TEXAS A&M UNIVERSITY Engineering

Self Balancing robots - BLNC

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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 V1 chassis for a fixed CG robot
- Software for wireless control and setting up PID controller
- developing math model for balancing robots and learning non-linear controls

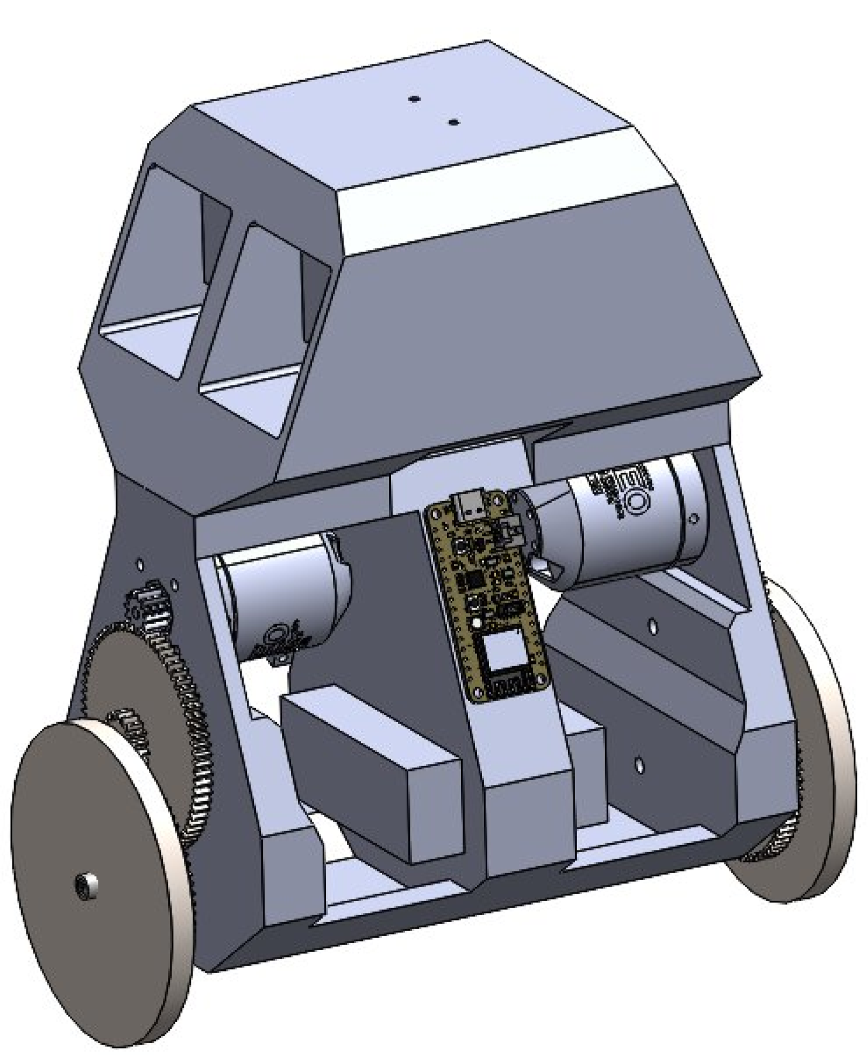

Figure 1. balancing robot V1 model

Engineering Analysis

Mechanical:

- Chassis with high center of gravity
- a 21:1 reduction drive train to aid acceleration

Electrical:

- Neo 550 motors for high torque and speed
- ODESC motor controllers
- IMU and built in motor encoders
- RP2040 and ESP32 controllers

Software:

- Arduino as the main programming software
- PID Controller for simplicity

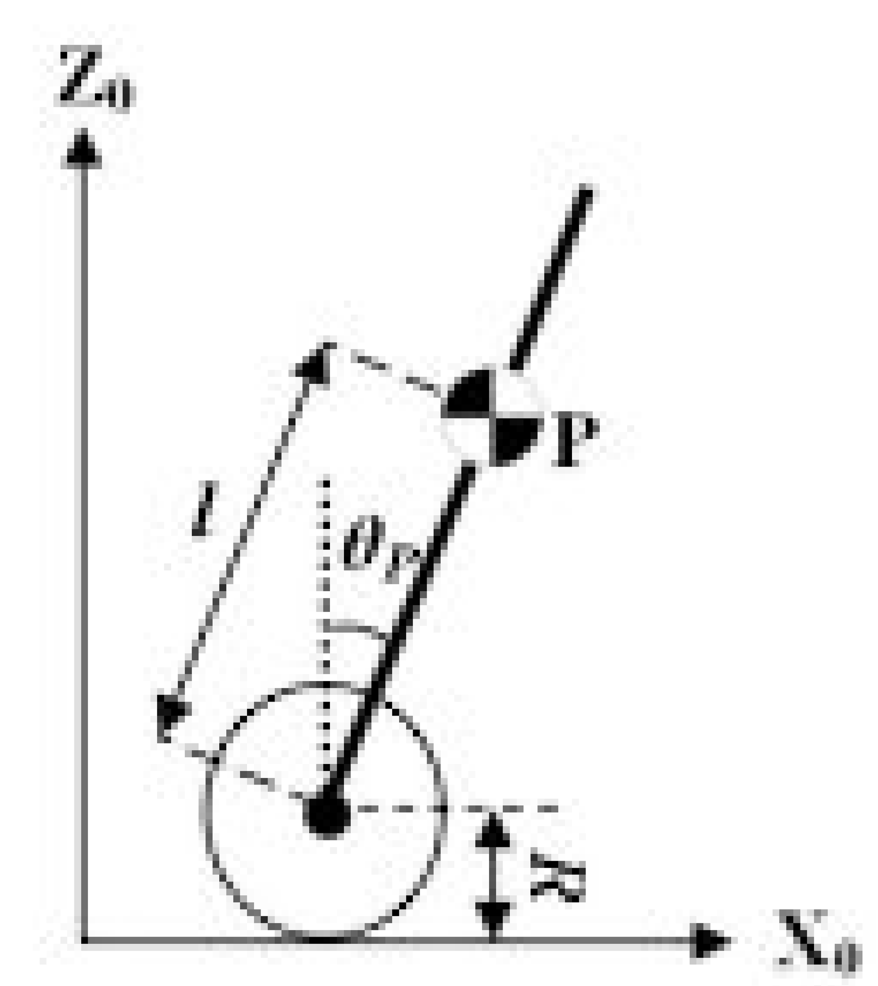

Figure 2. simplified math model of a balancing robot

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 parameters: proportional, integral, and derivative gains 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:

This semester made CAD models for 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:

This semester we established which microcontroller to use alongside wireless communication to the robot. To talk to everything on the robot, we are using a mixture of I2C and CAN due to simplicity and wide support.

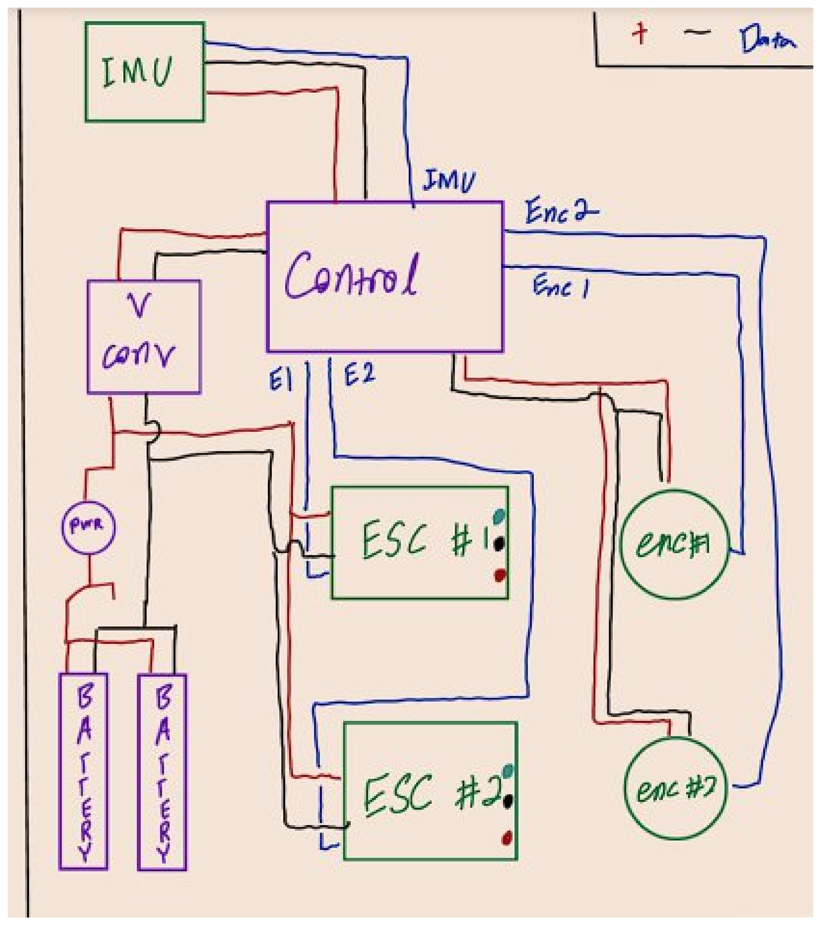

Figure 5. Electrical schematic for the V1 robot

Future Development

- Testing and optimizing a balancing PID controller for the fixed inertia robot
- Begin development of omni directional chassis on a sphere instead of wheels
- Begin CAD and development of a variable inertia wheeled robot to test self correction

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