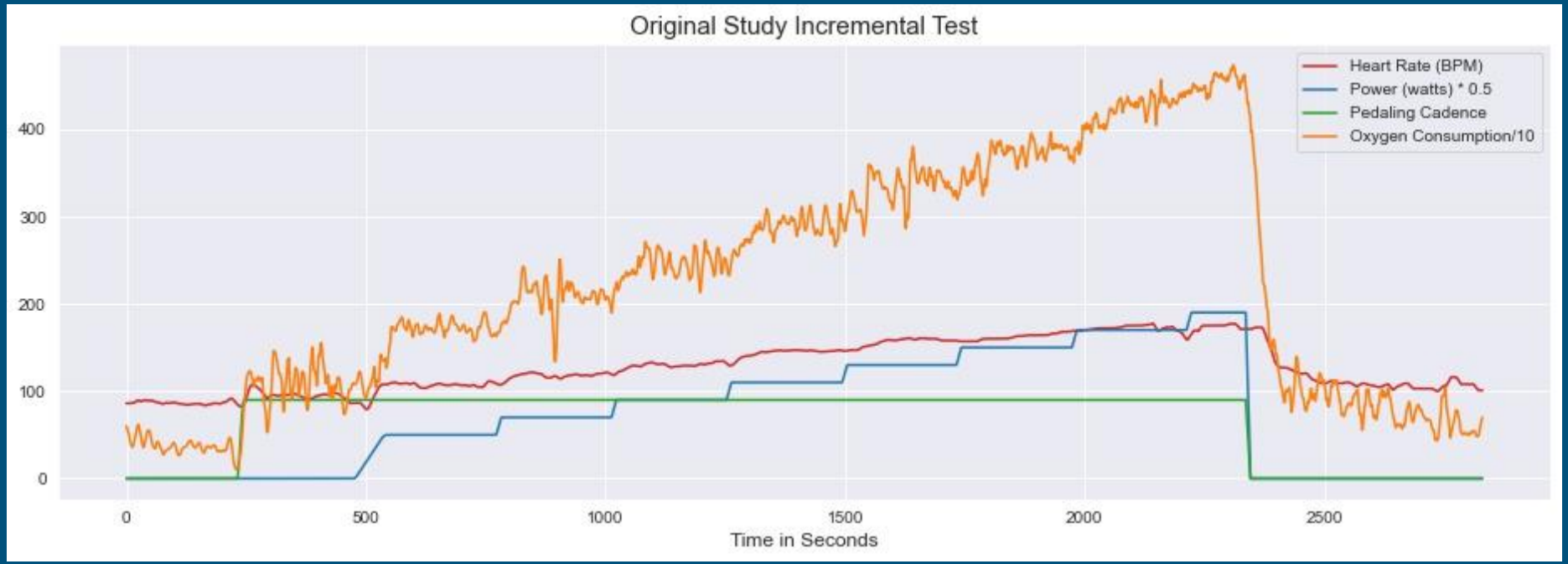
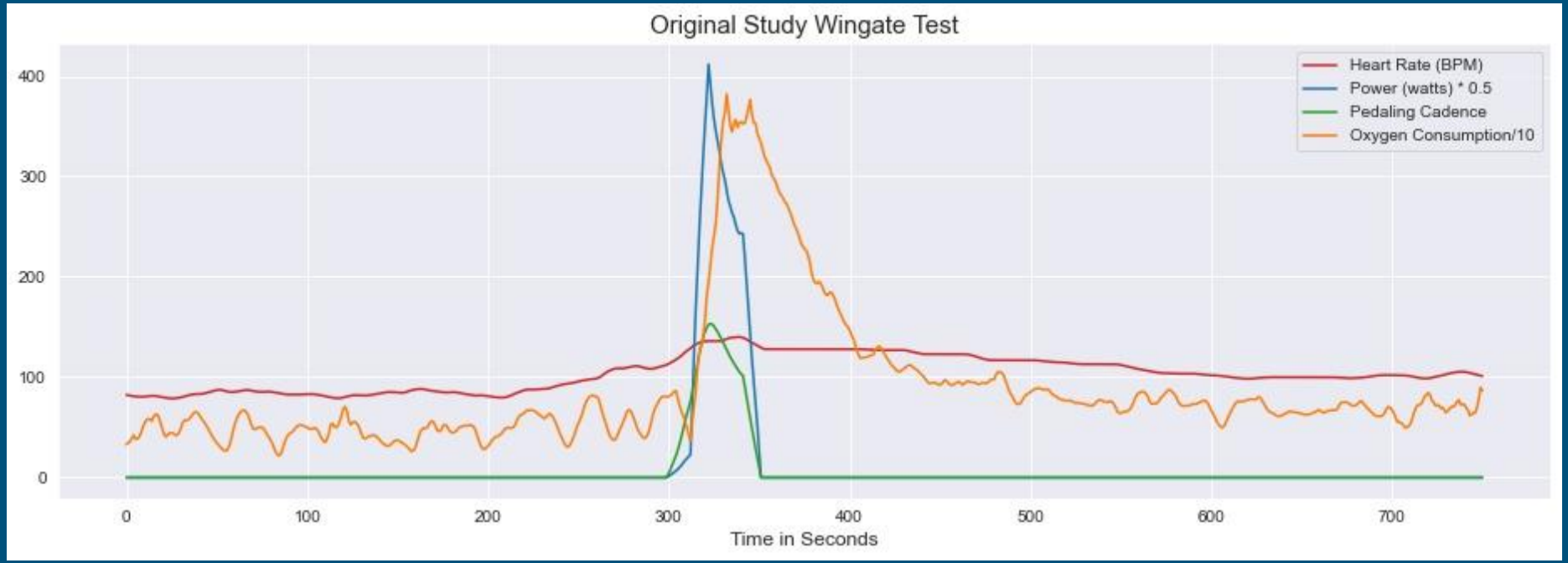
Can physiological performance metrics be reliably predicted with neural networks?

By: Jordan Gates

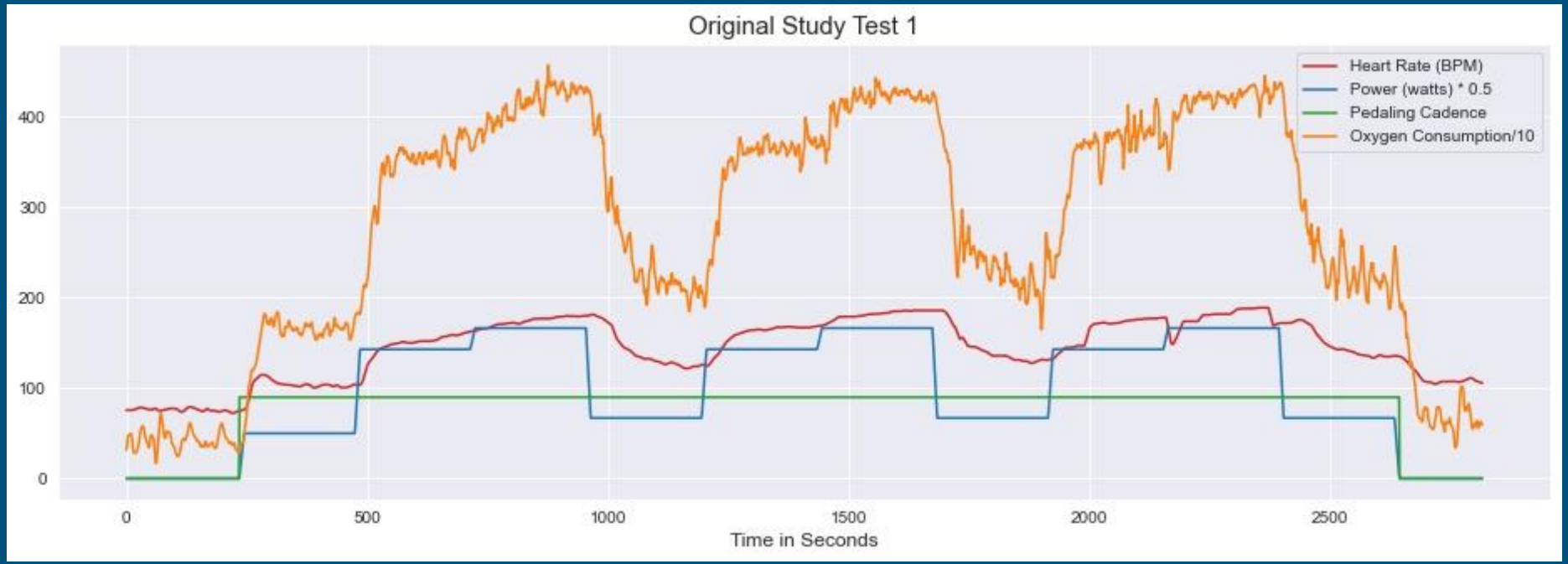
Incremental Resistance Test



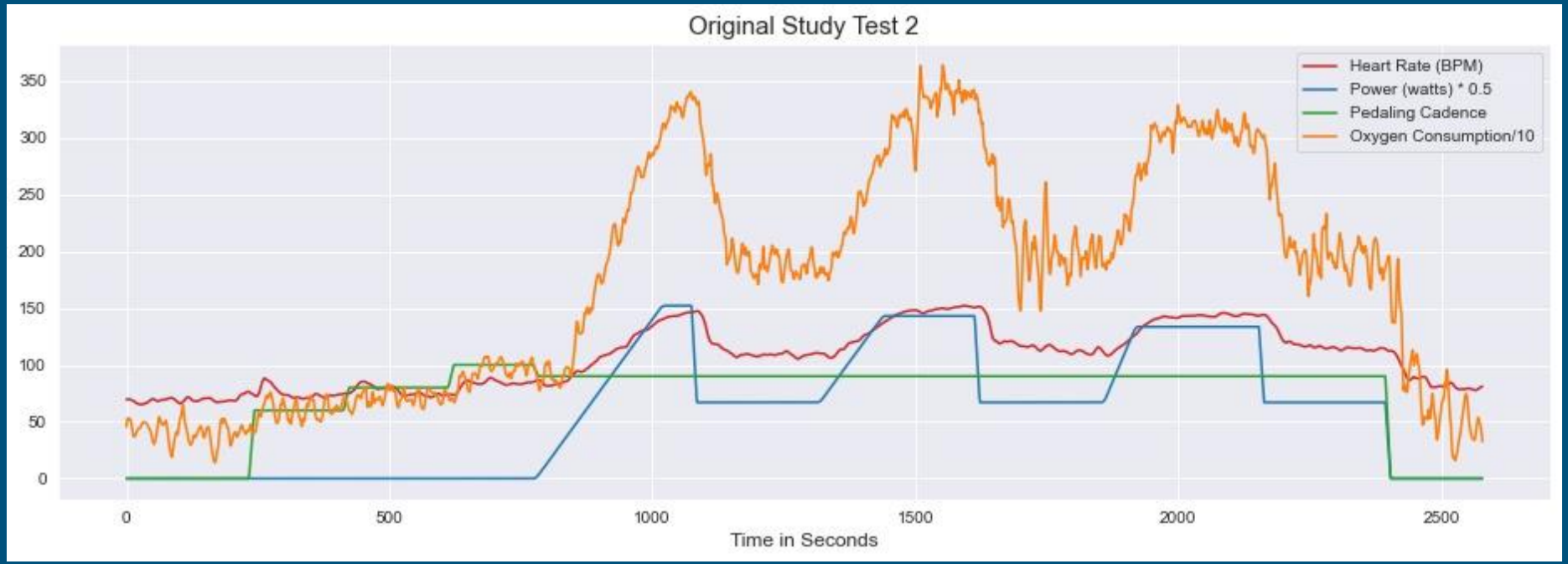
Wingate Test



Interval Test 1



Interval Test 2



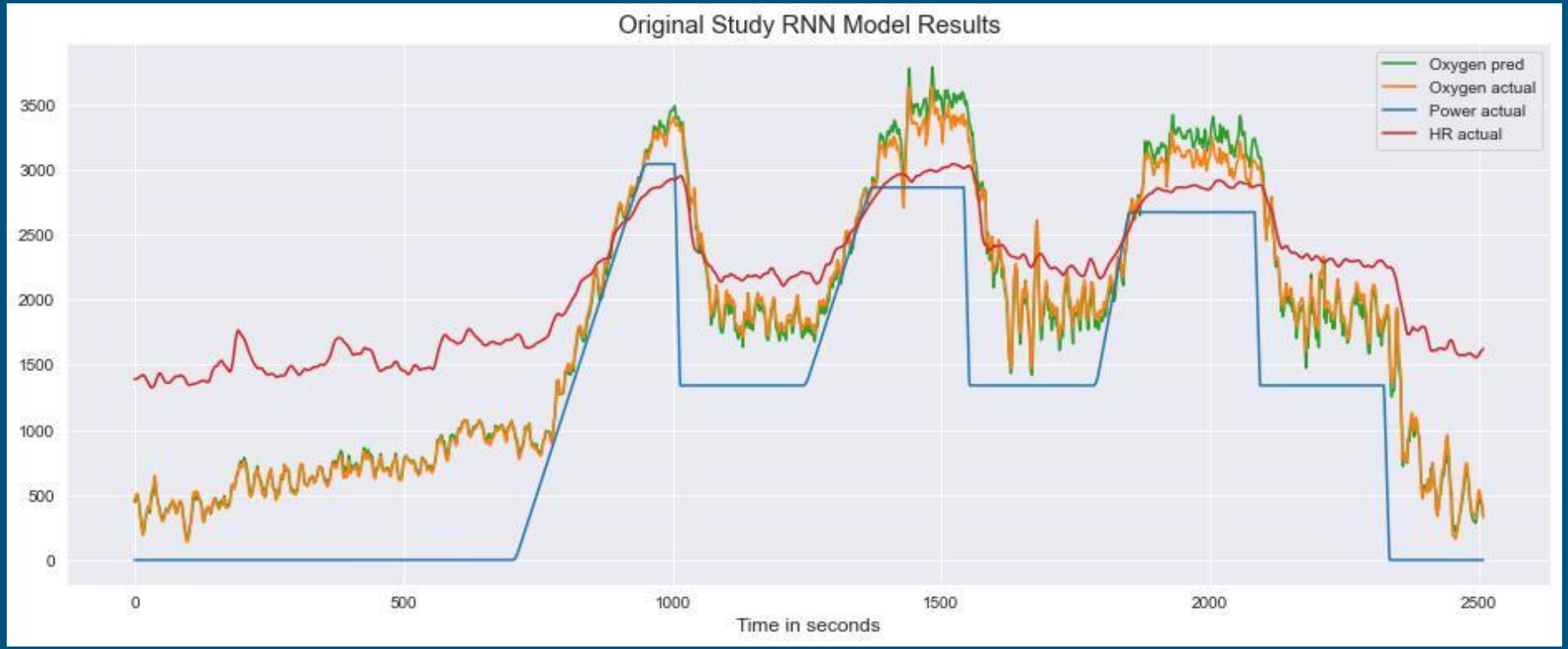
Data Collection and Processing

During each test, Time, Power, Oxygen, Cadence, Heart Rate, and Respiratory Frequency data was collected with the goal of developing a model that would predict the oxygen consumption of an athlete during a cycling workout. For each test subject, three tests were used to train a Recurrent Neural Network (RNN) model with Long Short Term Memory (LSTM) layers.

Original Study Modeling

The model from the original study that was developed produced good results, with an R2 score of just over 0.9 for some tests, but instead of just reusing that model structure, I developed a more complex model that is focused more on optimizing the accuracy of the model at the expense of increased complexity and computing time. It was able to achieve much higher R2 scores, coming in at 0.997 on training data and 0.994 on testing data.

Model Results

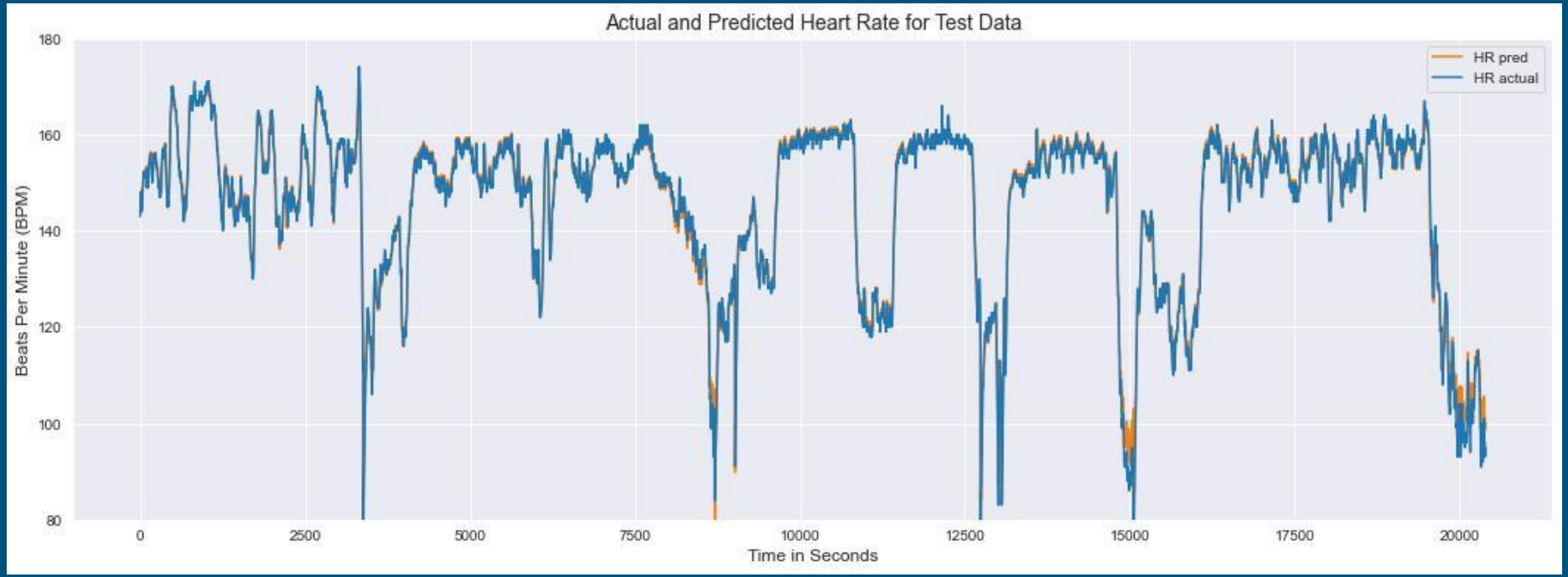


Working With Real World Data

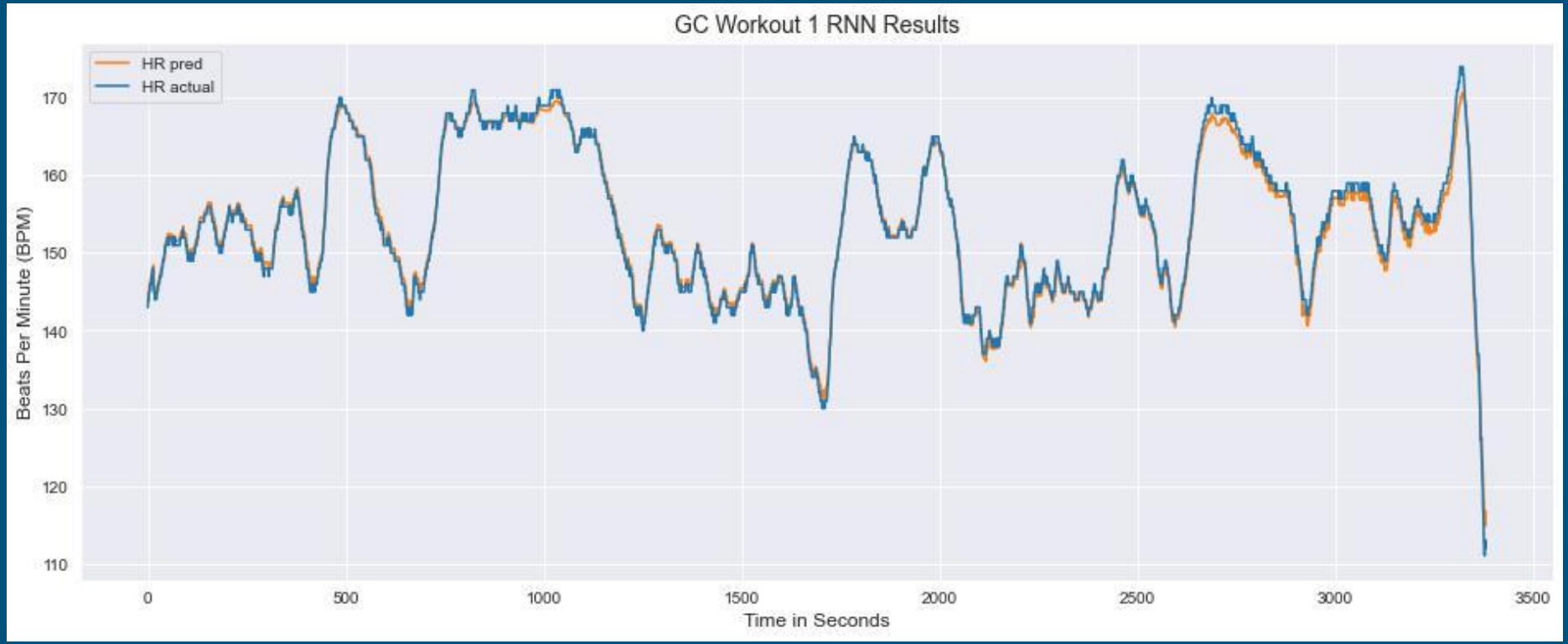
It’s interesting to see how the original study could be reproduced and even improved upon by modifying the RNN structure, but how well would a similar model work on real world data? Could it be used to reliably predict heart rate?

By gathering data from an open source platform called Golden Cheetah (GC) that allows athletes to upload, store, and share their workout data, I was able to test out the RNN model on some real world data.

GC Modeling Results



GC Test 1 Results



GC Test 2 Results

GC Test 3 Results

Conclusion

The RNN model that was used with both the original study data as well as the GC data proved to be very reliable at predicting both oxygen consumption and heart rate.

Potential Areas for Improvement

- The models currently predict one second (row) ahead, but the ability to reliably predict 3 or even 5 seconds ahead would be much more beneficial to users.
- The ability to deploy the GC heart rate prediction RNN model in a mobile phone app that would monitor your power, cadence, and heart rate data, in order to provide real time heart rate predictions would be very helpful to cyclists who are interested in heart rate based pacing strategies, particularly if it could be deployed in a cycling computer.

References

Original Study

- https://www.researchgate.net/publication/339890475_Estimating_an_individual%27s_oxygen_uptake_during_cycling_exercise_with_a_recurrent_neural_network_trained_from_easy-to-obtain_inputs_A_pilot_study

- https://www.kaggle.com/andreazignoli/cycling-vo2/activity

GC Study

- http://www.goldencheetah.org/
- https://github.com/GoldenCheetah/OpenData
- Data retrieved from: http://goldencheetah-opendata.s3-website-us-east-1.amazonaws.com/?prefix=data/
  - file name: 'ffea5c2b-1898-4cbd-8fb4-64502aa4e962.zip'