STEADY

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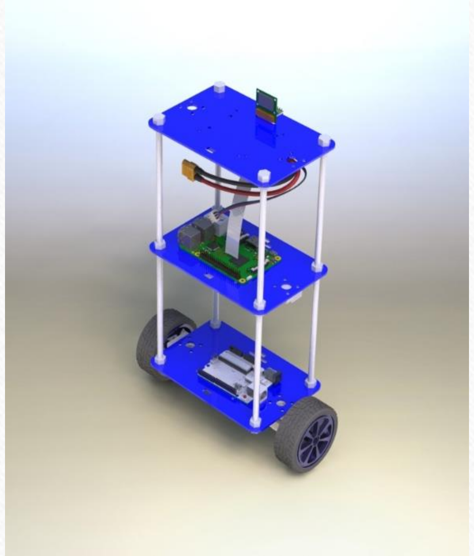
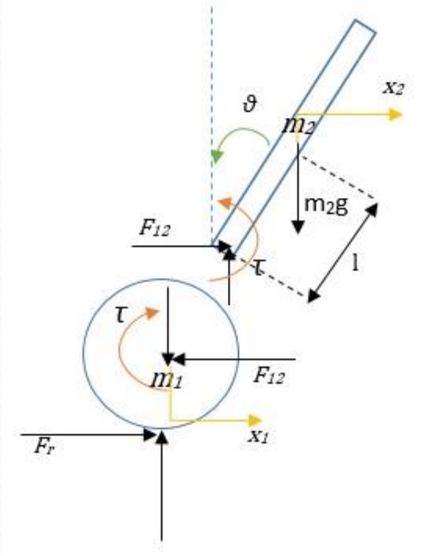
Introduction

A self-balancing robot is essentially an inverted pendulum on wheels





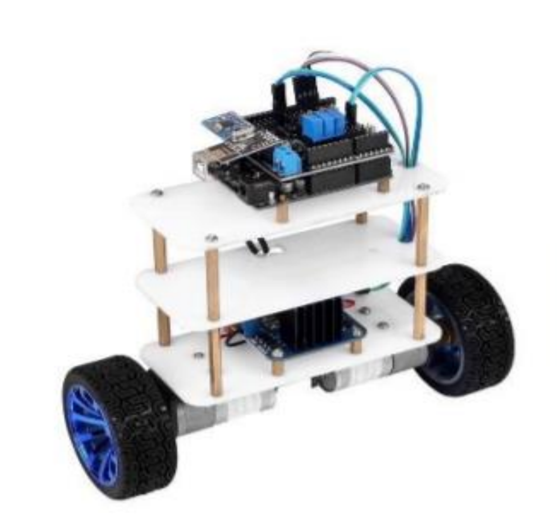
Goals

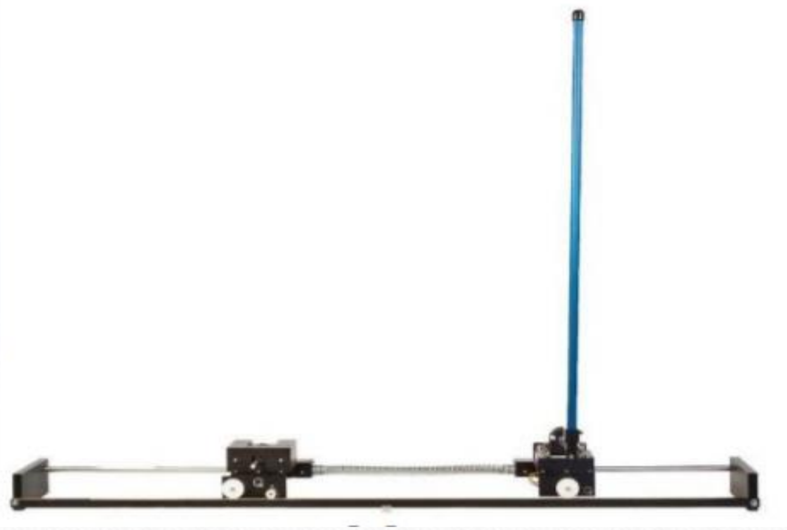
To design, construct and program a self-balancing robot, the following objectives have been set:

- Design and assemble the chassis of the robot
- Mount all the electronic hardware on the chassis and make all the electrical connections
- Develop the software to read from the sensors and to control the actuators
- Implement a PID controller to enable the robot to stay upright
- Add a cascaded PID controller to control robot's position
- Develop the software for wireless control and camera streaming

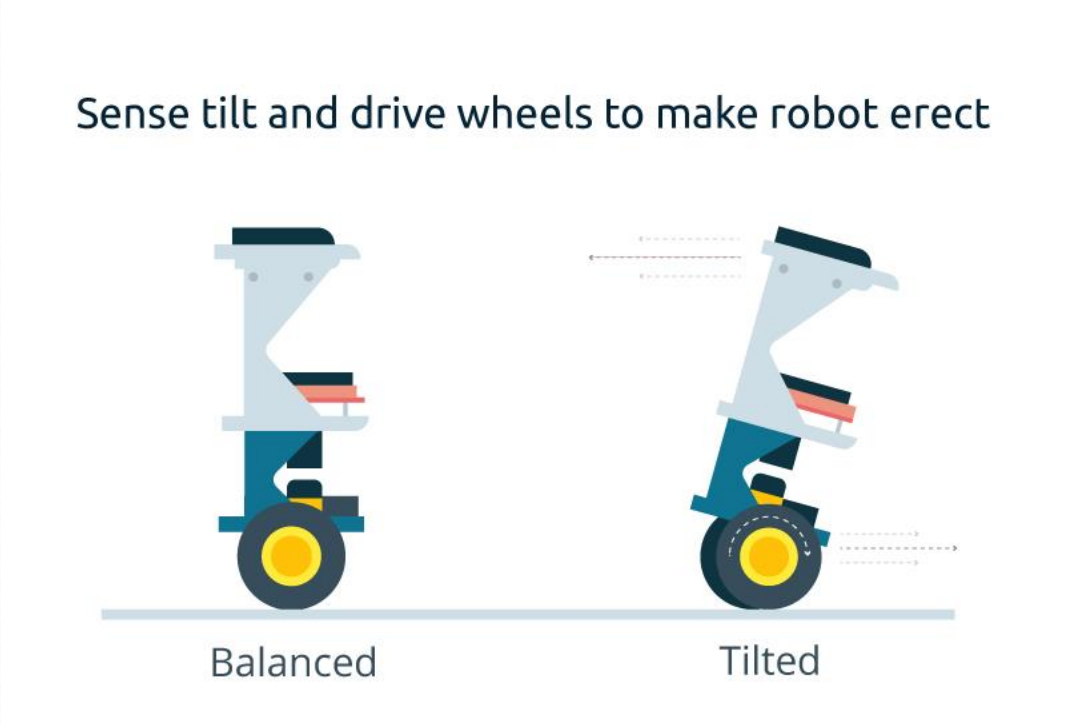
Background Research

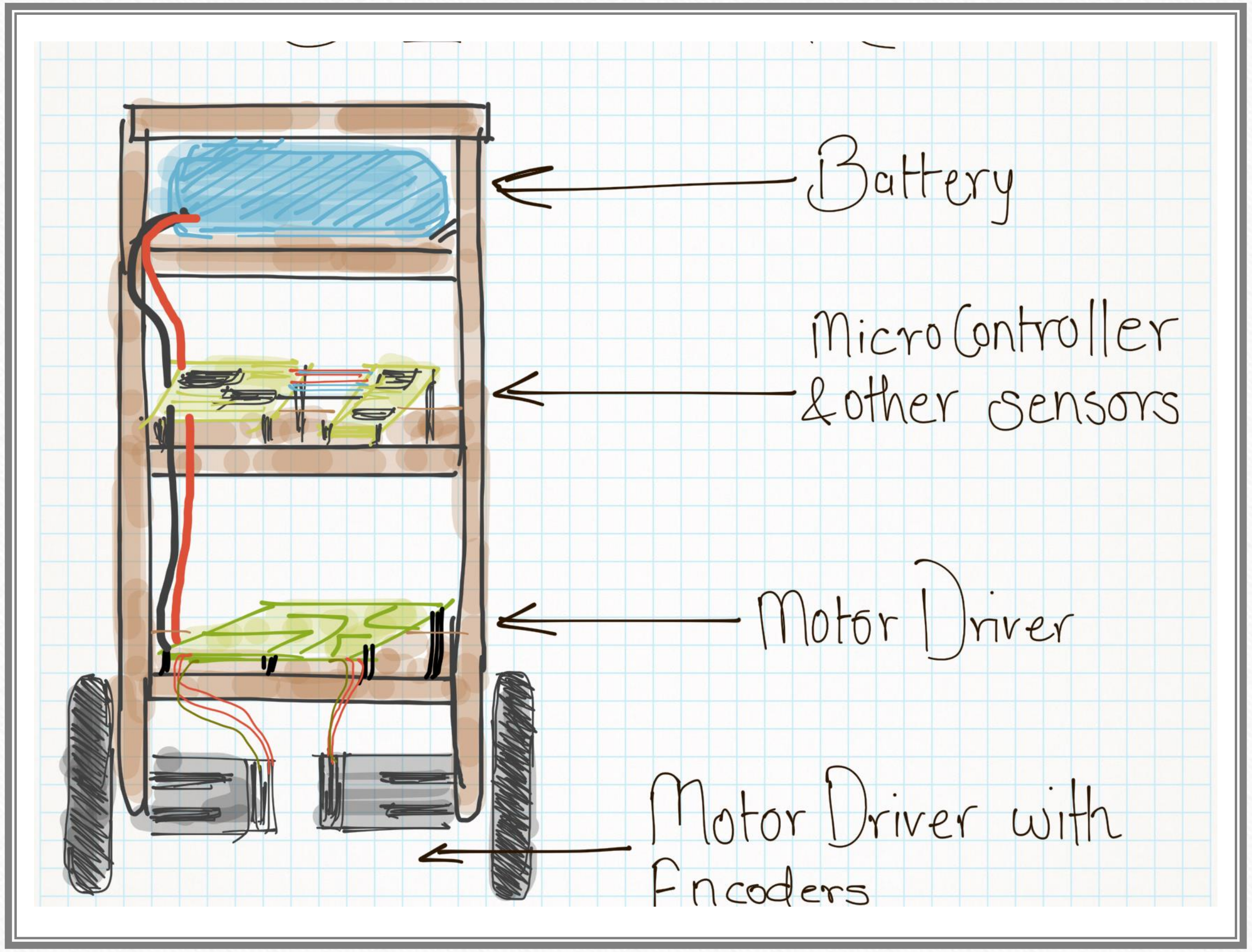
The most common types of inverted pendulums are the self-balancing robot, inverted pendulum on a cart and an inverted pendulum on a linear track





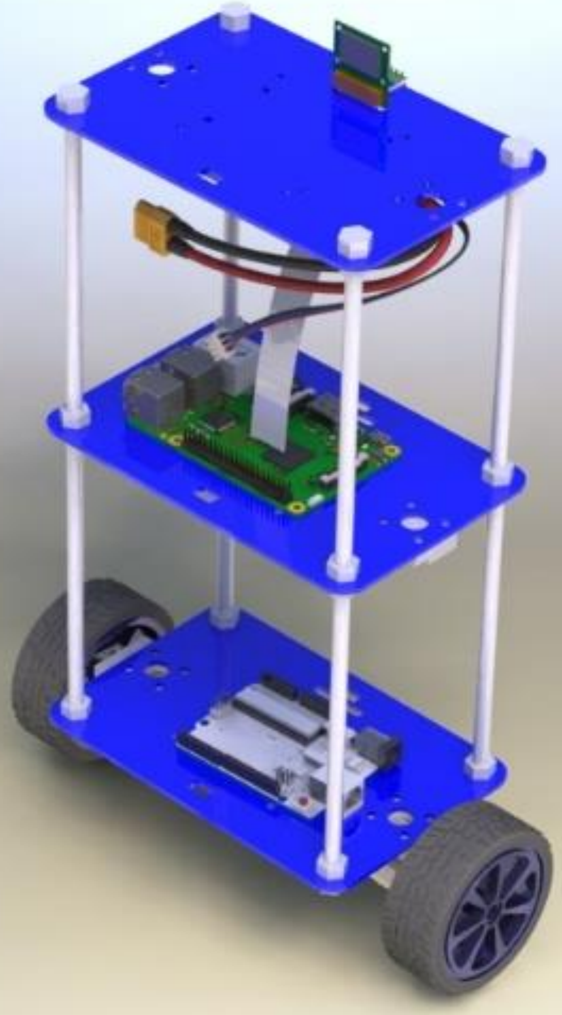

Working Principle

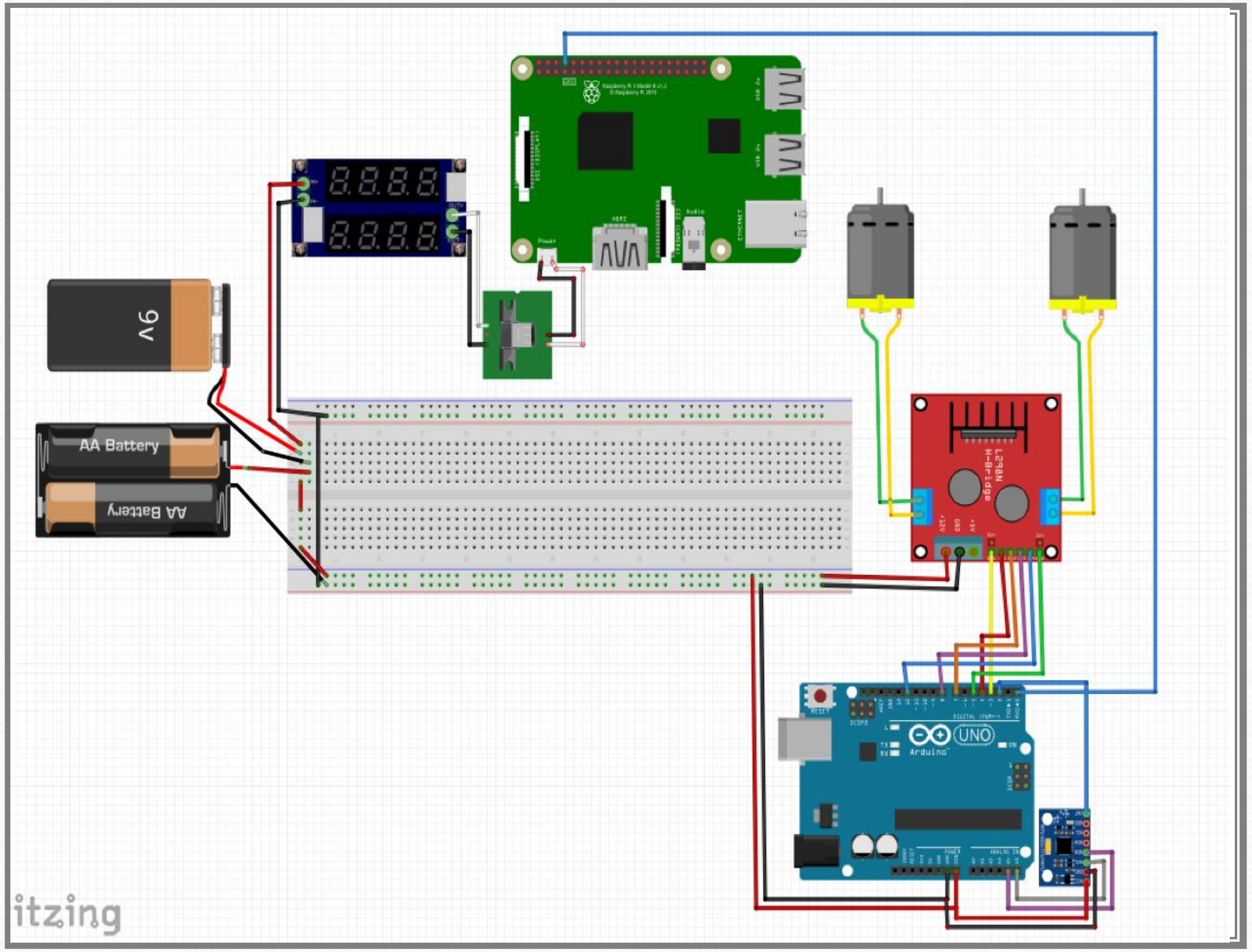




CAD & Manufacturing

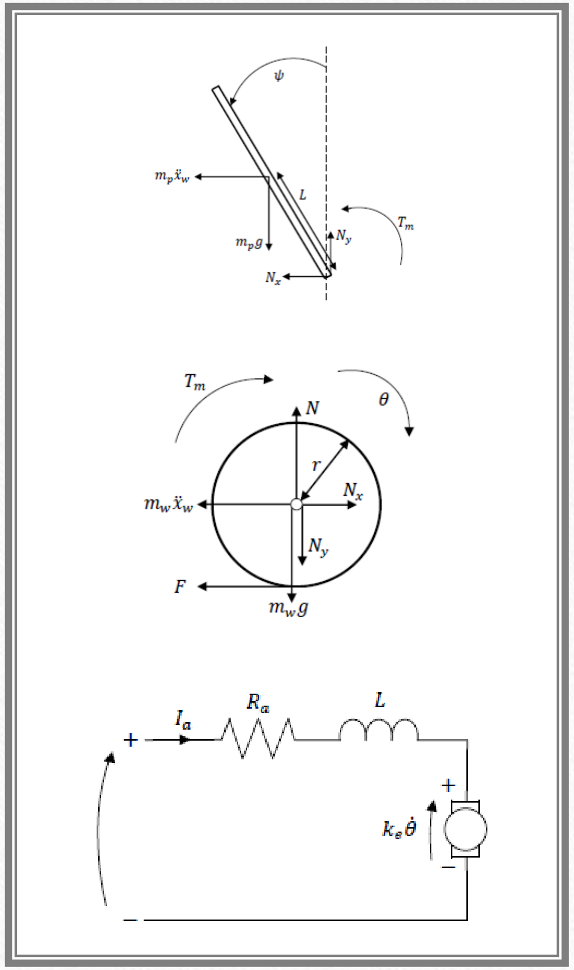
- Arduino
- Raspberry Pi + Camera
- MPU6050
- Motor Driver
- Step-down DC Transformer
- Battery
- Geared motors with encoders





Powering & Wiring

- Main power supply: 12V
- DC transformer for Raspberry Pi (5V)
- Arduino regulator output for MPU6050 (3.3V)



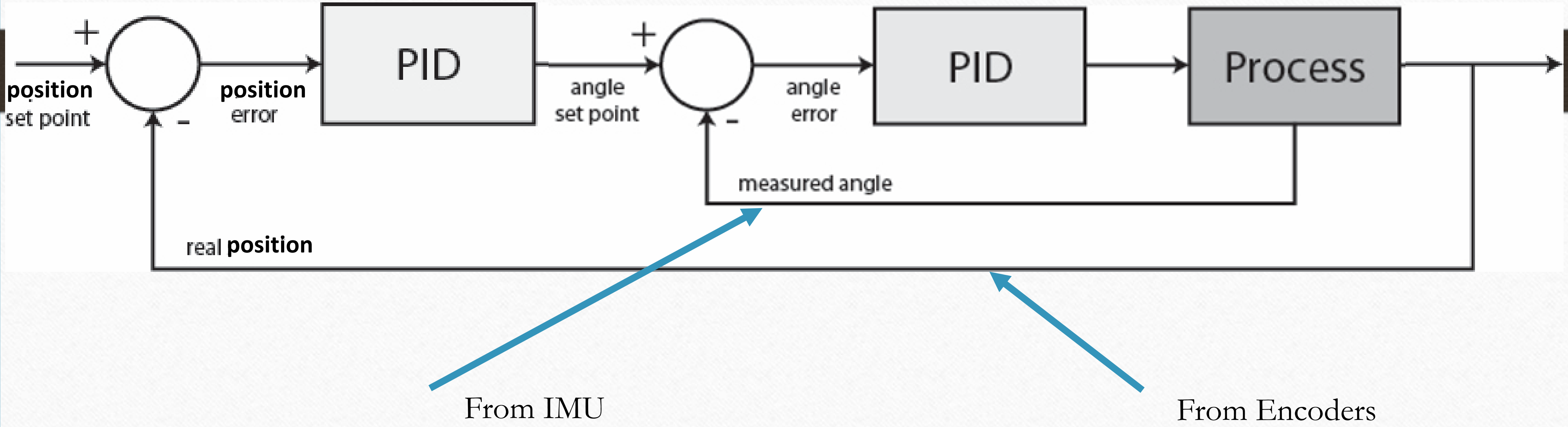
Modeling

$$(20)\ \ddot{\psi} = \frac{(Jw\,(gLRamp\psi + 2nkt\,(U - ke\,\dot{\theta})) + r(LrRamp\psi\,(mp(g - L\dot{\psi}2) + gmw) + 2nkt\,(U - ke\dot{\theta})(mp\,(L+r) + rmw)))}{(Ra(Jp(Jw + r2\,(mp + mw)) - L2r2m2\,p))}$$

$$(21)\ \ddot{\theta} = Lrm_p\,(gLR_am_p\psi + 2nk_t(U - k_e\dot{\theta})) + J_p(2nk_t(U - k_e\dot{\theta}) - LrR_am_p$$

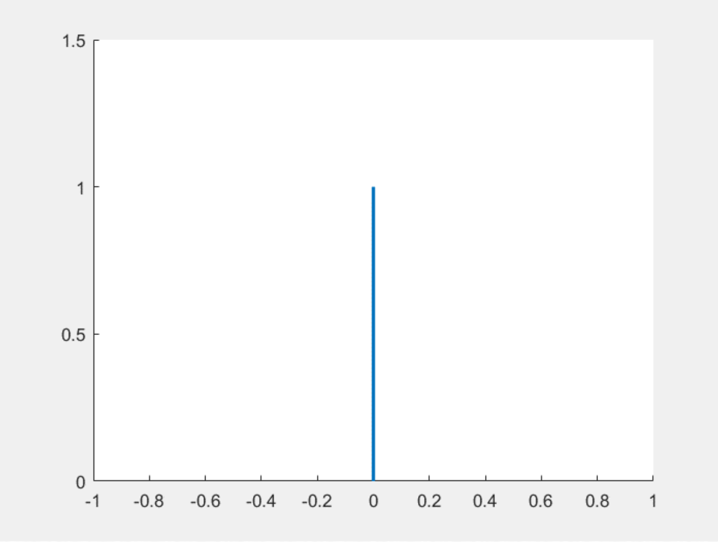
$$\dot{\psi}^2\psi\ (R_a(J_p(J_w + r^2(m_p + m_w)) - L^2r^{\,2}m^2\,p))$$

Control System

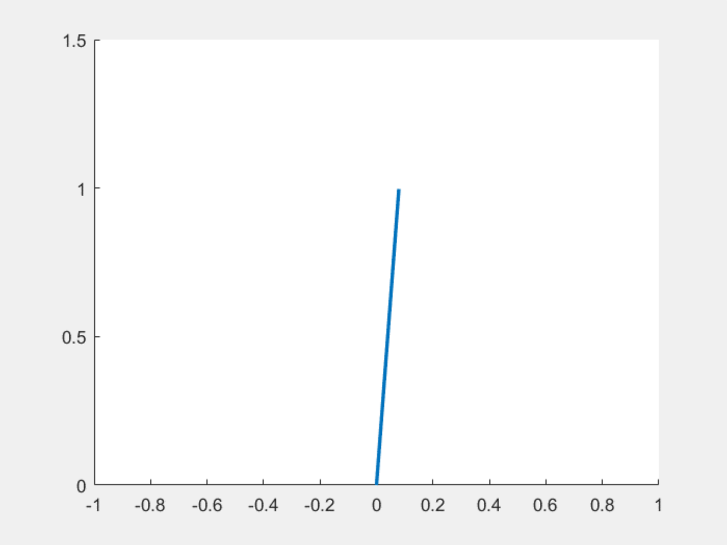


Simulation

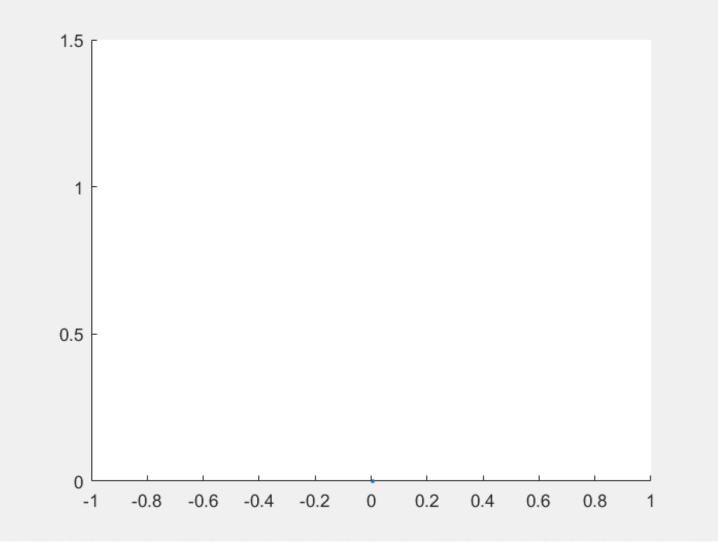
Unstable



Underdamped

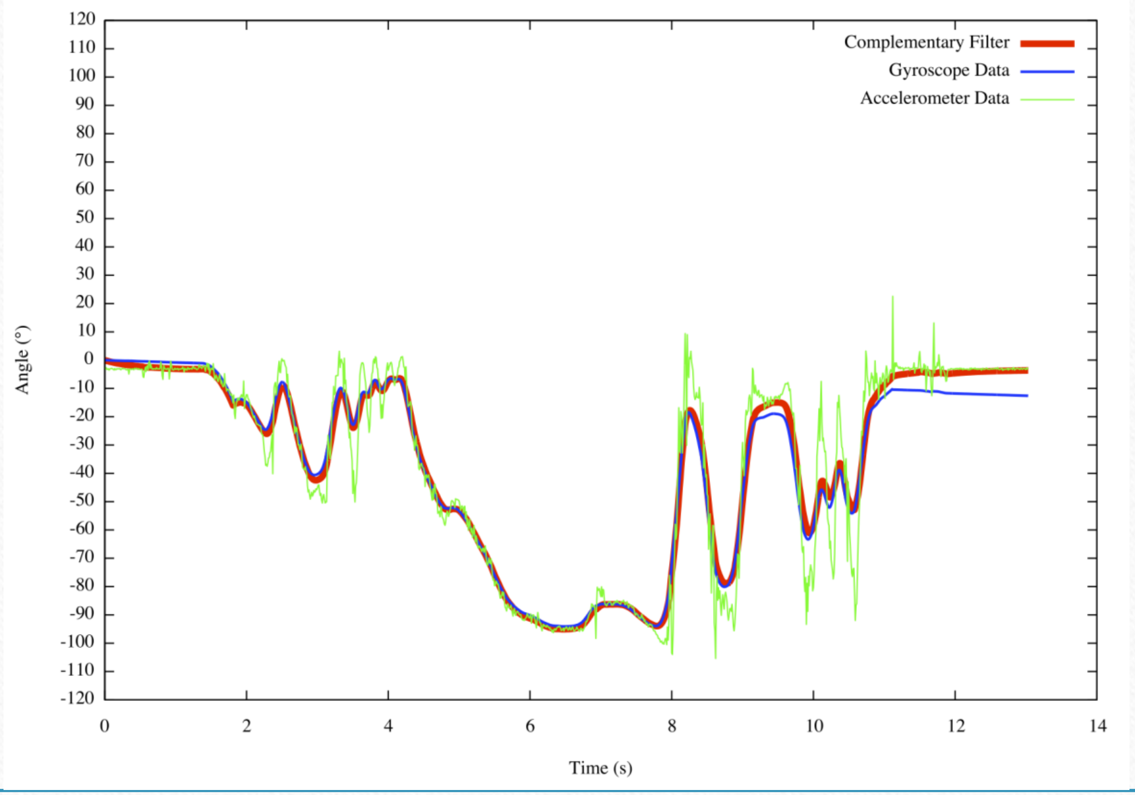


Critically Damped



Kalman Filter

Out of the scope of this presentation but here's a quick explanation



Future Enhancements

- Smoothening the controllers for better transient response
- Adding: computer vision (to follow a ball for example)
- Adding ultrasonic sensors for table/stair edge detection
- Adding side arms for fall cushioning and automatic stand up.

Results

Time for the Demo!

THANK YOU