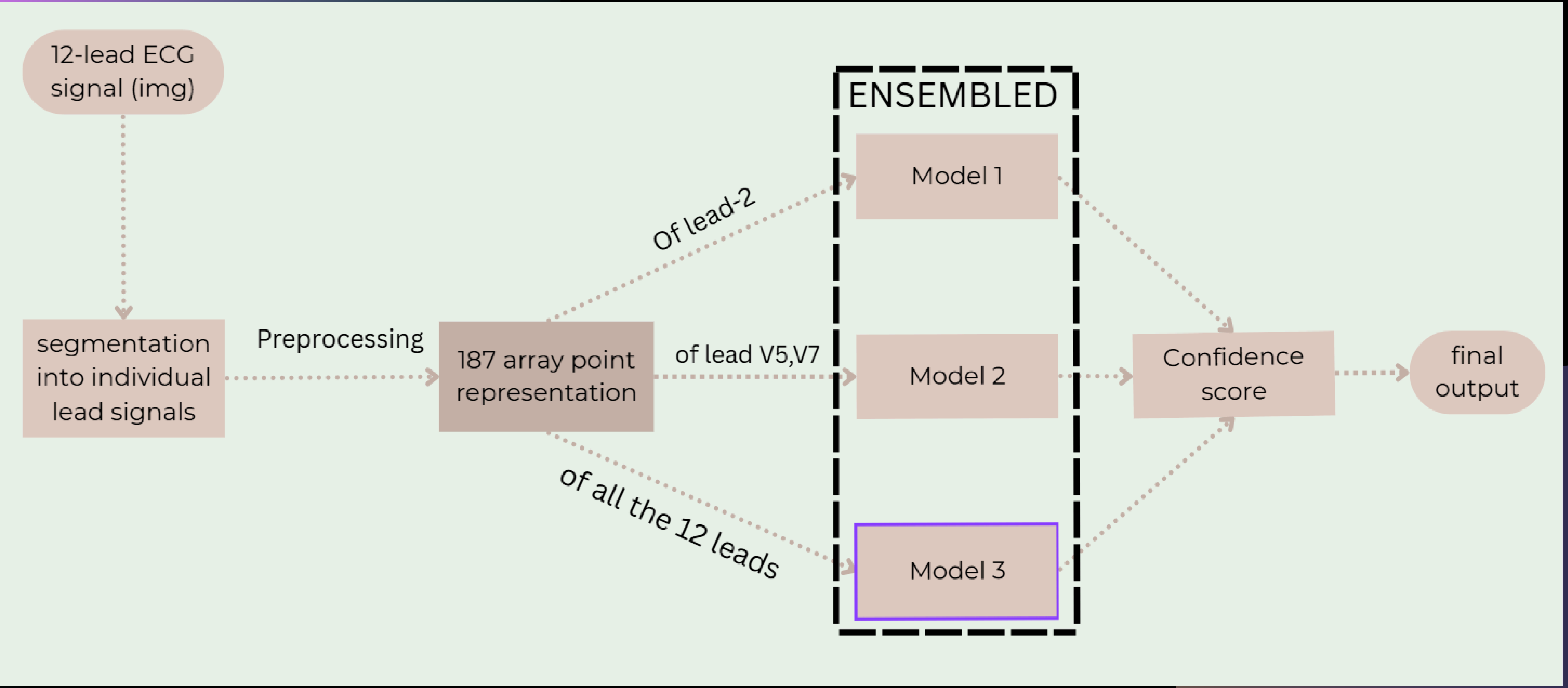


- KNN accuracy: 79.3 %
- Logistic reg accuracy: 77.68 %
- SVM accuracy: 90.51 %
- XGBoost accuracy: 85.3 %

- **Ensembled Accuracy:92.4 %**

Pipeline And Its Architecture

The multi-model ensemble enhances detection of fleeting or low-signal features in ECGs that traditional interpretation misses, enabling population-scale screening and automated follow-up flags for wearable and at-home monitoring devices.



Our AI-driven ECG diagnosis system delivers robust performance, validated by rigorous evaluation metrics and optimized for efficient operation in clinical environments.

Detectable Cardiovascular Diseases

Atrial Arrhythmias(M-I)
- Normal
- Atrial Premature
- Fusion Paced Normal

Ventricular Arrhythmias (M-I)
- Fusion Ventricular Normal
- Premature Ventricular Contractions (PVC)

Ischemic Conditions (M-II)
- ST - T - Change
- Normal
- Myocardial Infarction (MI)
- Conduction Disturbance
- Hypertrophy
- Others

Other Mayocardinal Infraction(M-III)
- Normal
- Abnormal
- MI
- History MI

Challenges

- Preprocessing:

  To down-sample and transform the ECG signal into 187 array points without loosing the significant features and use it for the prediction

- Homo-ensembling:

  Diverse model architectures in an ensemble may produce conflicting predictions, inconsistent feature interpretations can reduce ensemble consensus and accuracy , inorder to handle them maintainig homogeneity was crucial

- Non native Datasets:

  As the datasets used to train the models were not native to India, its an important consideration that the product is not marketable for Indian natives due to Generalizability issues on indigenious population

Potential Use Cases

- Decision Support for Personalized Treatment
- Reducing Diagnostic Errors in Outpatient and Primary Care Settings
- Rural and Remote Telemedicine Diagnosis Hub

Conclusion.
Future Enhancements

- Clinical Integration
- Edge & Wearables
- Larger Datasets
- Improved Transformers

Key References

- PhysioNet: Comprehensive physiological waveform databases for research.
- WHO Statistics: Global health data on cardiovascular diseases.
- Deep Learning for Time Series Analysis: Foundational research and methodologies applied to sequential data.

Project Repository

- Access the full codebase, documentation, and further details of the project on our GitHub repository: https://github.com/SAISriram19/cardiovascular-super4

WE`RE READY FOR QnA

Thank You