Evaluating the Relationship between Arterial Blood Pressure (ABP) and Electrocardiogram (ECG) Waveforms

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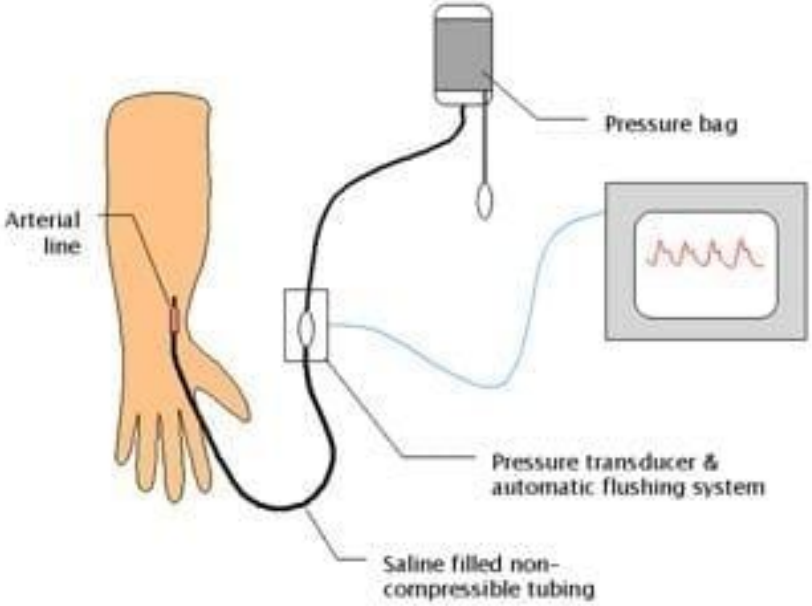
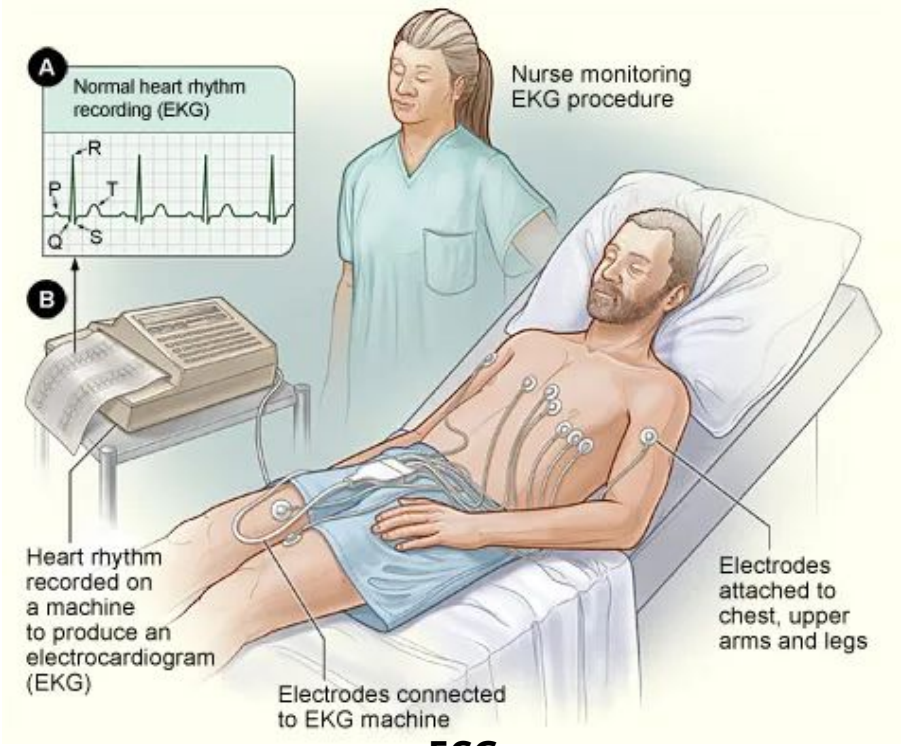
ABP vs ECG Monitoring Cases

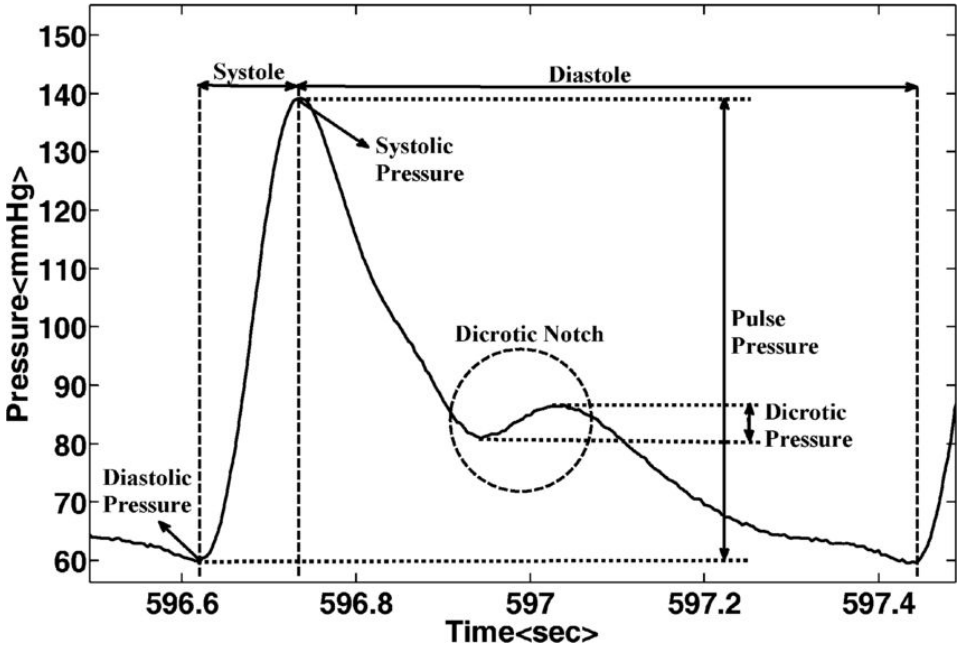


Invasive ABP

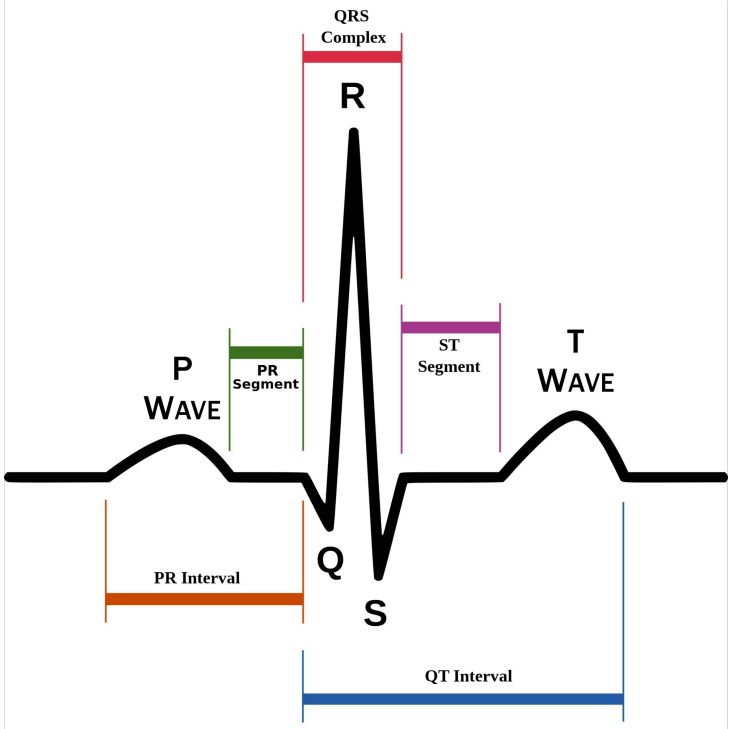


ECG

A Closer Look at the Waveforms…



ABP Waveform Morphology



ECG Waveform Morphology

Investigation Goals

1. Quantify the correlation between ABP and ECG
2. Predict the mean ABP value for a window of time only using time and frequency domain features from ECG
3. ECG - ABP Waveform Prediction

Investigation Goals

1. Quantify the correlation between ABP and ECG
2. Predict the mean ABP value for a window of time only using time and frequency domain features from ECG
3. Forecast ABP/ECG

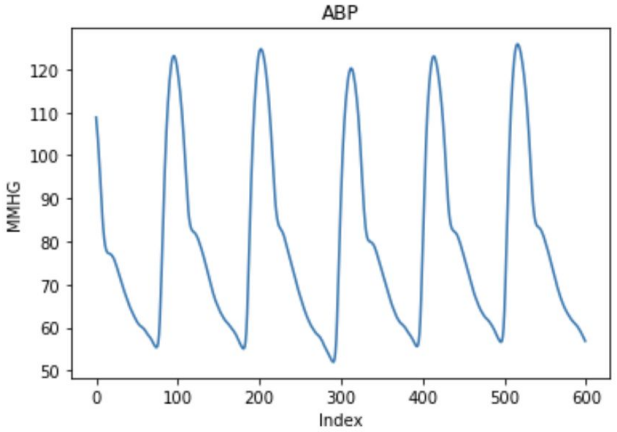
Tools/Concepts Assessed:

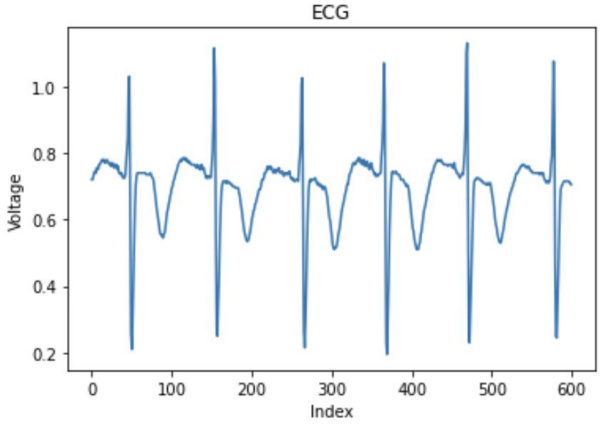
1. Dynamic time warping
2. Feature extraction and classical ML algorithms
3. LSTM and ARIMA

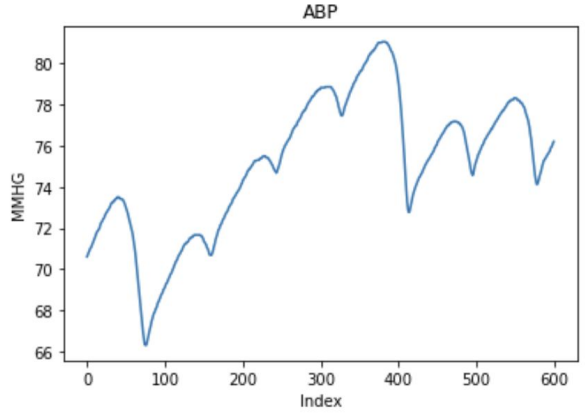
Data: MIMIC III Physiological Waveform Database V1.4

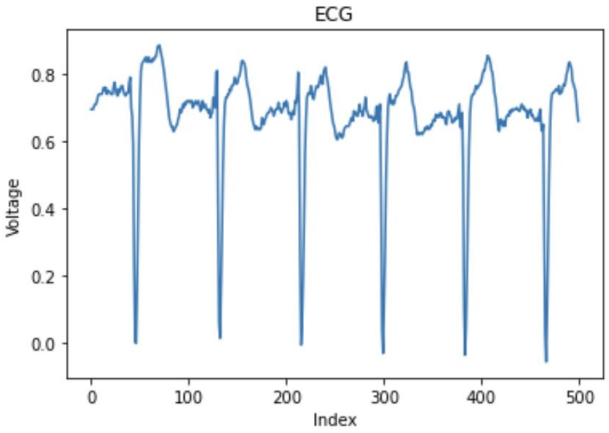
- MIMIC III data recorded from very own Beth Israel Deaconess hospital
- Extracted 33 patients' ABP and ECG data
- Preprocessing Procedure
  - Identified patients with ABP and ECG recordings (co-occurring)
  - Broke data into 5 minute segments (125 Hz -> 37,500 data points)
  - Dropped any segments with NaN

Correlation between ABP and ECG

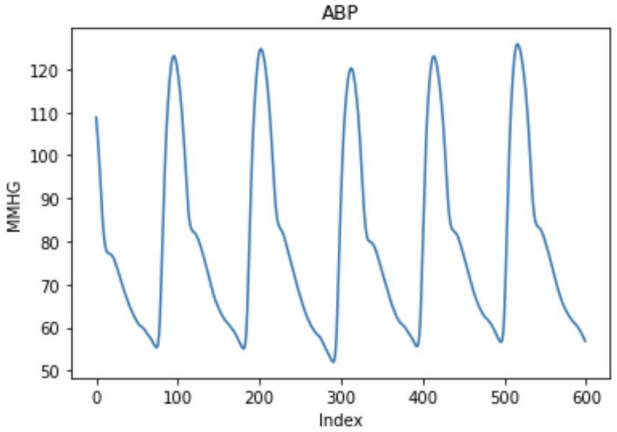




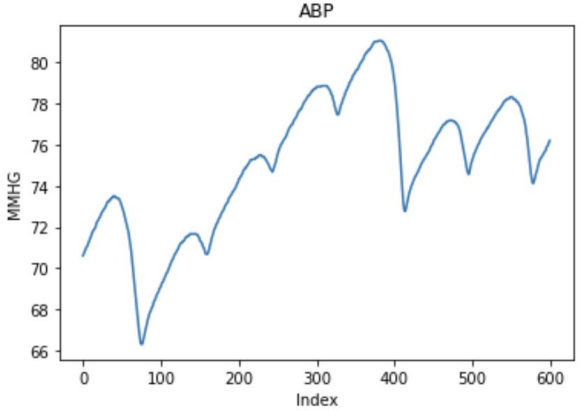


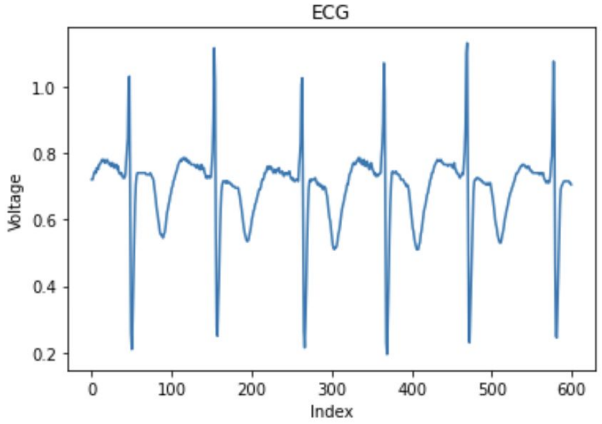


DTW - Correlation between ABP and ECG

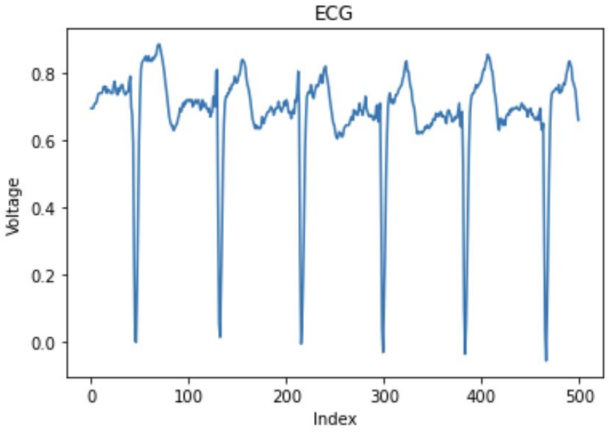


Compute DTW

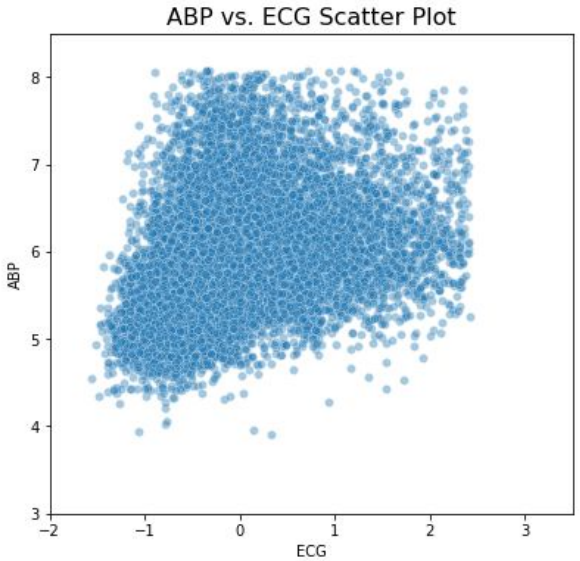


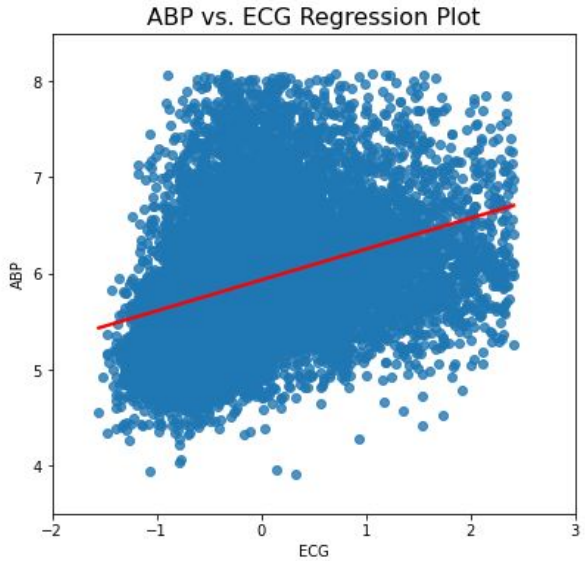


Compute DTW



DTW Analysis Slide






```
rho, p = spearmanr(dtw_df_log['ECG'], dtw_df_log['ABP'])
print(f'Correlation {rho}, p-value {p}')
```

```
Correlation 0.4137075235478414, p-value 0.0
```

Predicting Mean ABP value from ECG Features

- **Goal:** predict mean ABP from five minute window of data
- **Features:** tsfresh features from a five minute window of ECG data
- **Models:** Random Forest and XGBoost
- **Results/Validation:**

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

$$\mathrm{MAE} = \frac{1}{n}\sum_{j=1}^{n} |y_j - \hat{y}_j|$$

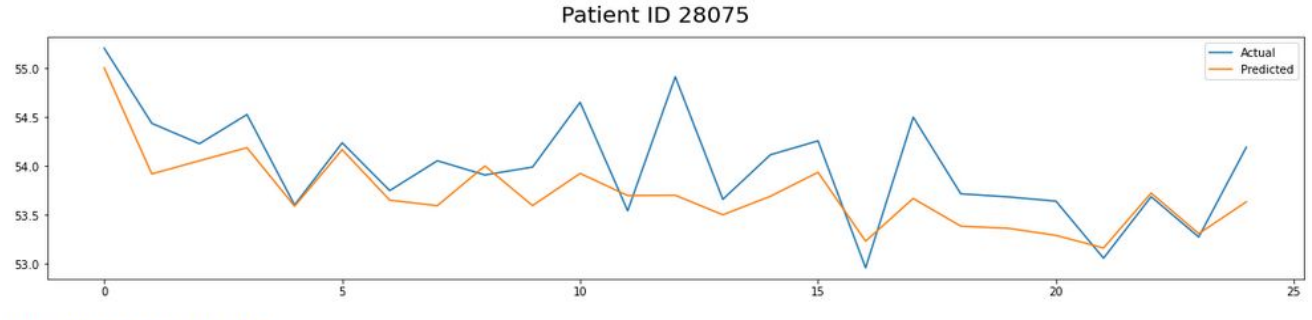
Mean Regression Results - Predicting ABP

1. XGBoost
    a. MAE: 16.8276 mmHg
    b. RMSE: 21.4651 mmHg

ECG - ABP Waveform Prediction

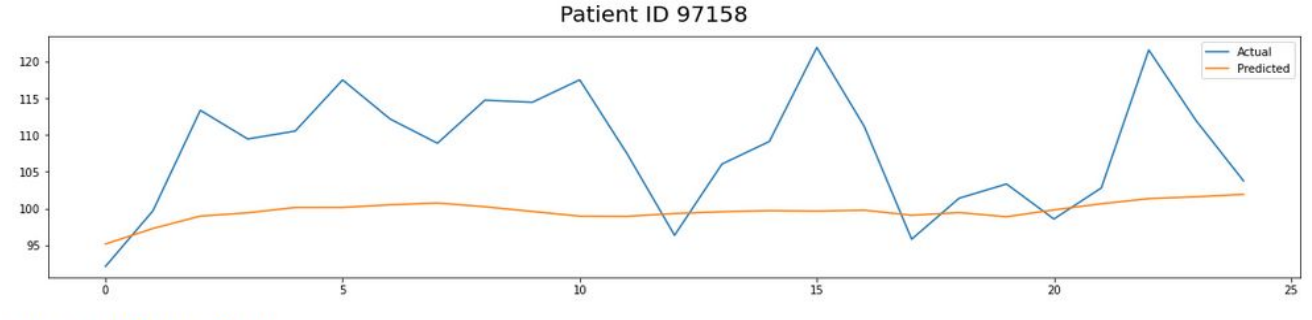
ARIMA MODELS

Fair



RMSE: 0.42874316260259443

Poor



RMSE: 11.140027605990374

Next Steps

1. Flip regression problem: predict mean ECG based off tsfresh features from the ABP waveform
2. Refine LSTM algorithm
    a. Improve architecture
    b. Add two time series inputs for forecasting (i.e. using both ABP and ECG to predict ABP further ahead in time)