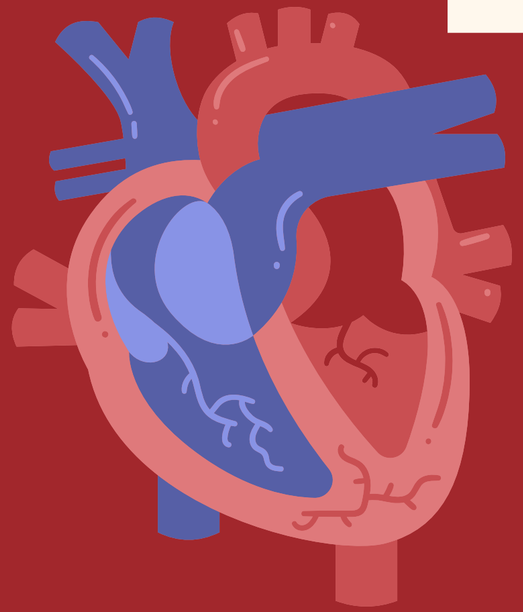
CUFF-LESS BLOOD PRESSURE PREDICTION USING ECG AND PPG SIGNALS



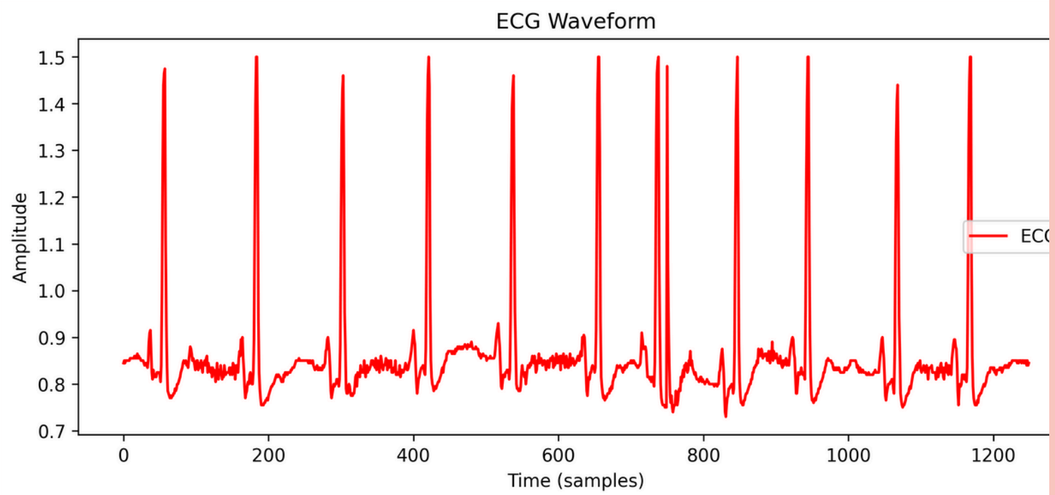
Using MIMIC II online waveform database from PhysioNet

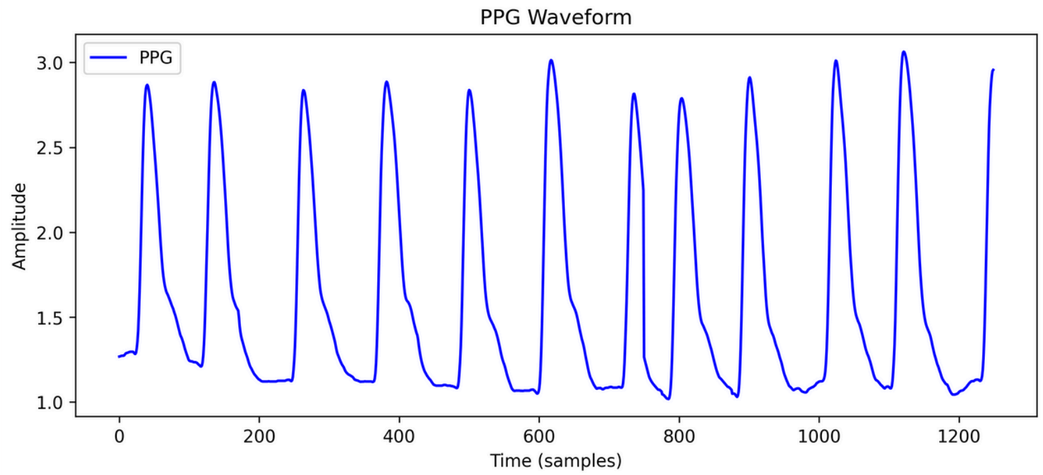
PROBLEM STATEMENT AND APPROACH

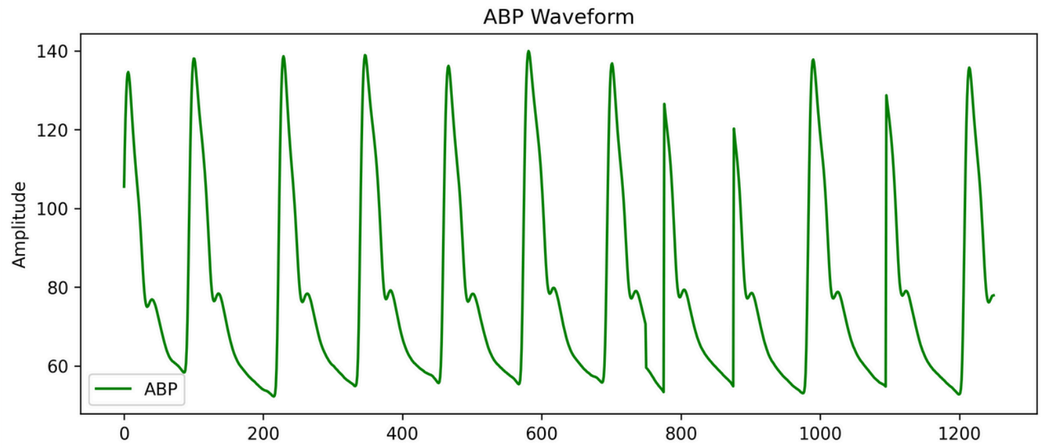
- **Problem Statement:** Develop a model to predict blood pressure (BP) using simultaneously obtained ECG (Electrocardiogram) and PPG (Photoplethysmogram) signals, where ECG and PPG are inputs, and the ABP (Arterial Blood Pressure) wave is the target.
- **Approach:** Utilize machine learning models to predict systolic and diastolic BP from ECG and PPG signals.

DATASET OVERVIEW

- **Dataset:** MIMIC II online waveform database from PhysioNet
- **Signal Types**: ECG, PPG, and ABP
- **Sampling Rate:** 125 Hz
- **Total Records:** 70,270 records
- **Duration:** 10 seconds per waveform







FEATURE EXTRACTION

PTT & PAT

Pulse Transit Time and Pulse Arrival Time

BP Relationships

Systolic and Diastolic BP

Statistical Features

Mean, Std Dev

Additional Metrics

Heart Rate, Area under PPG, Shannon Entropy, etc.

RELATIONSHIP BETWEEN FEATURES AND BP

- **Pulse Transit Time (PTT) and Pulse Arrival Time (PAT):** Measures the time difference between peaks in ECG and PPG signals. These features are indicative of cardiovascular health and can be used to estimate BP. Increased PTT is generally associated with lower BP.
- **Statistical Features:** Mean and standard deviation of ECG and PPG signals capture the overall signal characteristics and variability, which are essential for understanding BP fluctuations.
- **BP Relationships:** Direct relationships based on known physiological equations (e.g., SBP = 1.95 * PTT + 20.3 and DBP = 1.57 * PAT - 12.8) provide initial estimates of BP values from PTT and PAT.
- **Heart Rate:** Derived from ECG peaks, it helps in understanding the overall cardiovascular condition which impacts BP.
- **Area under PPG Curve:** Reflects blood volume changes and can correlate with BP levels.
- **Shannon Entropy and Hjorth Features:** Measure signal complexity and can provide insights into the regulatory mechanisms affecting BP.

PERFORMANCE METRICS

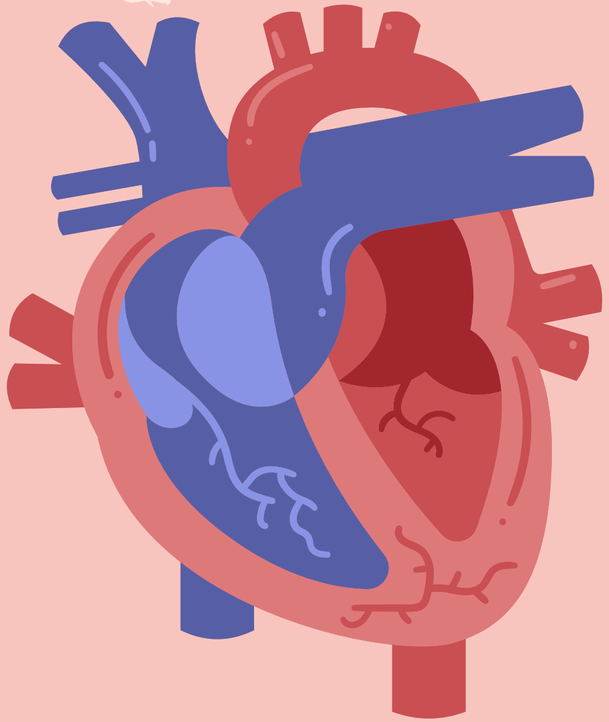
- **Root Mean Squared Error (RMSE):** Measures the average magnitude of the prediction errors, giving insight into how well the model's predictions match the actual BP values. Lower RMSE indicates better model accuracy.
- **R-squared (R^2):** Indicates the proportion of variance in the target variable (BP) that is predictable from the features. An R^2 value close to 1 implies a strong model fit and good predictive power.

RESULTS (DIASTOLIC BP)

Model	Validation				Test			
	RMSE	MSE	R^2	MAE	RMSE	MSE	R^2	MAE
Fine Tree	4.953	24.528	0.811	3.015	4.671	21.822	0.821	2.835
Medium Tree	4.744	22.510	0.827	2.976	4.519	20.418	0.832	2.822
Coarse Tree	4.769	22.742	0.825	3.098	4.532	20.542	0.831	2.973
Ensemble Boosted Trees	5.877	34.541	0.734	4.343	5.729	32.820	0.730	4.308
Ensemble Bagged Trees	3.819	14.582	0.888	2.337	3.629	13.171	0.892	2.222
Narrow Neural Network	5.205	27.088	0.792	3.657	4.971	24.706	0.797	3.526
Medium Neural Network	5.025	25.248	0.806	3.528	4.921	24.218	0.801	3.489
Wide Neural Network	4.584	21.018	0.838	3.124	4.469	19.973	0.836	3.084
Bilayered Neural Network	4.992	24.922	0.808	3.475	4.741	22.473	0.815	3.319
Trilayered Neural Network	4.937	24.372	0.812	3.426	4.658	21.699	0.822	3.236

RESULTS (SYSTOLIC BP)

Model	Validation				Test			
	RMSE	MSE	R^2	MAE	RMSE	MSE	R^2	MAE
Fine Tree	10.103	102.077	0.789	6.036	9.715	94.381	0.806	5.703
Medium Tree	9.724	94.548	0.805	6.122	9.365	87.711	0.820	5.839
Coarse Tree	9.983	99.663	0.794	6.625	9.486	89.990	0.815	6.265
Ensemble Boosted Trees	12.839	164.850	0.660	10.032	12.787	163.501	0.664	10.035
Ensemble Bagged Trees	7.807	60.956	0.874	4.813	7.500	56.248	0.884	4.598
Narrow Neural Network	12.043	145.039	0.701	8.832	12.161	147.888	0.696	8.974
Medium Neural Network	11.868	140.847	0.709	8.654	11.882	141.171	0.710	8.680
Wide Neural Network	10.772	116.031	0.760	7.697	10.681	114.082	0.766	7.695
Bilayered Neural Network	11.790	139.011	0.713	8.596	11.563	133.714	0.725	8.496
Trilayered Neural Network	11.404	130.055	0.731	8.293	10.870	118.152	0.757	7.908



Thank You

*All the ML models were trained in classification learner app in MATLAB, but the dataset was created using Python (project5.py).