# USING KINETIC AND KINEMATIC PREDICTION MODELS TO CHARACTERIZE ANKLE IMPEDANCE


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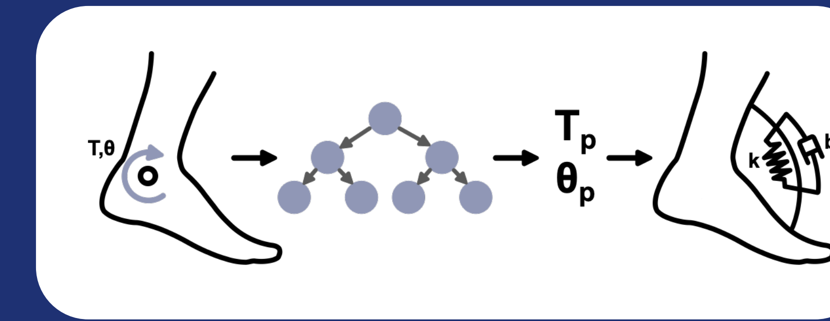
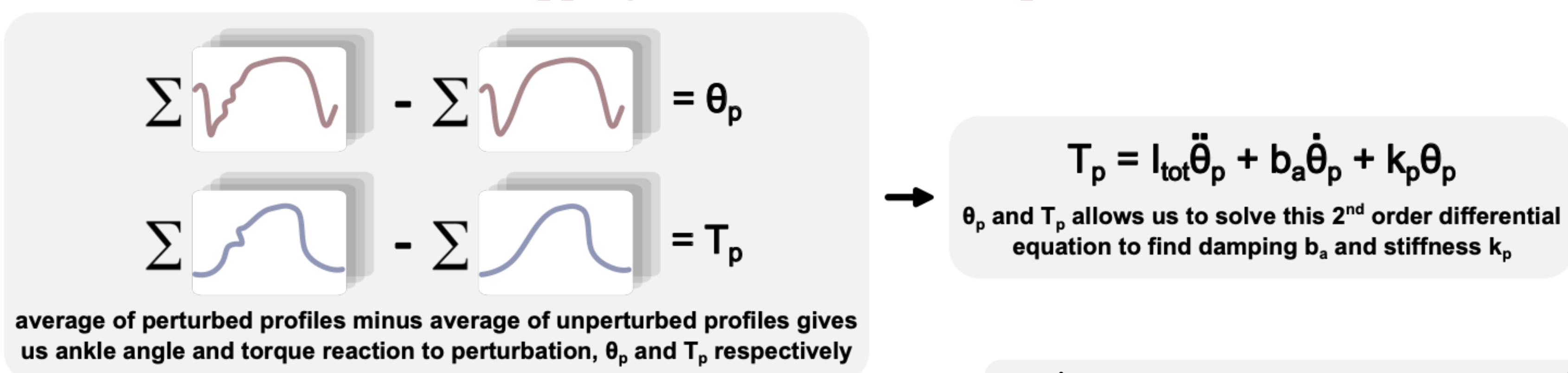



## Introduction

### Motivation

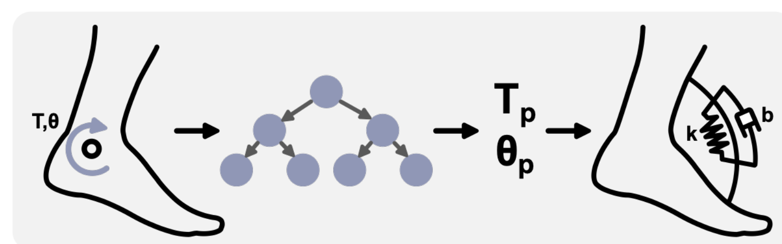
- Joint impedance is important for controlling biomimetic devices and understanding changes in gait following injury
- Characterizing impedance has been done using a bootstrapping method [1] which takes a lot of data

bootstrapping method for ankle impedance

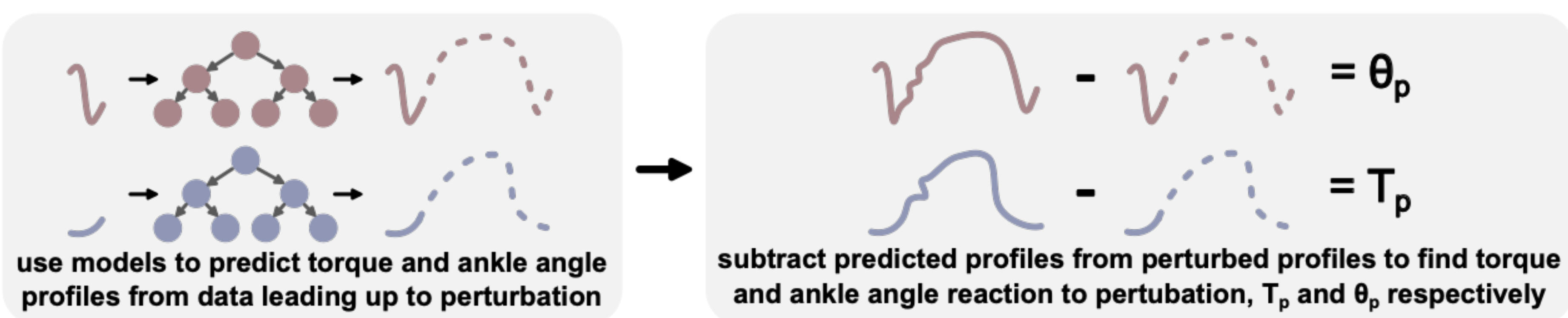



### Objective

- Build a time-series forecasting model to **predict ankle angle profile** following varying points during early to mid-stance




proposed method for ankle impedance

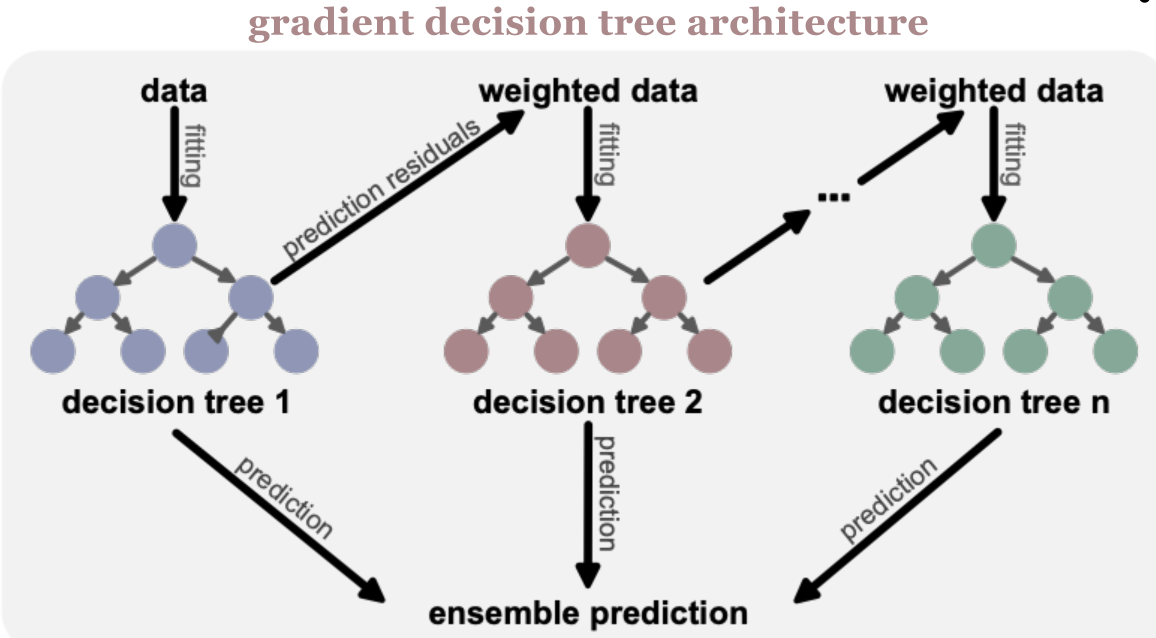



## Methods

### Gradient boosted decision trees

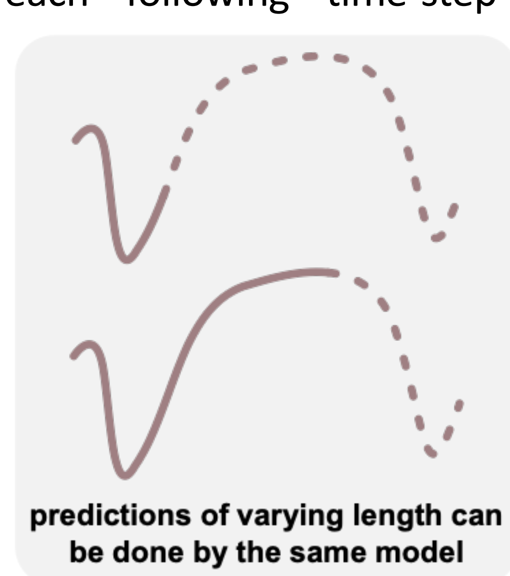
- Used the gradient boosted decision trees **XGBoost** and **LightGBM** regressors to build models and compare performance

gradient decision tree architecture

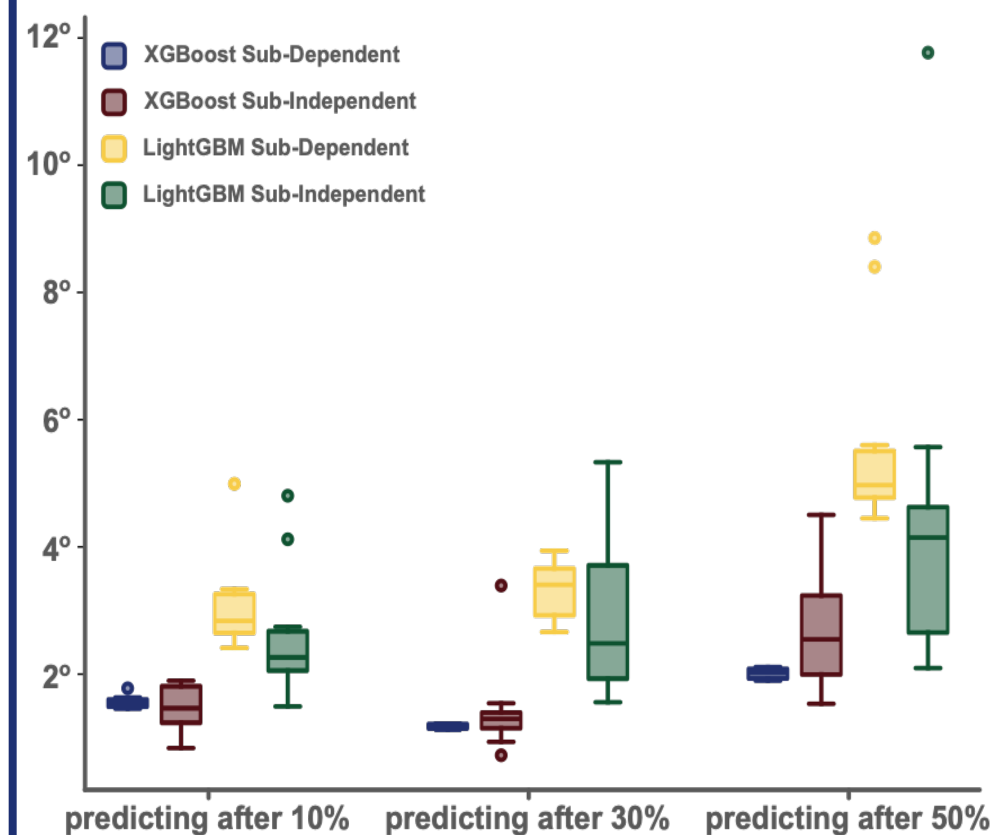



### Data augmentation

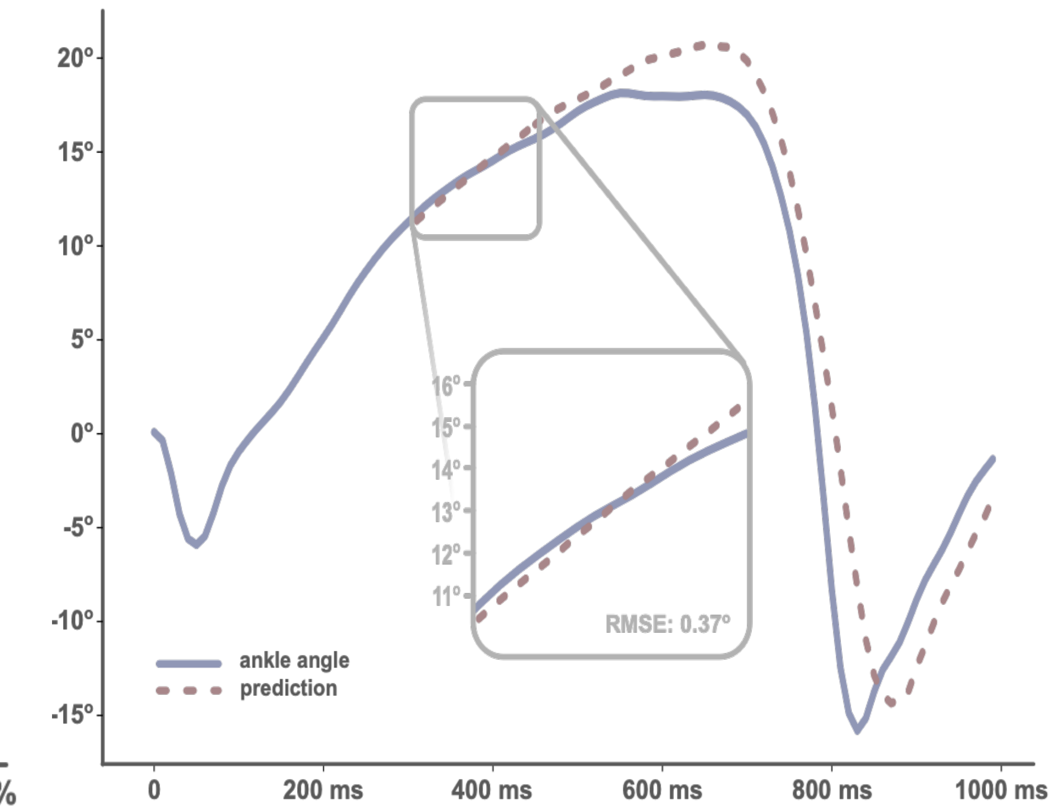
- Formatting the features as an upper triangular matrix for each trial and the labels as each following time-step allows us to use **one model to predict any percent of gait**




## Results




**Validation of models:** RMSE is calculated from the 150 ms following a given % of the gait cycle




**Representative ankle angle prediction:** XGBoost subject dependent model used for prediction

## Discussion

### Future work

**Improving ankle angle model**

- Currently the input feature space only consists of the sagittal ankle angle
- We will expand the feature space to include ankle acceleration, velocity and other (transverse, frontal) plane data as well which might help in improving the performance of the model
- Try different architectures like TCN, LSTM, and boosted neural networks

**Evaluating overall performance**

- Use ankle angle and torque models to characterize impedance for multiple trials from each subject then compare distribution to values calculated using bootstrapping method

**Build torque model**

- Torque model will be built in the same way as the ankle angle model at first
- Might be able to build a model that calculates ankle toque from ankle angle predictions using method laid out in Rouse *et al* [2]

### Alternate application of models

- Kinetic and kinematic prediction models can be used to build exoskeleton controllers or be used as an error feedback to optimize an existing controller

## References


[1] E. J. Rouse, L. J. Hargrove, E. J. Perreault, and T. A. Kuiken, “Estimation of Human Ankle Impedance During the Stance Phase of Walking,” *IEEE Trans Neural Syst Rehabil Eng*, vol. 22, no. 4, pp. 870–878, Jul. 2014

[2] A. L. Shorter and E. J. Rouse, “Mechanical Impedance of the Ankle During the Terminal Stance Phase of Walking,” *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 26, no. 1, pp. 135–143, Jan. 2018



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