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Neural Networks for Dissecting Pitching Biomechanics Data

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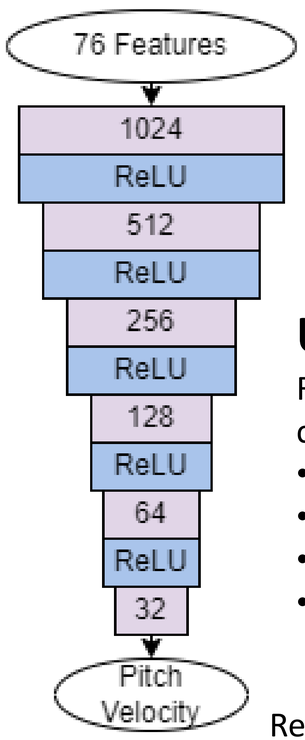
Motivation & Goal

Baseball is at the forefront of using 3D motion capture system to collect and analyze biomechanics data for pitchers and hitters. Pitching velocity is the most sought-after trait for pitchers and a good model provides guidance for player development decisions and evaluation. The goal of this project is to predict pitch velocity and perform feature analysis to determine the value of certain biomechanical traits.

Preprocessing & Tuning

Driveline Baseball's OpenBiomechanics Project includes **411** individual pitches collected in their markered biomechanics lab in Kent, Washington. It includes **76** numerical kinematic features as well as the pitch velocity. After removing rows with missing values and filtering for only numerical features, the data was split **90-10** for training and testing. The training features were **normalized**, and after trial-and-error **mean squared error** and **Adam** were found to be the best loss function and optimizer pair.



Neural Network Architecture

The network uses PyTorch to take an input of 76 biomechanical features and pass the data through **linear layers** accompanied by **ReLU activation functions** before outputting a predicted pitch velocity.

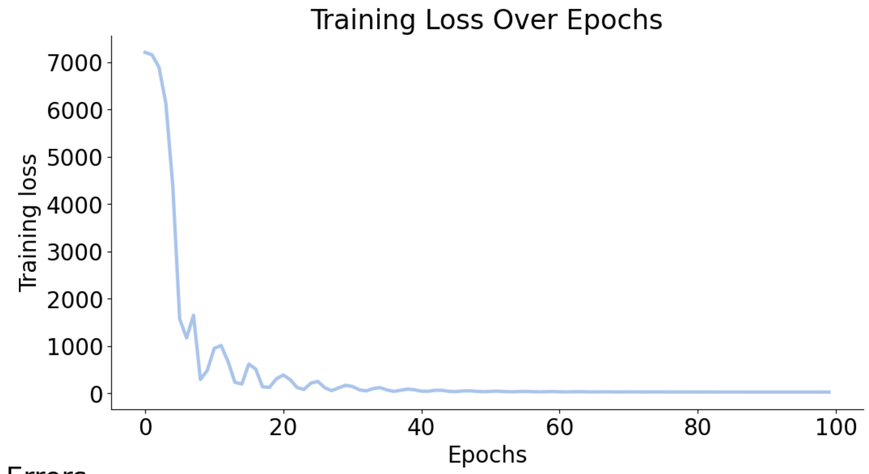
Use Cases

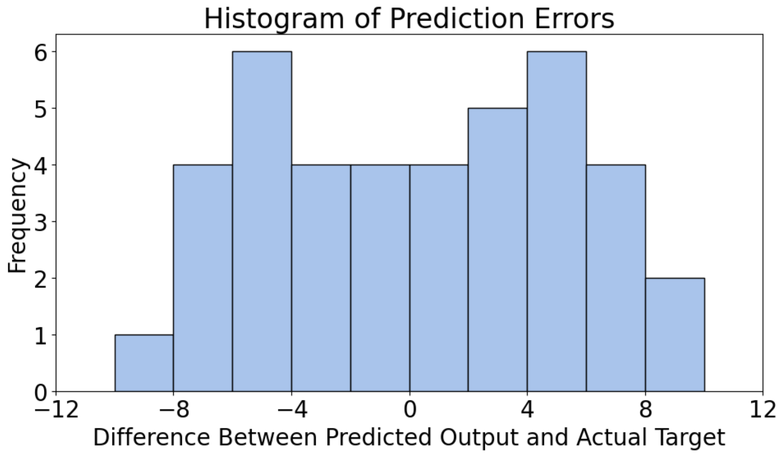
Radar guns can easy measure throwing velocity, but a well constructed model can help answer many questions:

- Where is overall training economy best allocated?
- How much will velocity change if a feature changes?
- How valuable are one's outlier traits towards velocity?
- What features have the best ROI for development?

Results

The network was able to minimize the mean squared error to **24.2** and the average difference between the predicted output and actual target to **5.7 mph**. This is very good given the data does not provide any general physical characteristics like height, weight, or strength metrics.





Feature Analysis

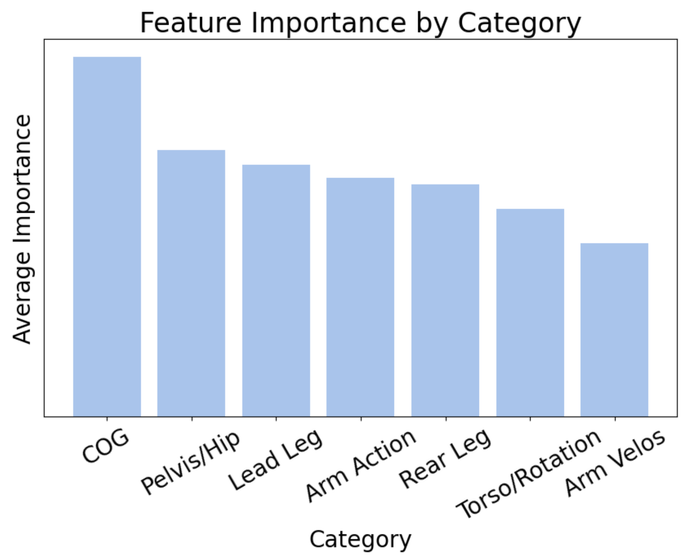
The importance of each features to the output is calculated using absolute gradients. Each feature is manually tagged as a member of a specific category, and each's category mean is used to depict its relative importance.

Most influence on pitch velocity:

1. Max center of gravity velocity
2. Max rotational hip-shoulder separation
3. Shoulder horizontal abduction at foot plant

Least influence on pitch velocity:

1. Rear leg max ground reaction force
2. Torso rotation at foot plant
3. Max elbow extension velocity



References

Boddy, Kyle, and Kyle Wasserberger. "OpenBiomechanics Project." *Driveline Research*, Github, 19 Dec. 2022, Accessed 28 May 2023.