A Hopping Two-Wheeled Segway

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Abstract

Two-wheeled mobile robots (such as Segways) provide a high level of mobility and maneuverability and have great potential to be adopted in real-life settings. However, the current Segway platforms available in the market are unable of navigating unstructured environments. Our team took a commercial Segway and modified it to be driven autonomously and support a jumping mechanism. The Segway was retrofitted with an embedded control system and motor drivers. The final design provides a new class of two-wheeled mobile robots that employ jumping as a means of locomotion in non-continuous terrains.

Objectives

- ➢ Develop a Segway with the ability to:
- ❖ Self-balance
- ❖ Drive autonomously on different terrains
- ❖ Avoid obstacles through jumping

Jumping Mechanism Design

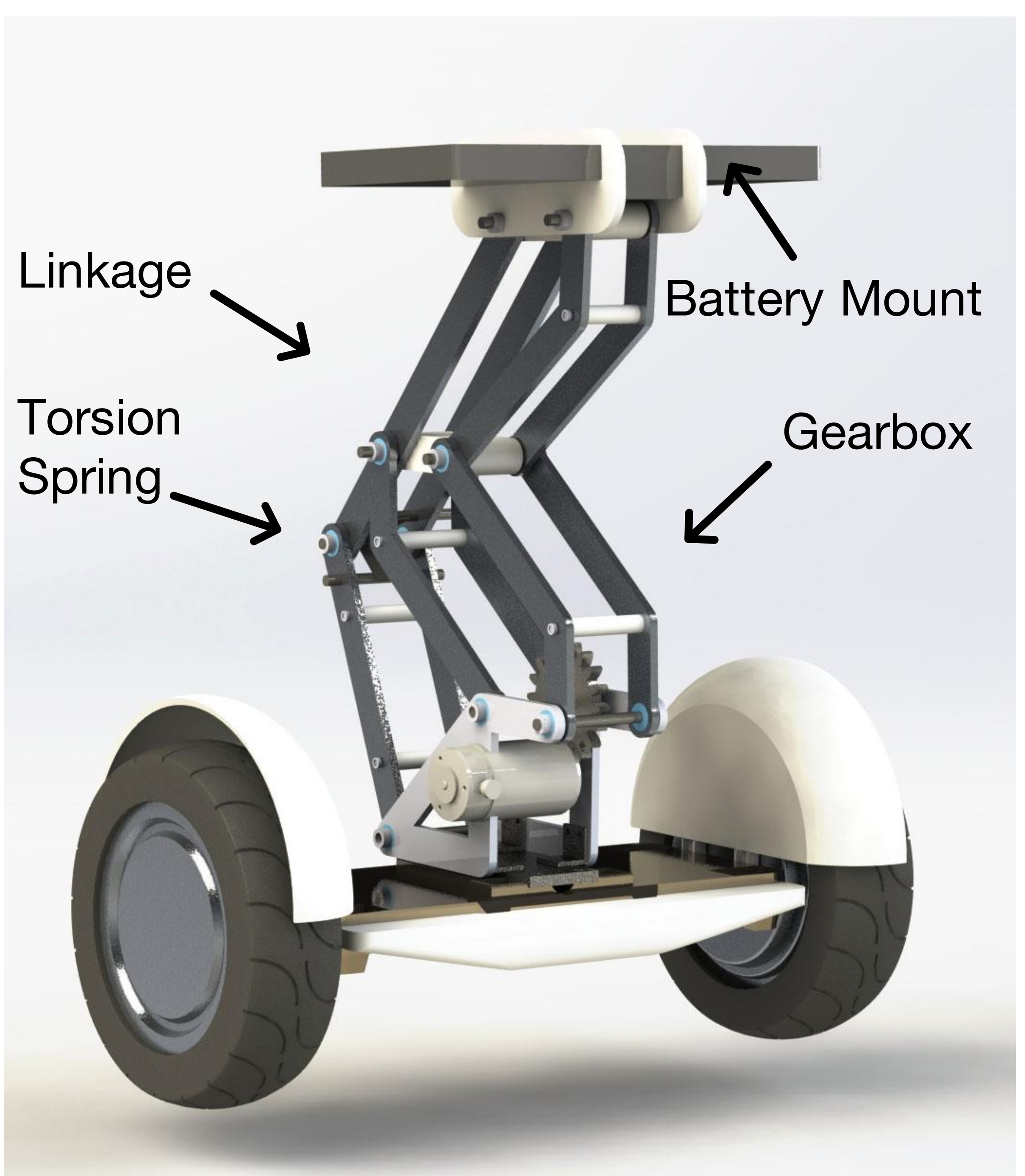

Figure 1: CAD Render of the Segway with Linkage Attached

Issues:

- ❖ 'Black box' manufacturer design
- ❖ Cannot be driven autonomously
- ❖ Feedback controller cannot be adjusted to achieve different performance
- ❖ Unable to navigate non-continuous terrains

Our Method:

1. Tear down the current Segway platform
2. Design and implement a custom embedded system for autonomous control
3. Design and implement a feedback control design
4. Model and prototype a jumping mechanism
5. Evaluate the performance of the design both in simulation and hardware experiments

Figure 2: Stock Segway

Figure 3: Modified Segway stabilizing autonomously

Brushless Motor Driver & Embedded System Design

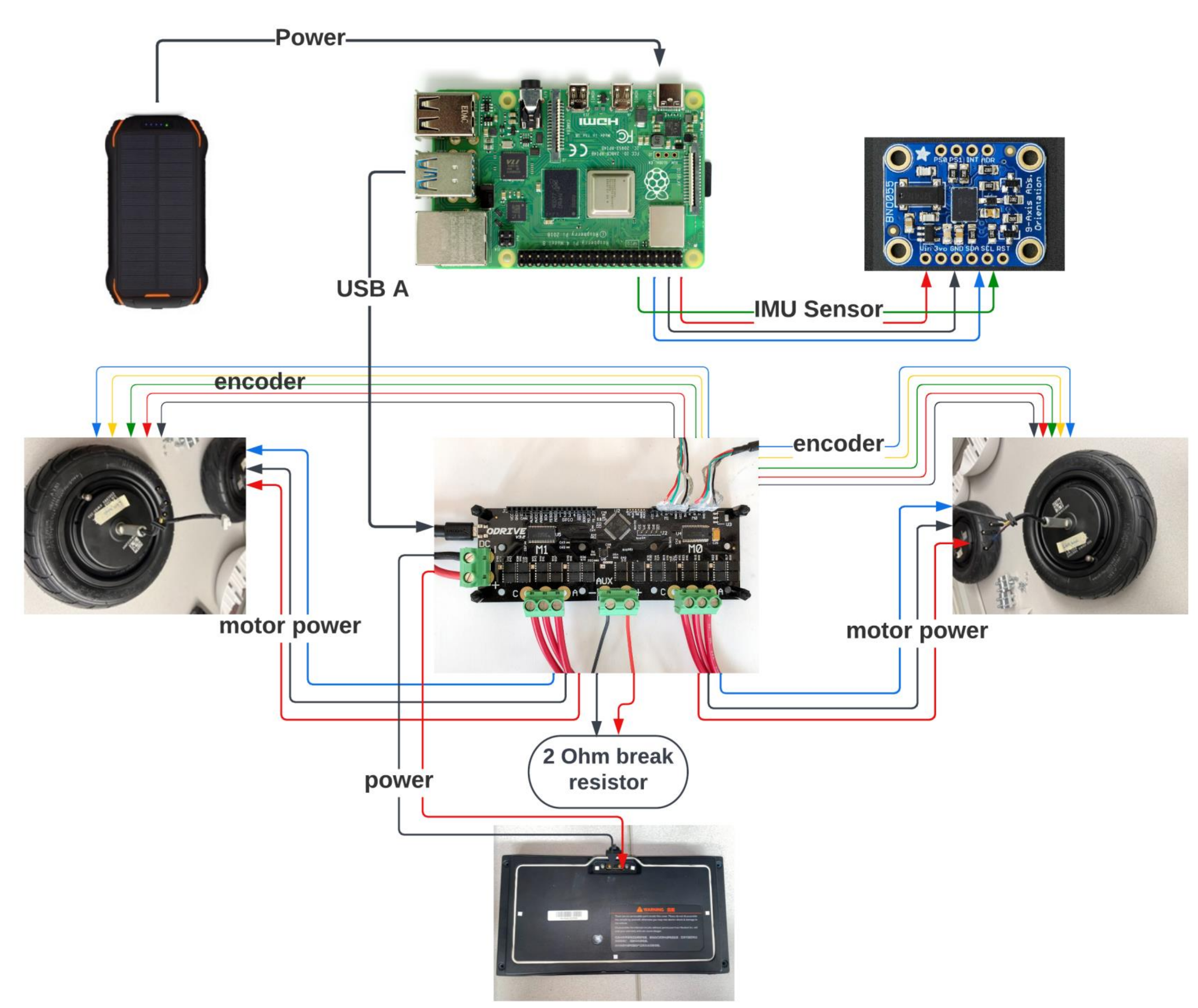

Figure 4: Wiring diagram for the brushless motors driver and the embedded system developed for the system

Self-balancing Control System

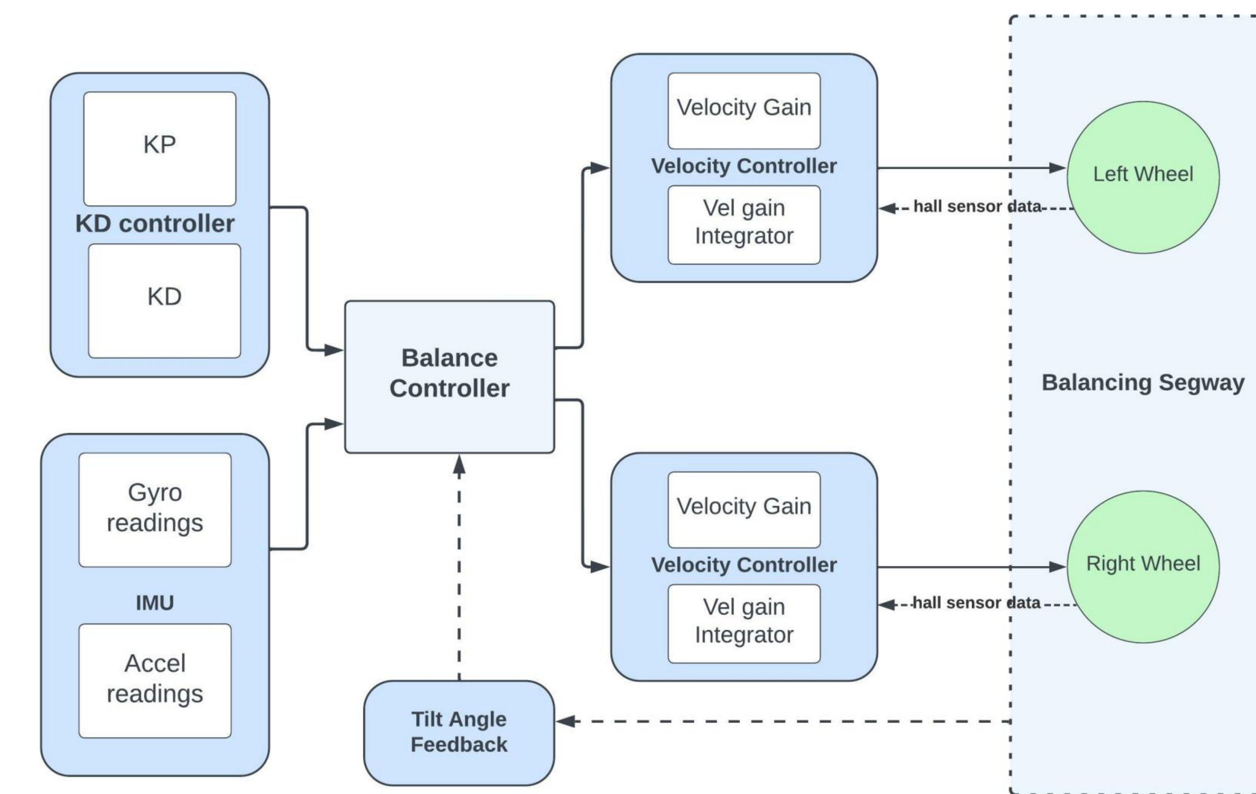

Figure 5: Control system block diagram for sensing and stabilization

Simulation

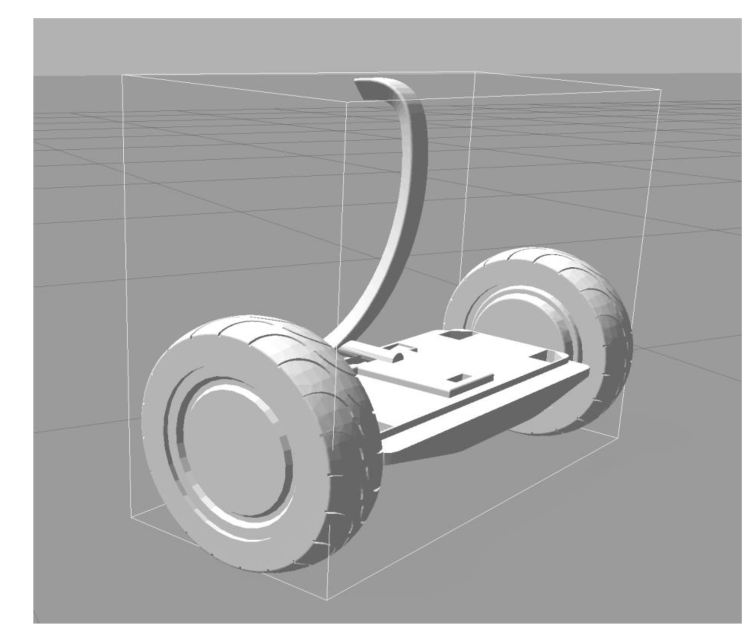

Figure 6: Segway in Gazebo simulation

A ROS-enabled Gazebo simulation environment for testing Segway control:

- ✓ Physics-based CAD model created in Solidworks
- ✓ Evaluation of control programs/parameters done in simulation to inform 'real' values

Achievements

- ✓ Autonomous self-balancing control mechanism
- ✓ ROS-enabled simulation in a physics-based environment
- ✓ Design and prototyping a custom jumping mechanism

Future Work

- ❖ Implement additional sensors to aid in control of the robot, e.g., Lidar sensors and industrial level IMUs
- ❖ Incorporate the jumping mechanism in the simulation model for further analysis and experiments.