Study of 2 wheeled self stabilization

binamics

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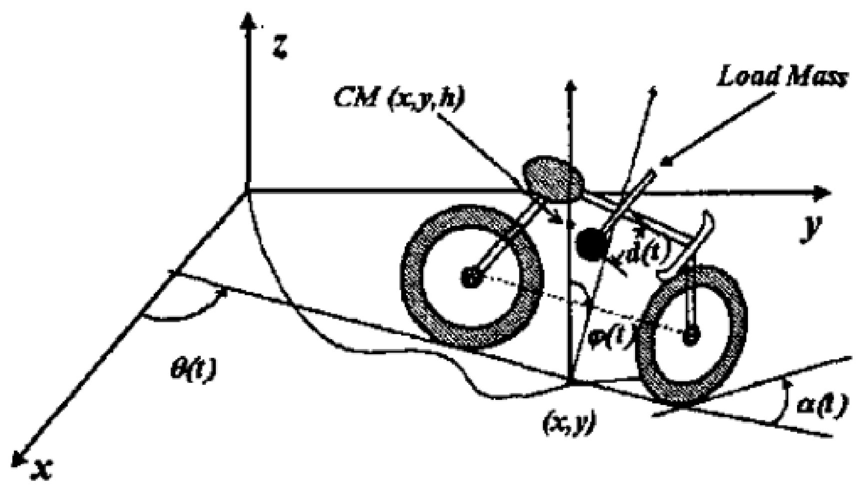
How to control it?

Our goal is to create a control system that can take advantage of the self stabilizing geometries of a bicycle. We are going to build an scale bike defined by the following parameters to do this.

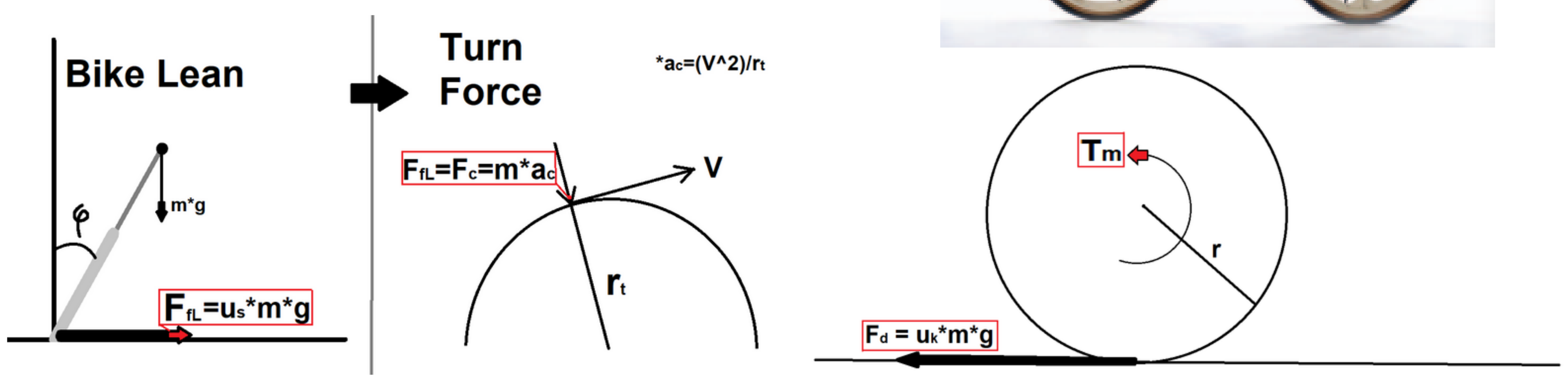


We do this so that we can replicate the model in all sizes and dimensions for riderless applications.

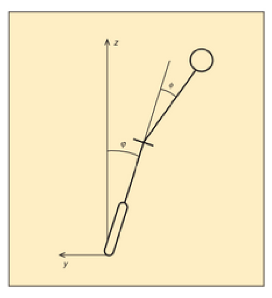
Theory

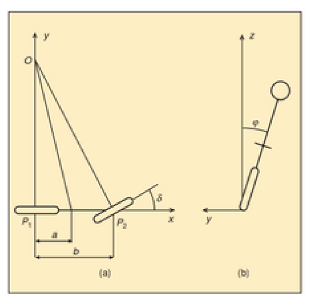
Using previous works:

- Develop Transfer Functions
- Define parameters of study
- Understand self stabilization phenomena
- Viable platforms (right)
- Analyze equations of motion
- Create static balance equations



Components



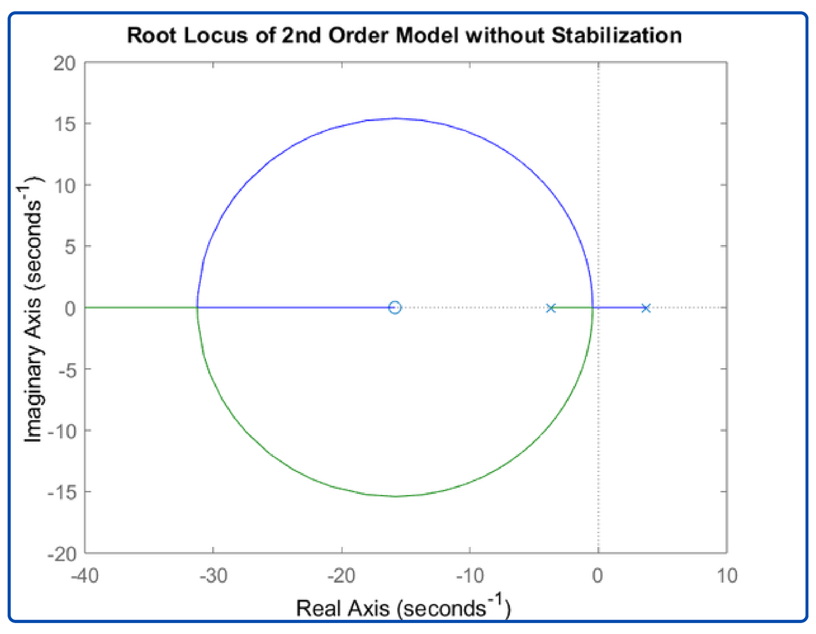


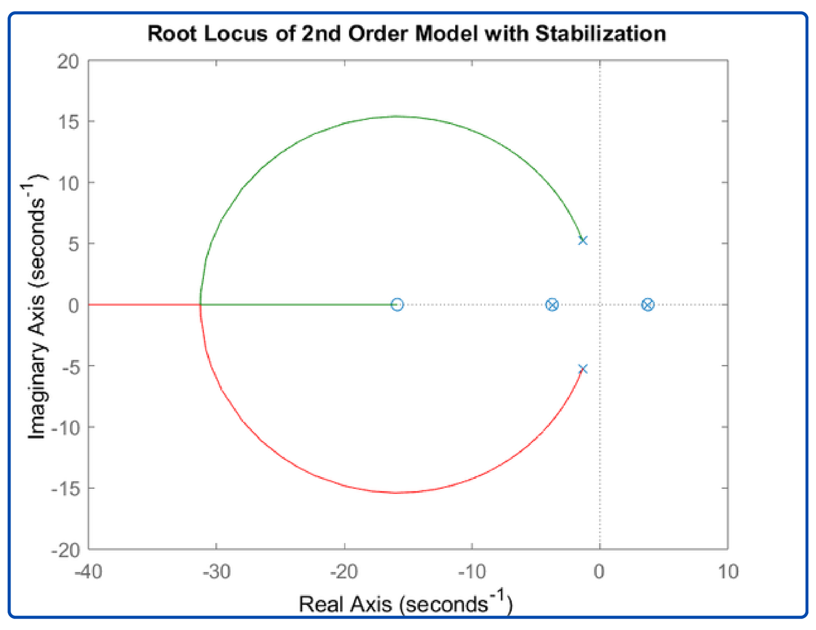
Important variables we have to take into account:

- Counter-Steer
  - Exploits the physics of turning and leaning on a bicycle.
- Center of Mass
  - Effects on the balance and stability of the bicycle.
- Castor Angle
  - Effects on the stability of the steering wheel.
- Critical Velocity
  - The minimum speed required for the bicycle to maintain self-stability.

Simulation & Modelling

Using simple mathematical models from [1], we tested for stability of a bicycle with and without active control (similar to riding with and without hands).





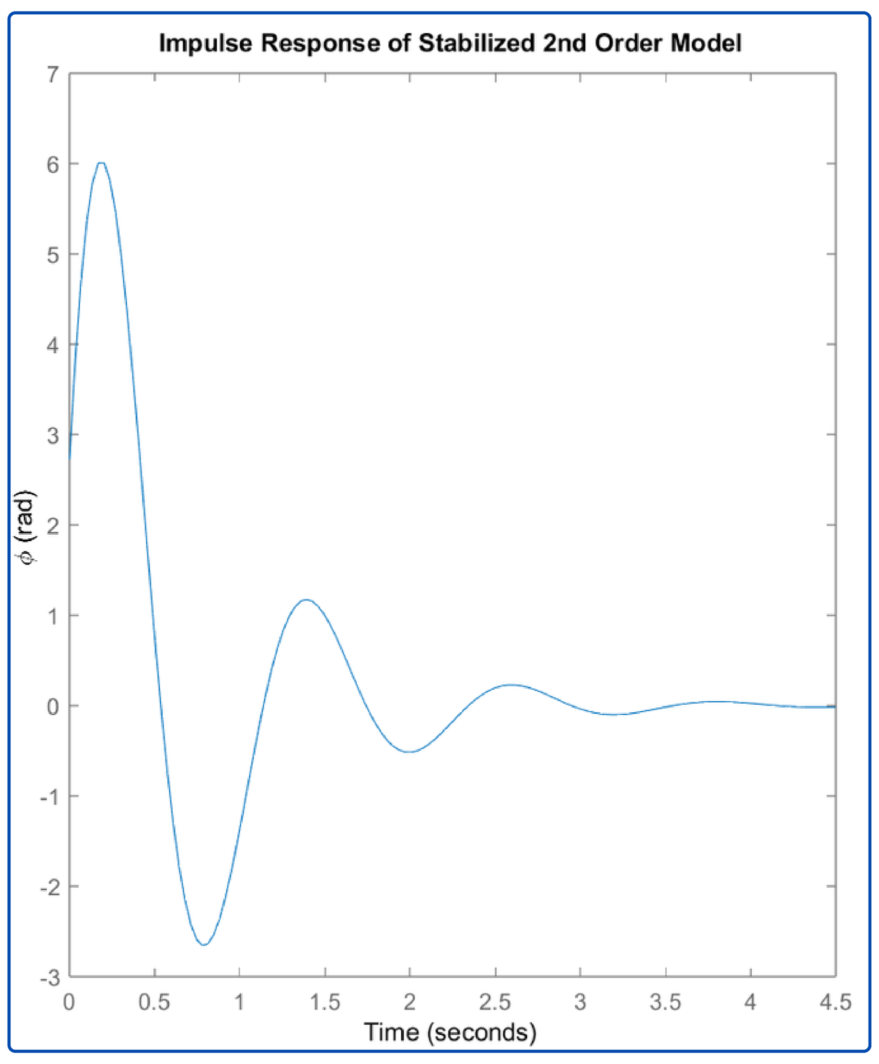
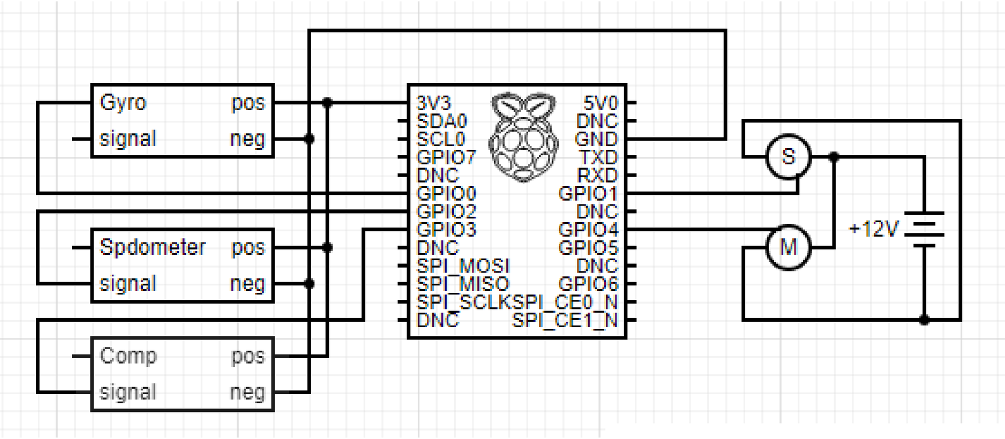
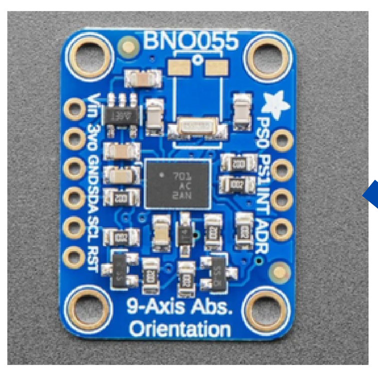


Figure 1: The left plots (1a and 1b) show the pole locations of the models. 1a is unstable but shows potential to be stable, and 1b is stable. 1c shows the stabilization over time from an impulse.

Proof of Concept





RC Bike will move autonomously and collect data regarding tilt and speed to steer and re-stabilize.

Projections

151B Contributions

- Going into 151B with this data, we can study the motions and behaviors of physical bicycles.

Impact

- This project shows that people can use a control system to test the self-stabilization of bicycles.

Improvements

- We need to find accurate values to the stated variables, so the bicycle can self-stabilize and self-turn.

References:

[1] K. J. Astrom, R. E. Klein and A. Lennartsson, "Bicycle dynamics and control: adapted bicycles for education and research," in IEEE Control Systems Magazine, vol. 25, no. 4, pp. 26-47, Aug. 2005

[2] Sangduck Lee and Woonchul Ham, "Self stabilizing strategy in tracking control of unmanned electric bicycle with mass balance," IEEE/RSJ International Conference on Intelligent Robots and Systems, Lausanne, Switzerland, 2002, pp. 2200-2205 vol.3