Use this to play around and brainstorm how we want to organize and outline the Engineering report, rather than playing around on LaTex w/ Overleaf.

1 Introduction

- Hamstring Injury in NFL
- Current Methods for Rehabilitation (GHD exercises)
- Current method to analyze rehabilitation (i.e Nordbord)
- Limitations of nordbord (difficulty, size restraints, seperate machine that does not represent rehab training
- Purpose of project
    - Incorporate versatility of GHD with sensing capabilities of NordBord

2 Methodology

2.1 Overall Plan

- Develop of method to measure the force output of the hamstrings during various exercises on the GHD. This includes
    - integrating force sensors onto the ankle rests of the GHD
    - Modeling the human body on the GHD for a variety of positions and movements
    - Coverting the measured external force into internal force
    - Providing a user friendly interface to observe and compare the produced data

2.2 Sensors

- Researched different types of force sensors to determine which is the best for measuring ankle reaction force
    - Looked into piezoelectric sensors, load cells, and pressure pads
    - Criteria for selection involved testing for repeatability, ability to physically integrate, price, force capacity, and NordBord method of force measurement
- Designed and built multiple test setups to determine the optimal locations for the load cells
    - Informed designs of test setups with GHD ankle supports
- Process the raw data into a more accessible format (excel)
    - Convert voltage readings from an arduino to lbs or newtons in an excel sheet

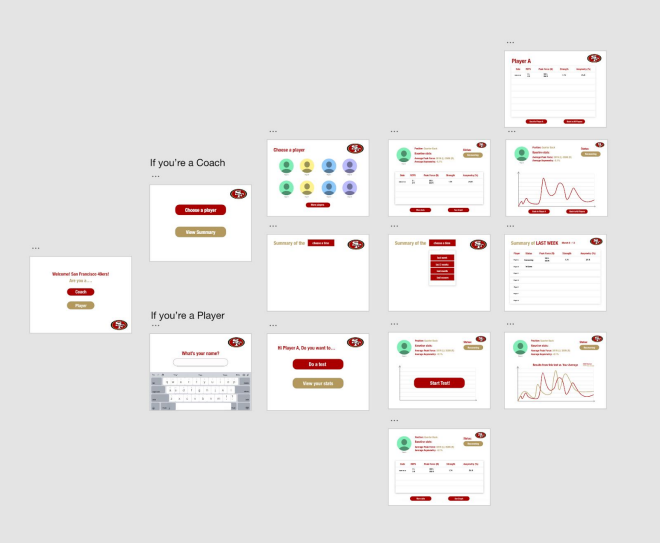
2.3 Biomech Model

- Explanation of model and variables

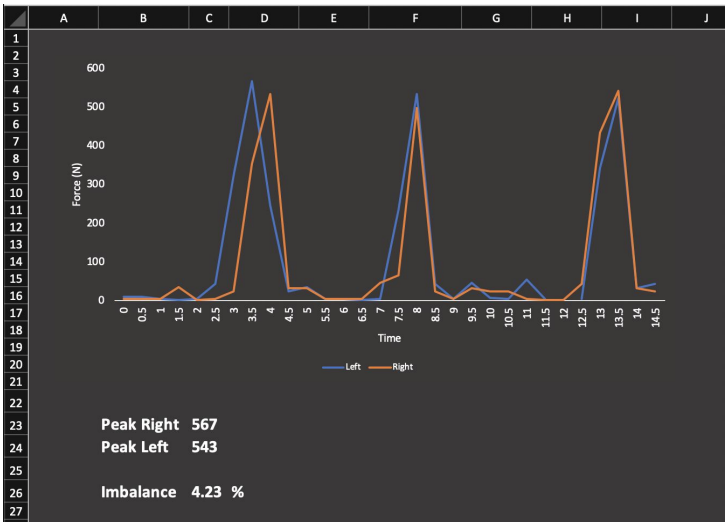
- Walk through of the input to the model, and how we get the output (internal forces
- See overleaf (mostly complete already)

2.4 UI

- Designed a user interface that is able to use data from the strength test sensors and biomech sub-teams using wireframing techniques on Sketch and Adobe XD
    - Takes in in input from sensors, coaches/trainers, athletes (strain gauge data, goals from trainers)
        - Inputs defined by 49ers coaches and biomech sub team
    - Outputs force exerted by both left and right legs over time, peak force and asymmetry
- Created wireframes for:
    - Trainers to input relevant information needed for an athlete and test they want to perform
    - Athletes to perform the exercise
    - Trainers to receive appropriate test information
    - Initial designs:



- Experimented with Excel macro scripts and MATLAB code to export data from MATLAB and immediately plot in Excel with a clear and streamlined User Interface



- Presented design iterations to 49ers coaches and took their feedback into account
    - Main feedback:
        - The player should have as little access to information as possible
        - Should only see the test they are currently taking and then be able to submit it
        - Trainers should be able to see more information like player recovery status and the player's trend over time
    - Implemented this feedback and continued to iterate

3 Results and discussion

3.1 Sensors

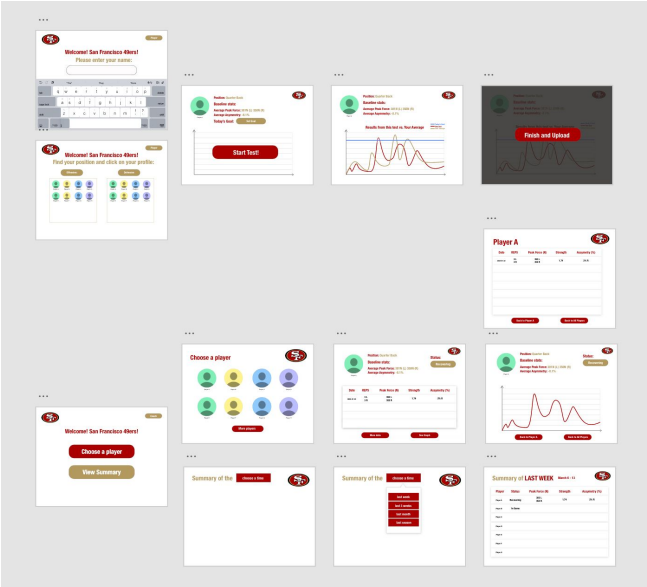
- Determined that a load cell is the best way to go for force measurement
    - Pulling force measurement is more reliable than contact force
    - We were unable to compare detailed effectiveness of specific test setups, but believe that the general direction of test setup is correct
- Example raw data and explanation

3.2 Biomechanical Model

- Show intermediate and final output data of the model. For example, for the given example raw data from sensors, show how the model predicts the knee angle for a given ankle force, and then show the output (Hamstring Force, Joint Force, Knee Angle)

3.3 UI

- Polished wireframe including use cases for a trainer/coach to set goals for players and see their test results and status and for a player to conduct a test



- Integration with the biomech and sensor teams to take in data from the sensors and perform calculations on them and then plot the information in excel

4. Conclusions and Future work

- Integrate sensors and software into a GHD machine to have both the adaptability of the GHD with the force sensing capability of our work