TEXAS A&M UNIVERSITY
Engineering

Self Balancing robots (BLNC)

Project Lead: Jonathon Foltyn
Sam Woravka, Keith Xavier Fernandez, Caleb Snider, Bryce Chuang,
Jaren Belda, Jorge Espino, Aaron Bailey

TEXAS A&M UNIVERSITY
ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Project Overview

This project aims to explore the principles and applications of self-balancing robots, focusing on the implementation of various control systems and mechanical design to improve stability and usability in various environments. To do this, we will test various sensor configurations, robot designs, and feedback mechanisms.

This semester, we focused on:

- Developing a fixed inertia 2-wheel chassis
- Software for wireless control and setting up PID controller
- developing math model for balancing robots and learning non-linear controls

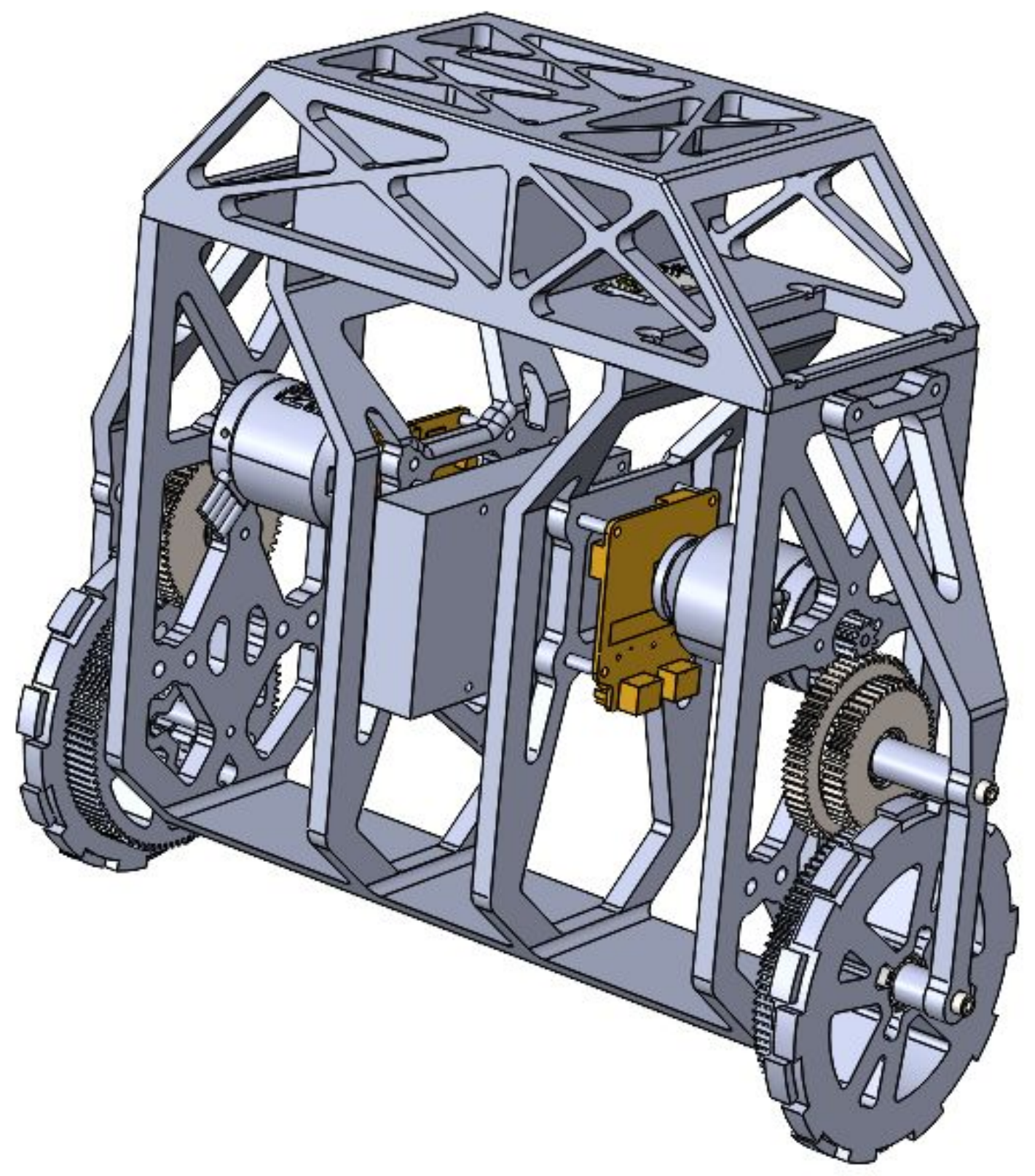

Figure 1. balancing robot V1 model

Engineering Analysis

Mechanical:

- Chassis with high center of gravity
- a 10:1 reduction drive train to aid acceleration

Electrical:

- Neo 550 motors for high torque and speed
- Moteus R4.11 motor controllers
- ISM330DHCX
- RaspberryPi 4B computer

Software:

- Python for all software
- PID Controller

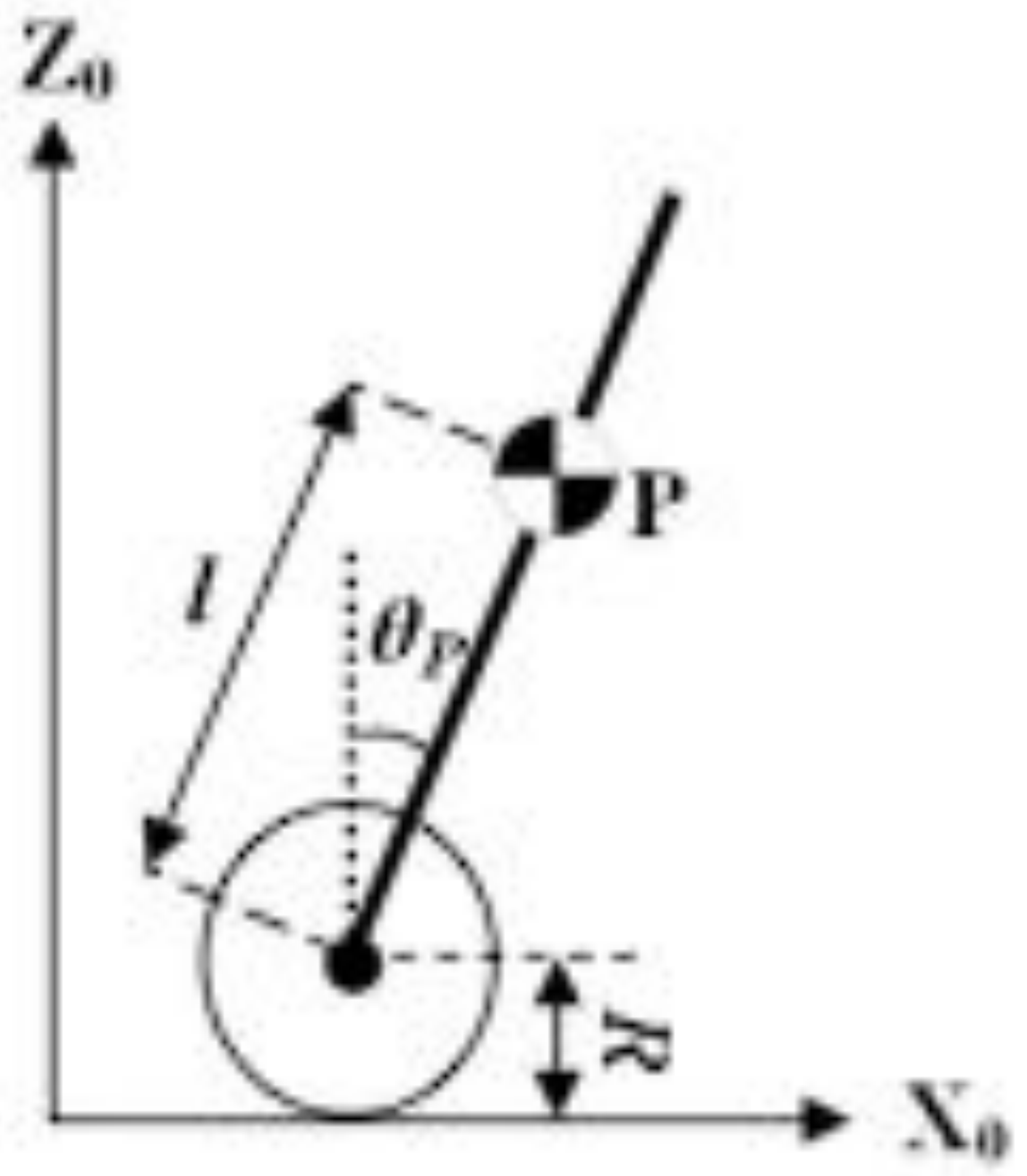

Figure 2. simplified math model of a balancing robot

Modeling

Self balancing robots are an application of the standard inverted pendulum problem. The goal is to maintain a fixed angle, in our case 0 degrees, from the vertical axis. The system can be represented by two main equations, one on the angle of the pendulum and the other the position of the chassis.

$$(I + ml^2)\ddot{\phi} - mgl\phi = ml\ddot{x}$$

$$(M + m)\ddot{x} + b\dot{x} - ml\ddot{\phi} = u$$

Figure 3. Equations of motion for an inverted pendulum

Controller

The PID controller is conceptually simple and easy to implement. It requires only three key gains (proportional, integral, and derivative) and can be tuned to optimize the robot's performance, Alongside this, speed of the controller is critical to the success of the robot. PID controllers also continuously adjusts the control input based on real-time feedback from the robot's sensors. This real-time correction ensures that the robot can react quickly to changes in its state.

Outcomes

Mechanical:

Designed and assembled the V1, fixed CG robot as seen in figure 1. This robot is a test bed for the software sub team to test tuning parameters and various motion planning algorithms.

Software / Electrical:

Wrote PID controller for the robot to correct for angle deviation. Selected new electrical components for shifting to a 15-volt system. Derived absolute angle position from accelerometer and gyroscope sensors.

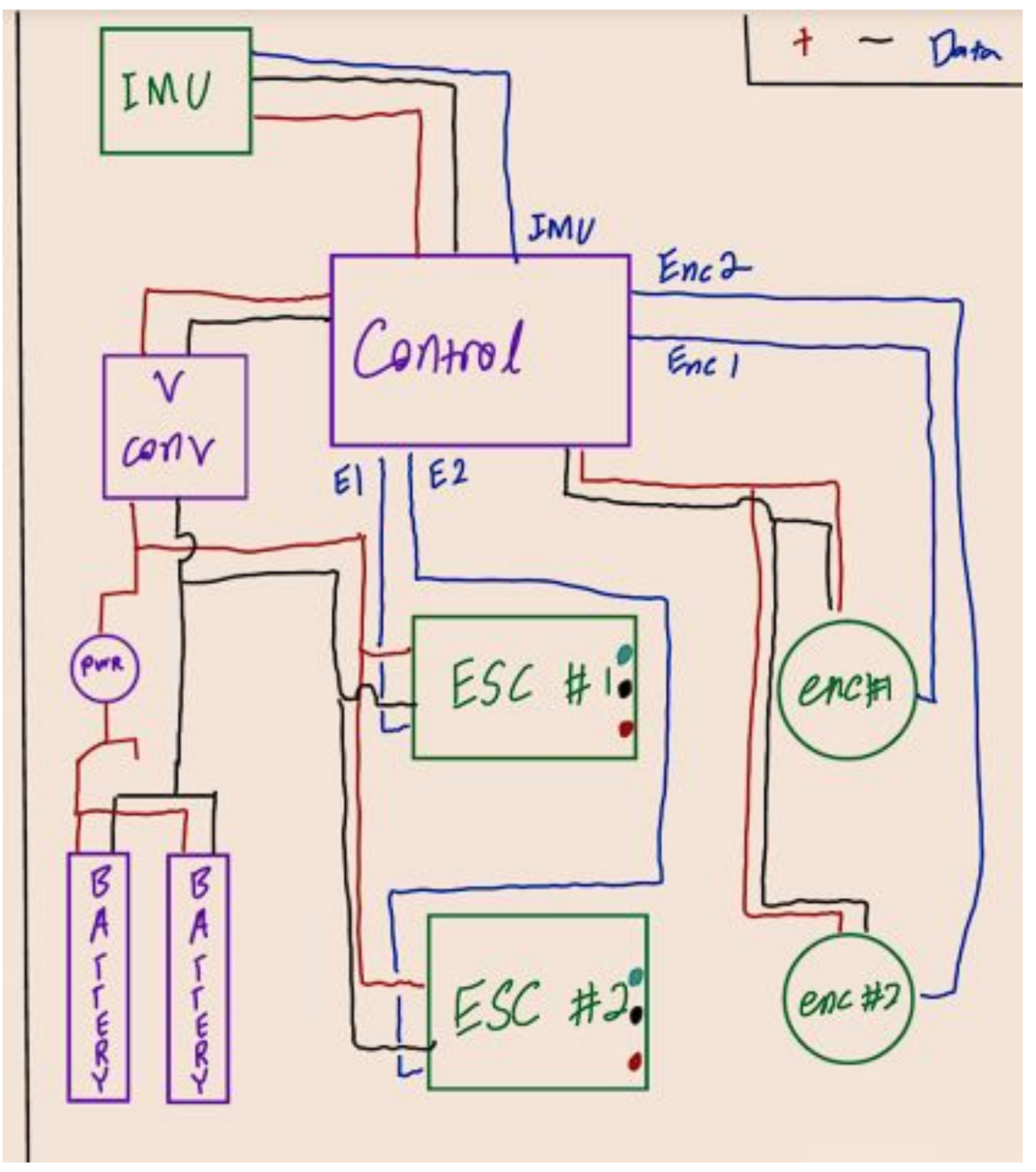

Figure 5. Electrical schematic for the V1 robot

Future Development

- Testing and optimizing a balancing PID controller for the fixed inertia robot
- Begin designing a system to balance on a spherical surface.

Texas A&M University Robotics Team and Leadership Experience (TURTLE) Lab