PREDICTING BLOOD PRESSURE WITH RNNS

APS360 Group 12

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Problem Statement

Why is this important?

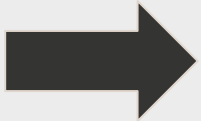
Blood pressure is an essential indicator of cardiovascular health

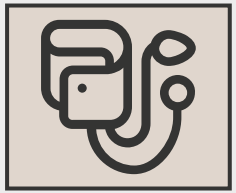
Blood pressure cuffs:

- Fails to capture continuous fluctuation

Goal: Predict blood pressure “cuffless” with Deep Learning

Definitions





Photoplethysmogram (PPG)

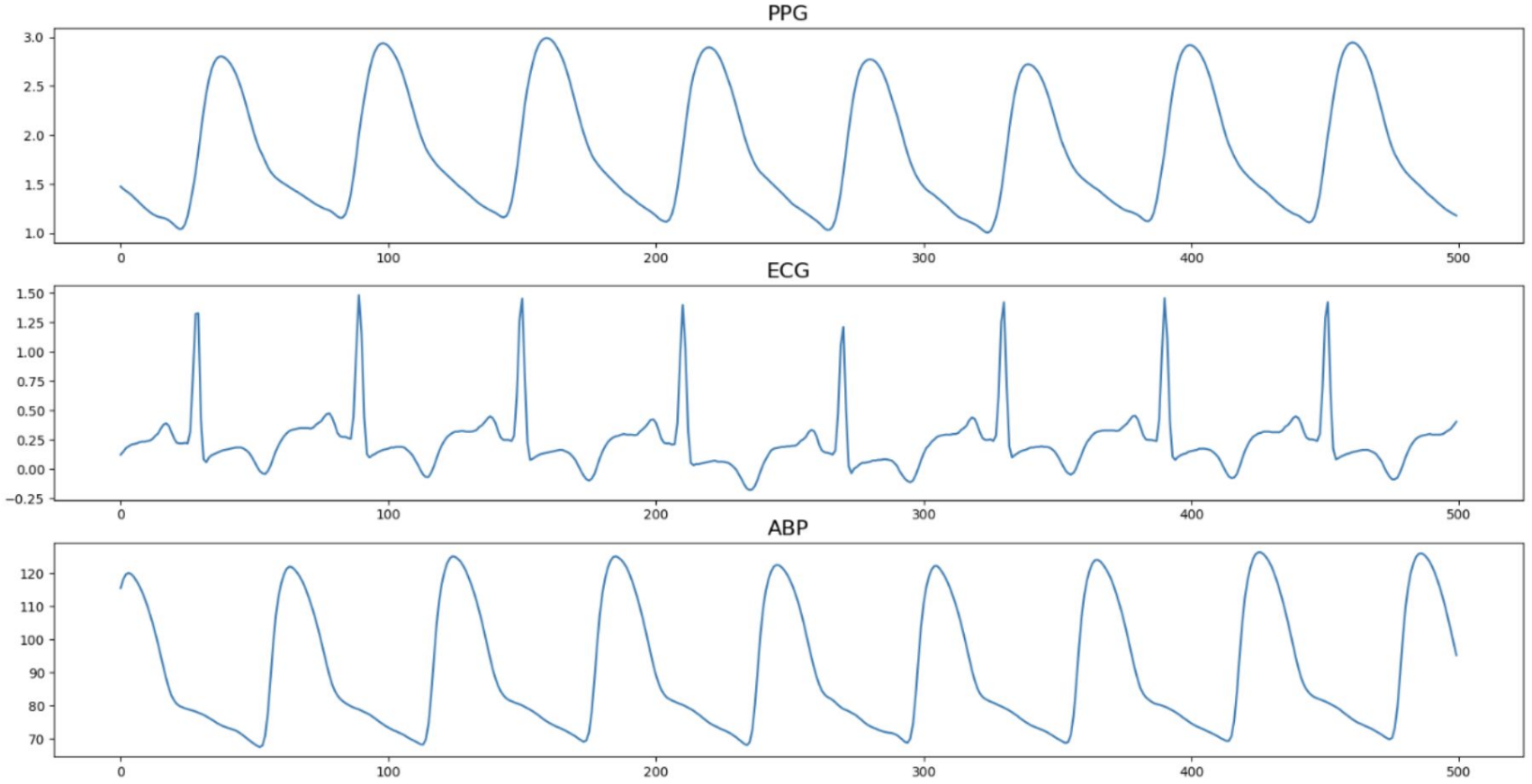
- Measure of blood volume changes in tissues
- Collected with a sensor that detects variations in by blood flow.

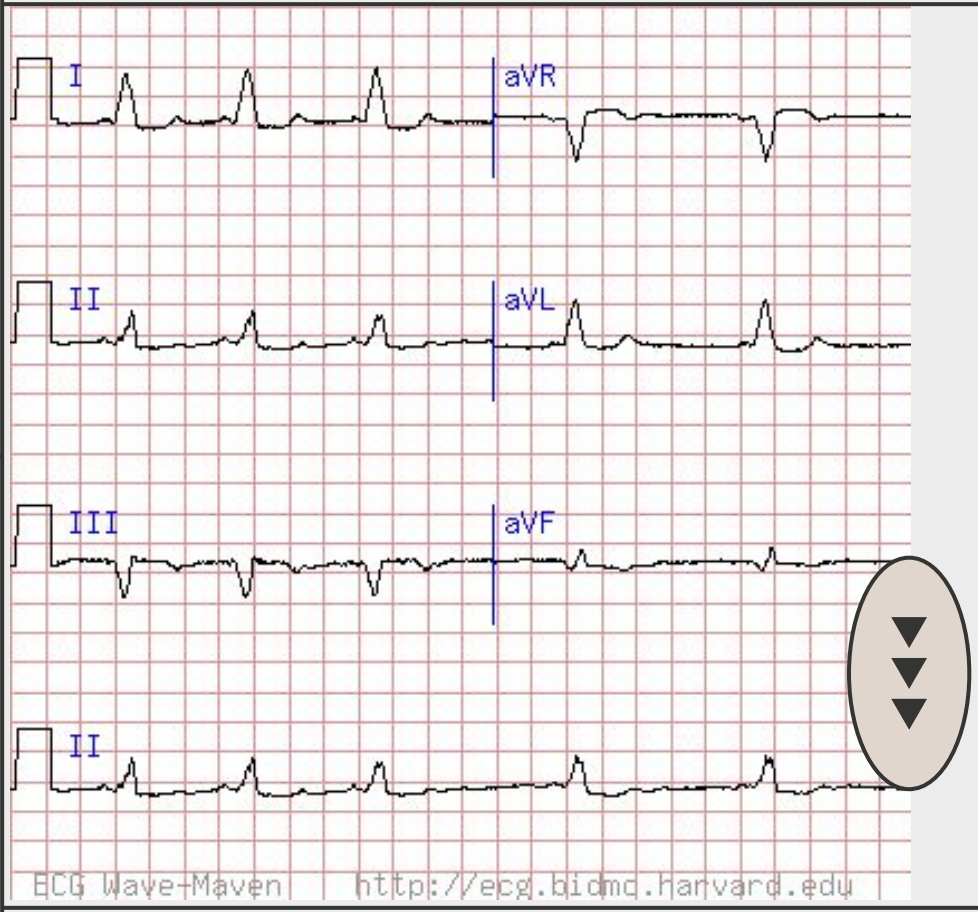
Electrocardiogram (ECG)

- Electrical activity of the heart over time
- Collected by placing electrodes on the skin

Blood Pressure (BP)

- The force exerted by circulating blood on the walls of the arteries
- Collected using an inflatable cuff
- **Deep learning model**


PPG
3.0
2.5
2.0
1.5
1.0
0
100
200
300
400
500
ECG
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
0
100
200
300
400
500
ABP
120
110
100
90
80
70
0
100
200
300
400
500



02

Data Processing

What data is used?

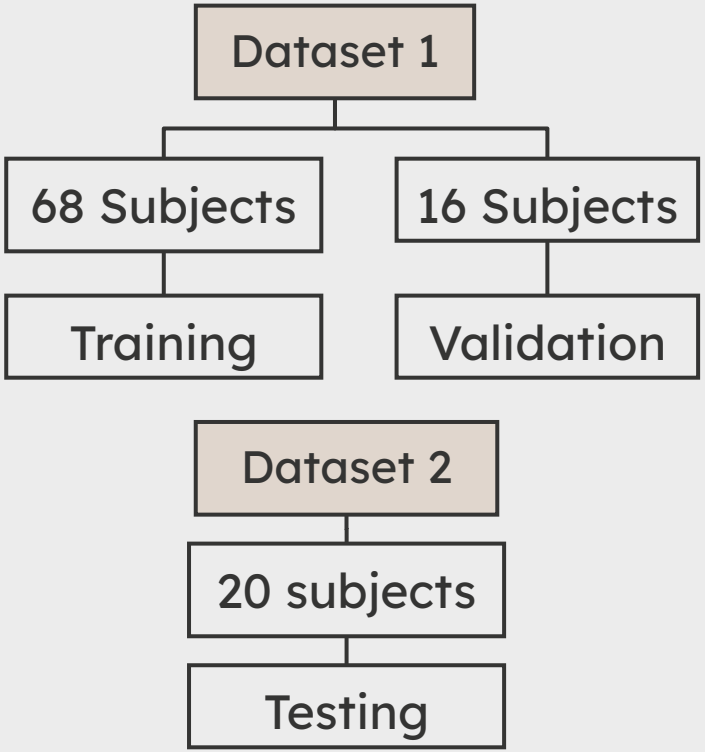
Train/Validation: UCI Machine Learning Repository “Cuff-Less Blood Pressure Estimation”

- Total of 3000 subjects

Dataset 2: MIMIC-IV Waveform Database

- More than 10000 records

It’s extremely difficult to collect those data ourselves!



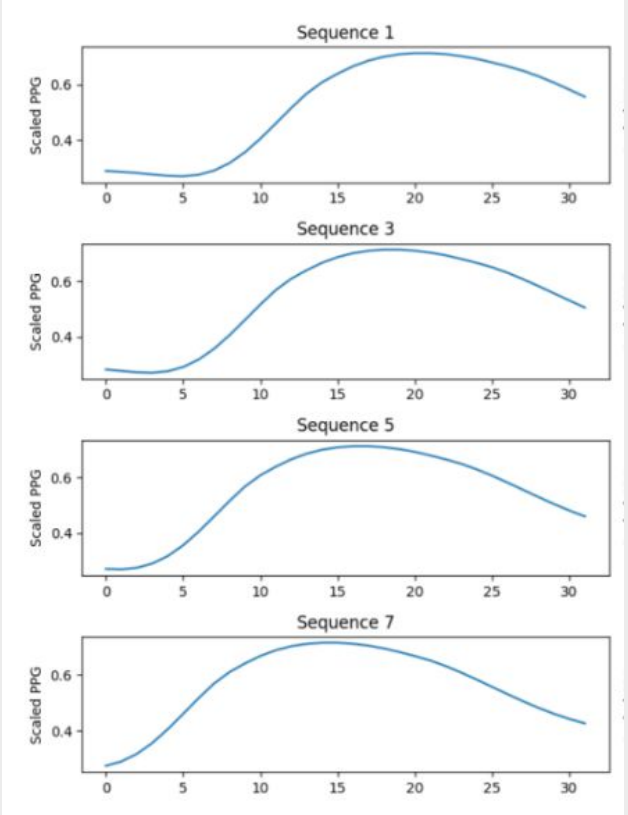
Preprocessing data

How?

- Clean up
- Normalize
- Time Series Structure

Limitations...

- All data is collected in ICU
- Computationally inefficient



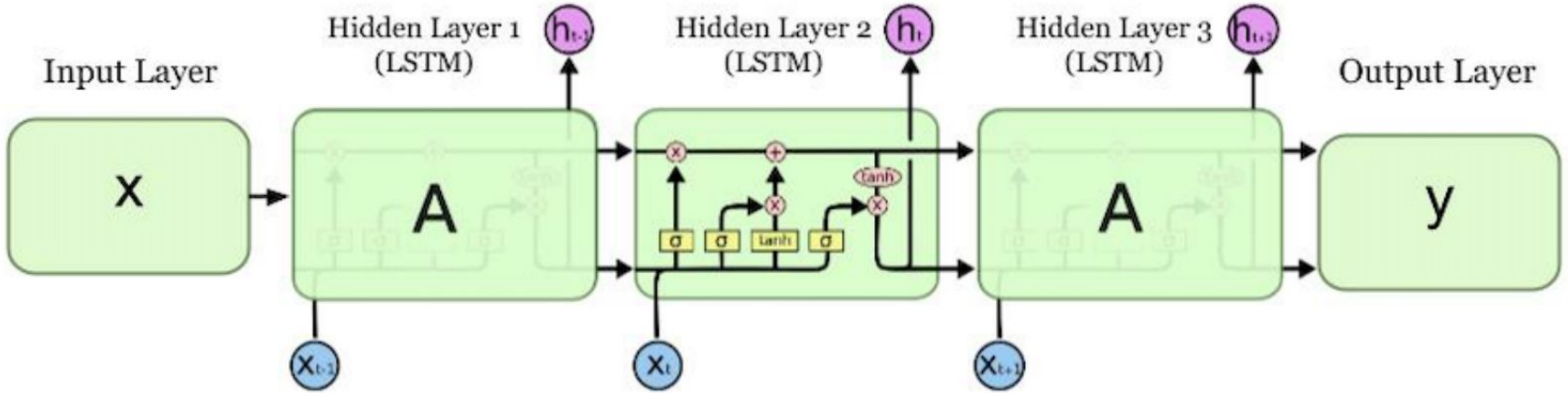
03

Model

Model Design

- Time-series data -> RNN
- Long Short-Term Memory (LSTM) model
- Learns long-term dependencies

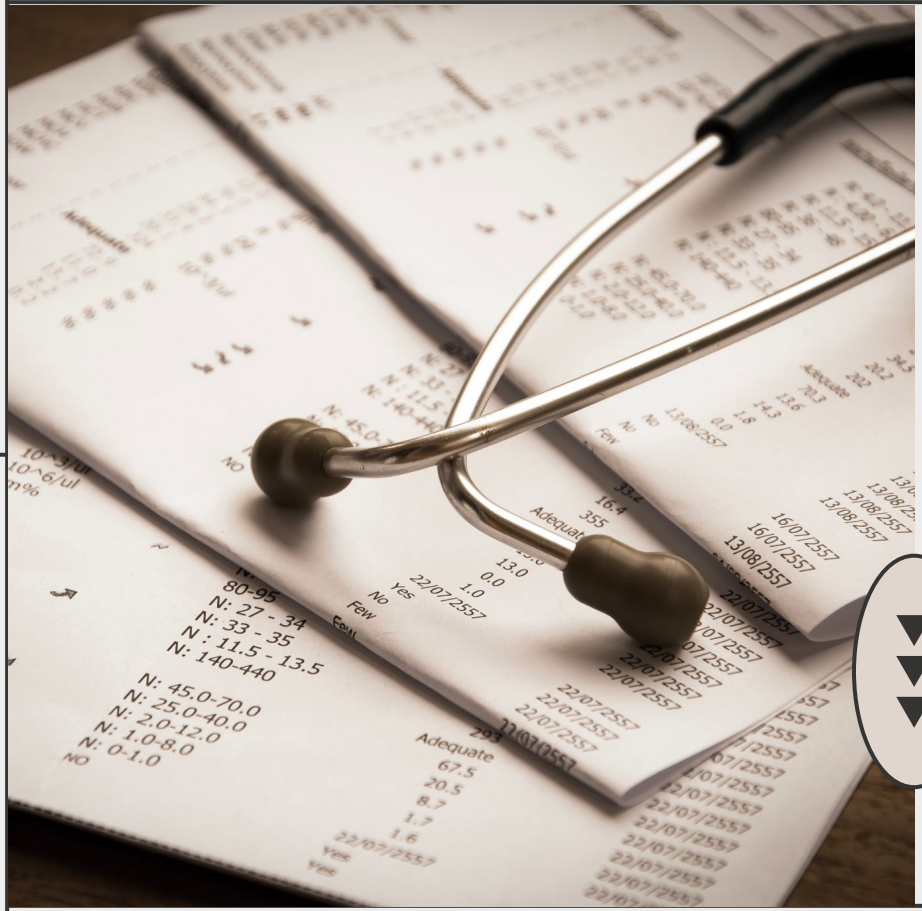
Architecture



Final Model Hyperparameters

- Random search hyperparameter tuning.
- Less data caused overfitting, more data caused noisy predictions.
- Utilized a Savitzky-Golay low-pass filter to “smooth” our predictions.

Parameter	Description	Value
input_size	The number of features expected in our input	2
hidden_size	The number of features in the model’s hidden state	128
num_layers	The number of recurrent layers. Essentially, the number of LSTMs we have stacked on each other.	3
batch_first	Whether the input and output tensors are provided by us	True



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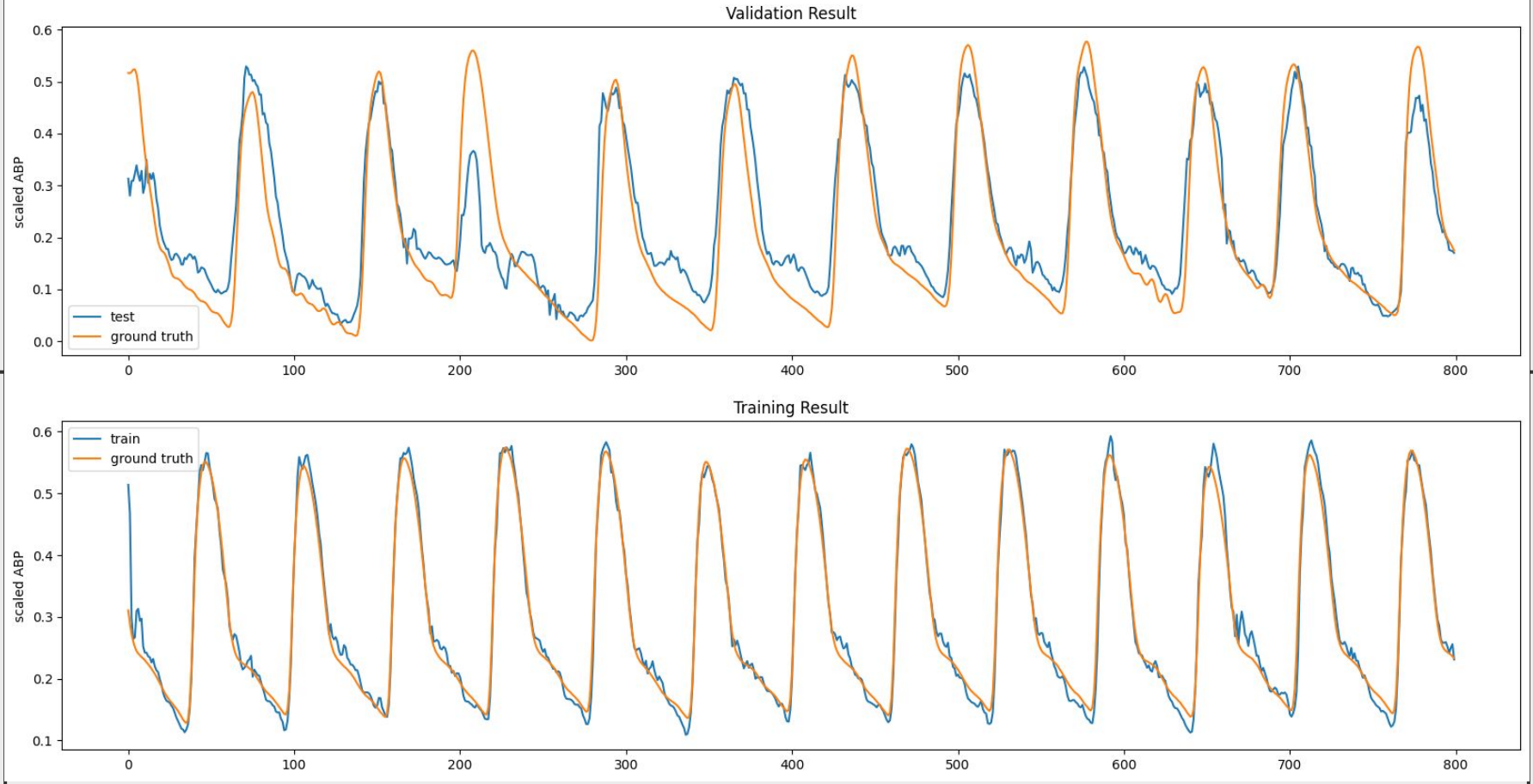
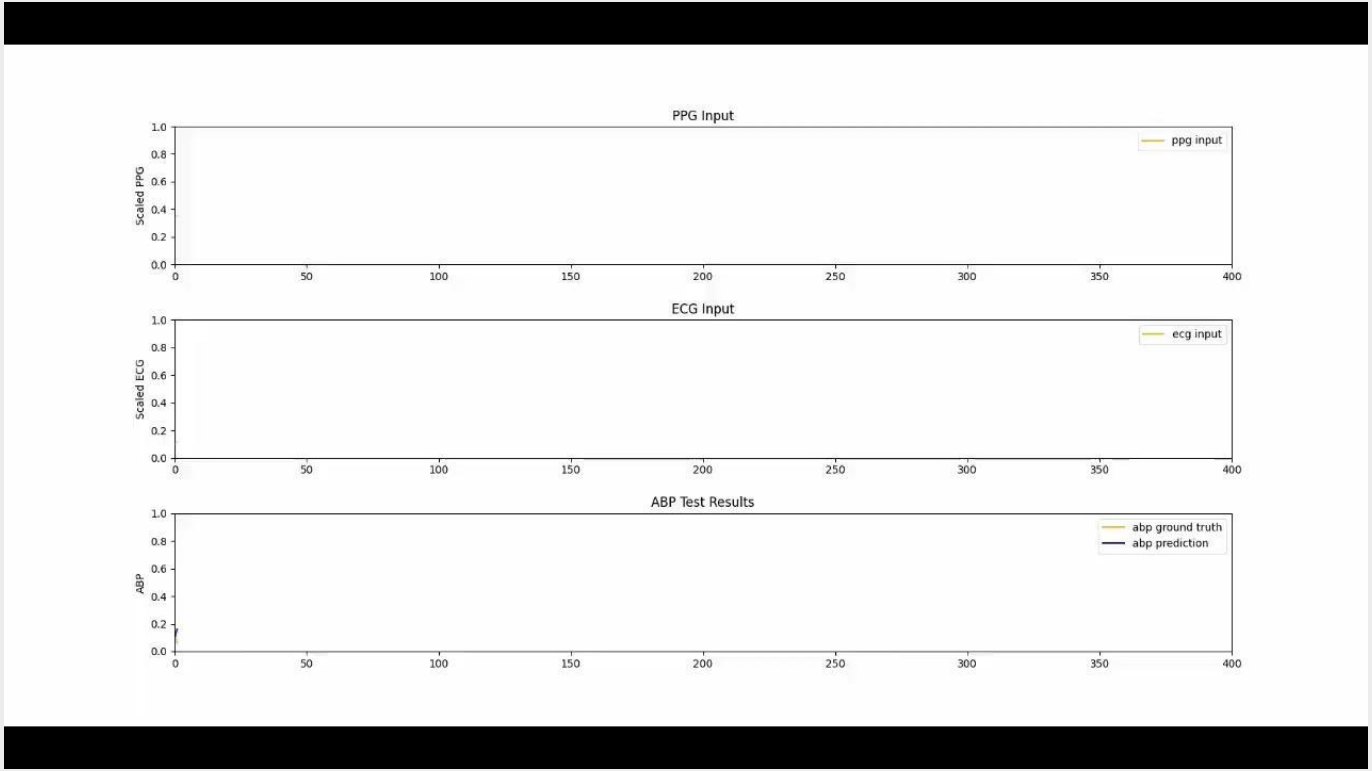
Results

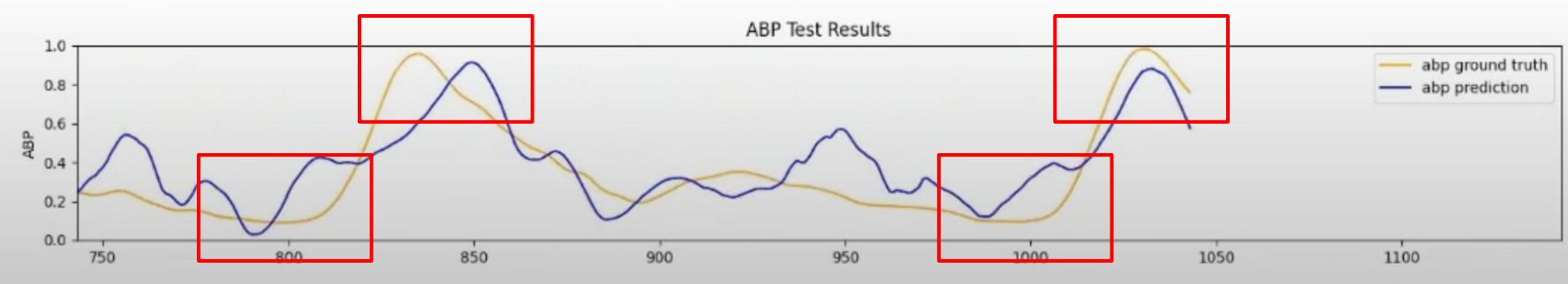
Validation and Training Results

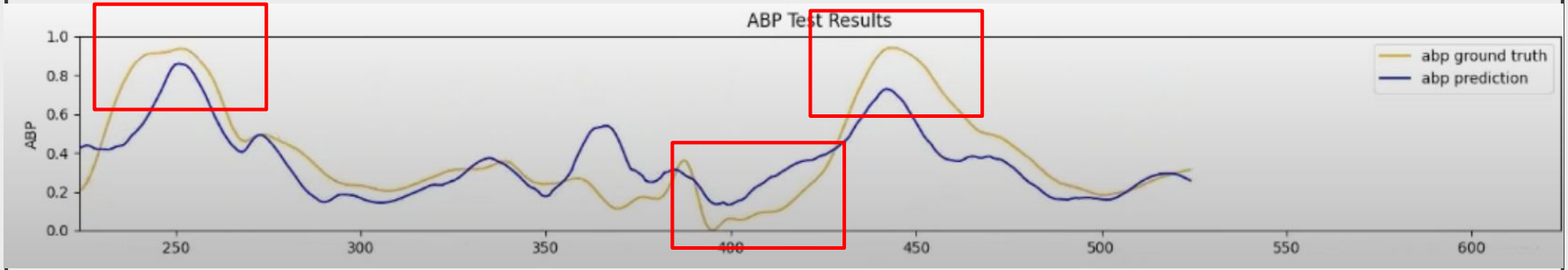


Demo


PPG Input
Scaled PPG
ppg input
ECG Input
Scaled ECG
ecg input
ABP Test Results
ABP
abp ground truth
abp prediction
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200
250
300
350
400

Qualitative Results





Quantitative Results

	Mean Squared Error (MSE)
Training	0.0185
Validation	0.0234
Testing	0.0629

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Discussion

Key Takeaways

- Trade off between overfitting and noisy prediction
- Accuracy at peaks and troughs are most important
- Explore transformer model as an alternative
- Ethical considerations

GitHub Repository Link: https://github.com/elizabethtang/APS360Project

References

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- M. Kachuee, M. Kiani, H. Mohammadzade, and M. Shabany, ”Cuff-Less Blood Pressure Estimation,” UCI Machine Learning Repository, 2015. [Online]. Available: https://doi.org/10.24432/C5B602.
- B. Moody, S. Hao, B. Gow, T. Pollard, W. Zong, and R. Mark, ”MIMIC-IV Waveform Database (version 0.1.0),” PhysioNet, 2022. [Online]. Available: https://doi.org/10.13026/9mw-f949.

Thank you!