Balance Controlled Electric Skateboard Utilising Membrain Style Force Sensors

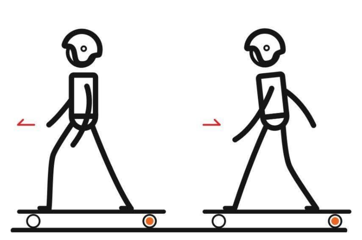
Student: Michael Nevins | Advisor: Dr. Nicholas Kirsch

Department of Electrical and Computer Engineering, University of New Hampshire, Durham, NH 03824

Introduction

Controlling any vehicle that requires balance should be able to be as natural as walking or running but conventional electric skateboards leave much to be desired as they use thumb controlled throttles.

This project set out to solve this issue using membrane style force sensors to determine the riders balance and act to keep them upright whilst also keeping competitive in terms of performance with other conventional boards out on the market.

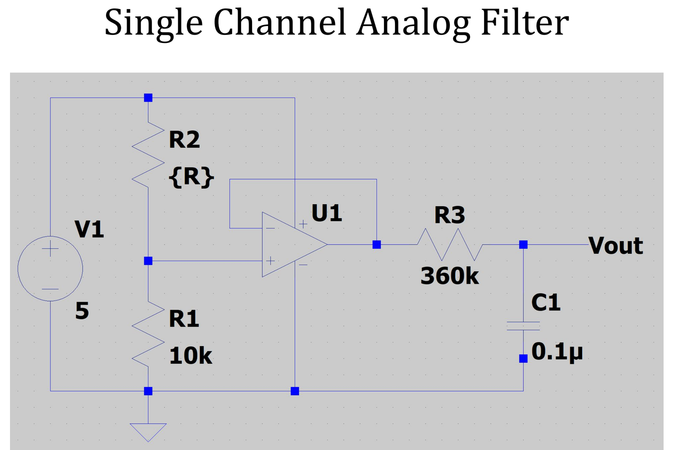


Methodology

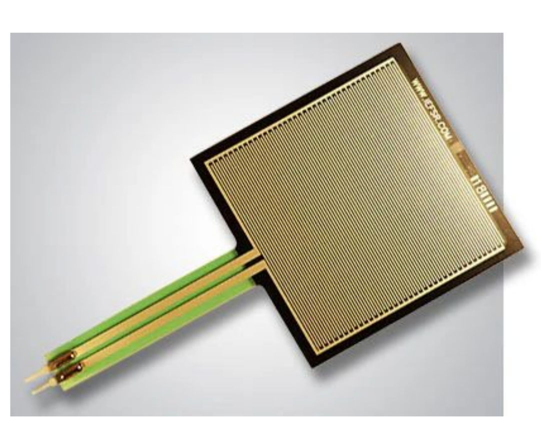
- The force sensors were comprised of 10 FSR UX 400 series force dependent resistors.
- The force sensors are used in the analog circuit depicted below before the signal is sent into the ESP32.
- This circuit produces a signal that is nonlinear to force, which is then read linearized in software using experimentally tested voltage values and known masses.

Analog Systems

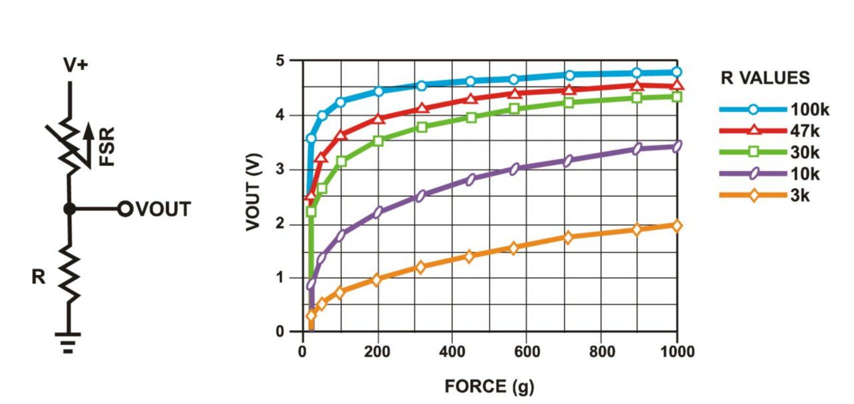
Single Channel Analog Filter



FSR UX 406

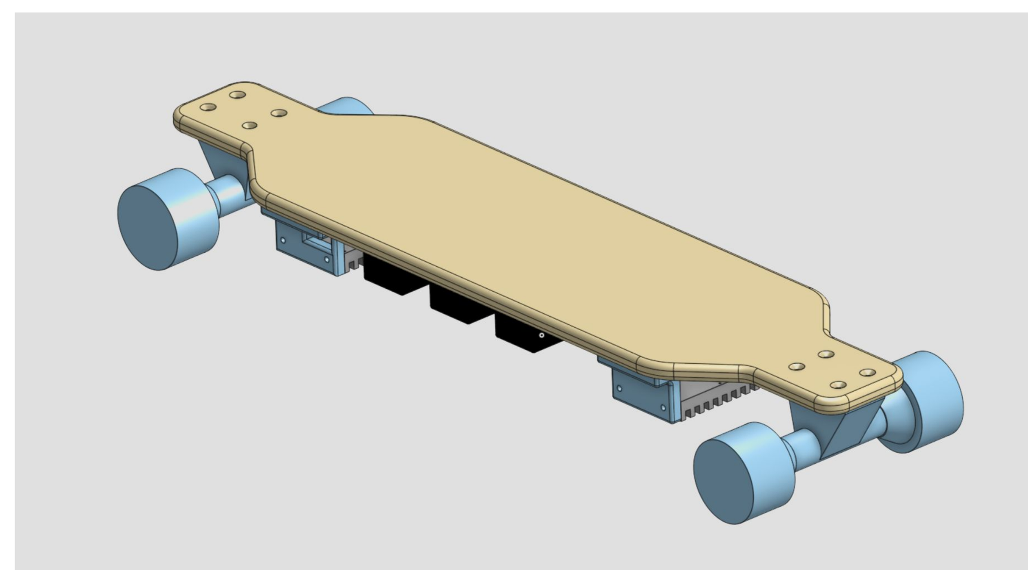


Example of Non-linear Output of Voltage Divider Circuit



Force Balanced Electric Skateboard

CAD Drawing of Full Board

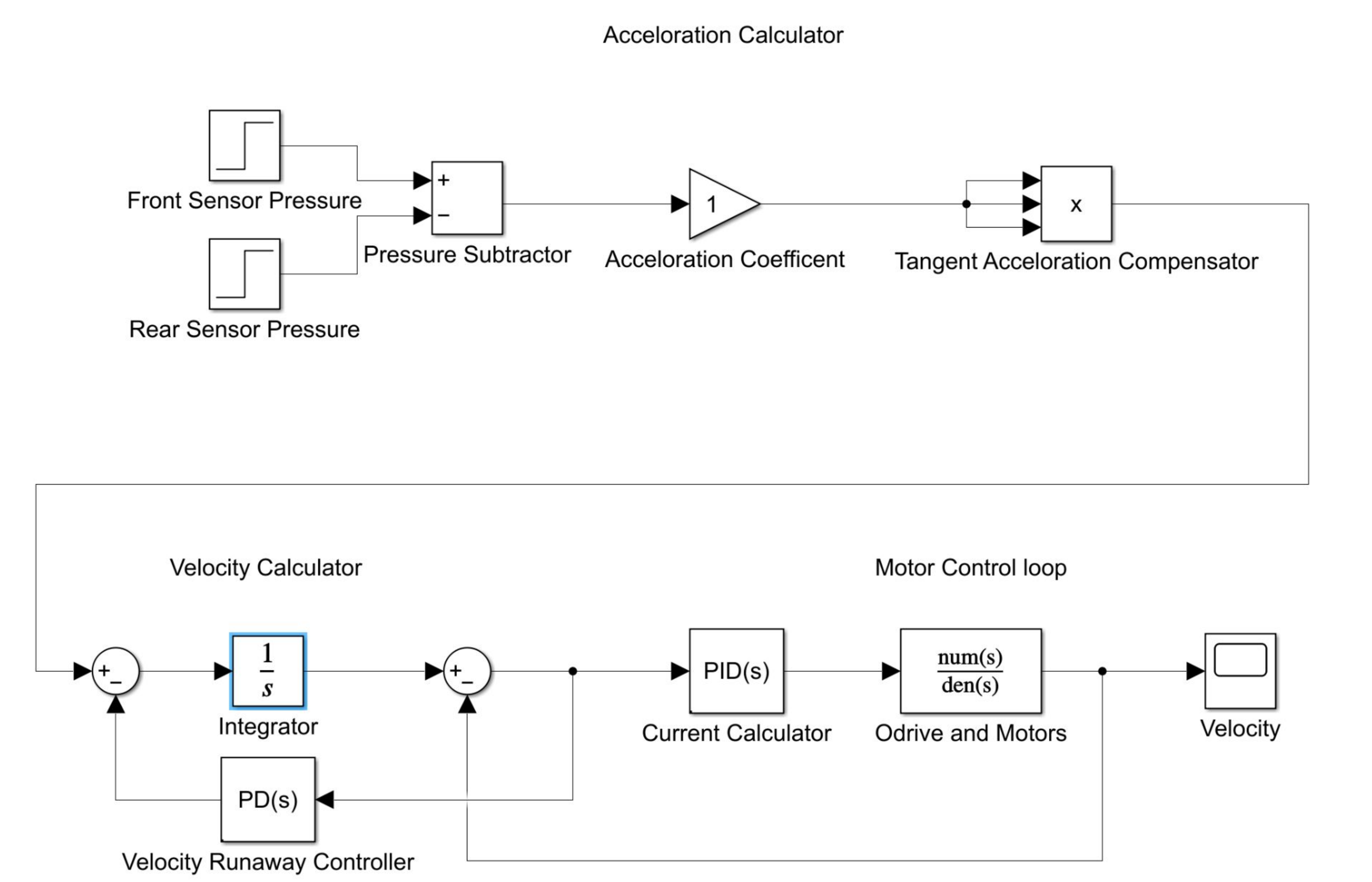


This model was constructed to aid the design of 3d-printed and machined parts.

Braking Test

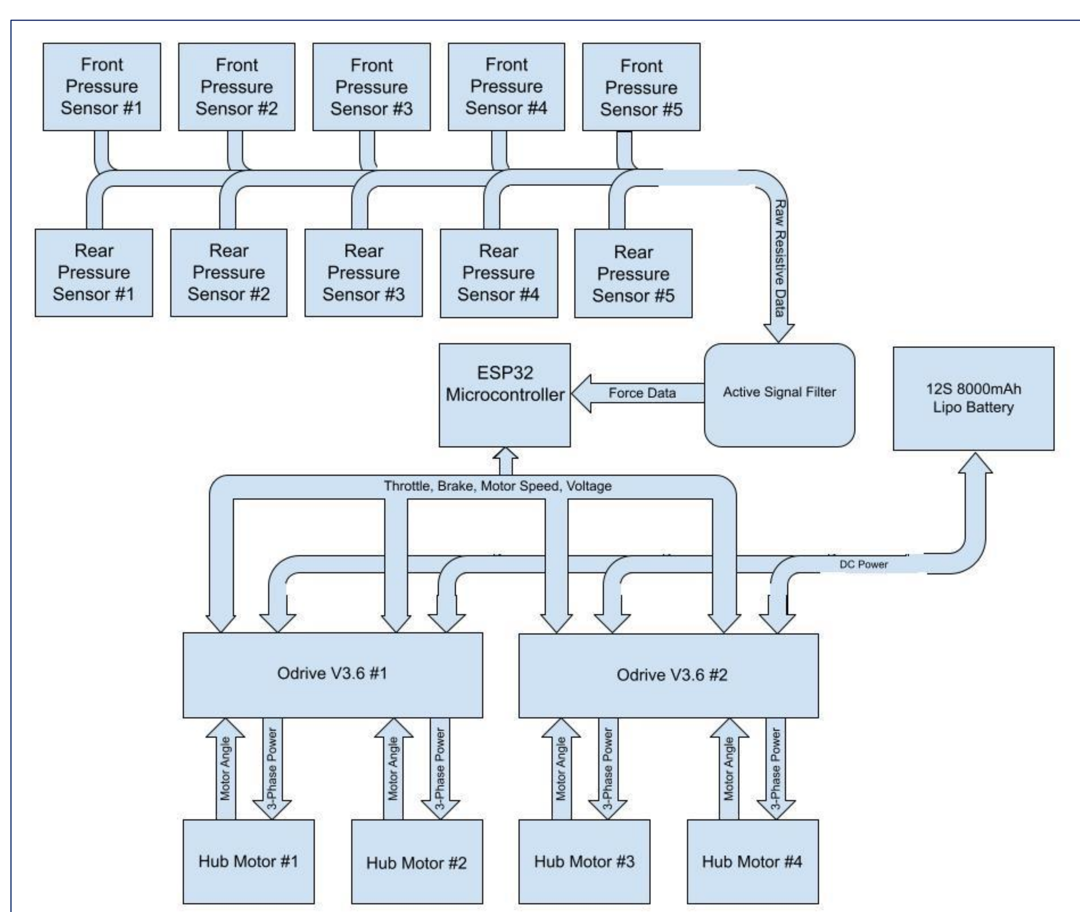
Photo taken during the first high speed braking test

Control System Block Diagram



- The board's control system consists of an acceleration calculator, velocity calculator, and motor control loop.
- The acceleration calculator approximates the acceleration required to keep a person standing at a specific angle by utilizing the force difference between the front and rear pressure sensor.
- The velocity calculator is a simple integrator utilizing negative feedback so the set velocity does not outpace the real velocity.
- The Motor Control Loop is a simple PID based control loop that sends current commands directly to both of drives to produce the desired velocity.

Boards Systems Block Diagram



- The microcontroller chosen for this project was an esp32 for its uart capabilities, number of analog to digital converters, and it's affordability.
- The active signal filter consists of an op amp wired in a buffer mode and an RC filter for each of the 10 channels.
- The Odrives are used to monitor the battery voltage which is then used by the ESP32 to prevent overcharge or over discharge.

Results

Expected Performance	Measured Performance
Motor power, 750W	Motor power, 300W
20 mile range	TBD mile range
20 MPH top speed	17 MPH top speed
Sampling rate 250Hz	Sampling rate 50Hz
Battery capacity 300Wh	Battery capacity 355Wh

Conclusions

The purpose of this project was to set out to find the reason why companies have yet to produce electric skateboards with this control scheme but none was found. The board was discovered to be extremely easy to ride and control in spite of its non-conventional approach which shows great promise for future development.

Errors and Shortcomings

The motor controllers chosen for the board proved themselves to be much more finicky than expected which has been a major source of delay in the Project's timeline.

The board's weight was not taken into consideration during its design as it was only intended to be a prototype but the use of overbuilt components has ended with a board that is over 32 lb. Any future attempts will have to take the weight of components into consideration as the portability of a skateboard is one of its most important features.

Future Work

The one major piece of Board needs before moving forward is custom firmware for the Odrives so they better cooperate with the ESP32 and have a much higher power output.