Title: *Multimodal Heart Disease Detection Using ECG Signals and Chest CT Scans with Synthetic Data Augmentation*

Heart disease remains one of the leading causes of mortality globally, often requiring both electrical and anatomical data for accurate diagnosis. This project proposes a multimodal approach for heart disease detection by integrating 1D electrocardiogram (ECG) signals and 2D chest computed tomography (CT) images. The goal is to enhance early diagnosis accuracy by leveraging the complementary information of signal-based and image-based modalities.

The ECG signals will undergo preprocessing for noise removal, heartbeat segmentation, and time-frequency feature extraction using techniques such as wavelet transforms and MFCCs. Chest CT images will be pre-processed through normalization, resizing, and denoising, followed by classification using convolutional neural networks (CNNs). To address data imbalance—common in medical datasets—synthetic ECG signals will be generated using Auxiliary Classifier Generative Adversarial Networks (AC-GANs).

Additionally, explainable AI techniques like Grad-CAM and SHAP values will be applied to visualize and interpret model decisions, thereby improving trust and transparency. The project aims to contribute to computer-aided diagnostic systems by improving classification accuracy, handling data scarcity, and offering a reproducible pipeline for future research in medical diagnostics.

Tasks Division Among Members

Member Responsibility

A ECG preprocessing, augmentation, 1D CNN

B CT image preprocessing, CNN model

C GAN implementation for ECG and CT

D Evaluation, explainability Grad-CAM & SHAP, final integration

The Project Acquisition:

We are combining:

* ECG signals (1D signal data) → from PhysioNet (<https://physionet.org/content/mitdb/1.0.0/>)
* Format: .dat, .hea files (can be loaded via Python).
* Includes labeled arrhythmias (types of heart issues).
* Chest CT scan images (2D image data) → from LIDC-IDRI dataset (<https://www.cancerimagingarchive.net/collection/lidc-idri/>)
* Contains DICOM images (used in medical imaging).
* Format: .dcm (DICOM medical image format)
* Labels: lesions, nodule characteristics, etc. (You could classify severity or disease type).

This is multimodal because we're using two different types of data to predict the same target (heart disease or related conditions).

*Multimodal Heart Disease Detection and Synthetic Signal Generation Using ECG and Chest CT Scans*

Most past projects focus only on ECG or only on CT/X-ray. Our project goes a step further:

* By combines 1D time-series data (ECG) and 2D medical imaging (CT scans). Mimics how real cardiologists diagnose: by looking at both electrical and anatomical information which also offers more robust, cross-confirmed diagnosis; higher clinical relevance.

Many healthcare datasets suffer from imbalanced classes (e.g., very few abnormal cases). Our project solves this using Auxiliary Classifier GANs (AC-GANs):

* Learns to generate realistic ECG signals for underrepresented arrhythmias.
* Enables balanced training without oversampling real data.

Our model won’t just predict - it will explain:

* Use SHAP or attention plots on ECG to show which wave segments triggered the decision.
* Use Grad-CAM on CT images to show which areas (e.g., ventricles, lesions) were important.

Our work is not limited to using pretrained models (e.g., VGG, ResNet):

* You’ll build **1D CNN or LSTM models** from scratch for ECG.
* You’ll design and train a **custom CNN for CT scans**.
* You’ll implement **GANs end-to-end** (not just use pretrained images).