National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

EE-379 Control Systems

Project Proposal

Self-Balancing Robot

Group Members:

1. Faris Imran 135083
2. Haris Mahmood 189641
3. M. Ali Haider 179947
4. Abdullah Ashfaq 129399

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Table of Contents

Idea

We will design a self-balancing robot. The primary goal of the project is to prevent the robot from falling over. If the time permits, we may extend the project by adding the capability to steer remotely.

Motivation

In the past decade, mobile robots have stepped out of the military and industrial settings, and entered civilian and personal spaces such as hospitals, schools and ordinary homes. While many of these robots for civil applications are mechanically stable, such as Aibo the Sony robotic dog, or four-wheel vacuum cleaners, one that ordinary on-lookers would find awe-inspiring is the Segway personal transport, a mechanically unstable, two-wheel self-balancing vehicle that has seen deployment for law-enforcement, tourism etc. The popularity of self-balancing robots has ignited active research on the control design for such platforms. It is fast becoming an important topic in both education and product development and therein lies our motivation for choosing self-balancing robots as our control systems project.

Equipment Required

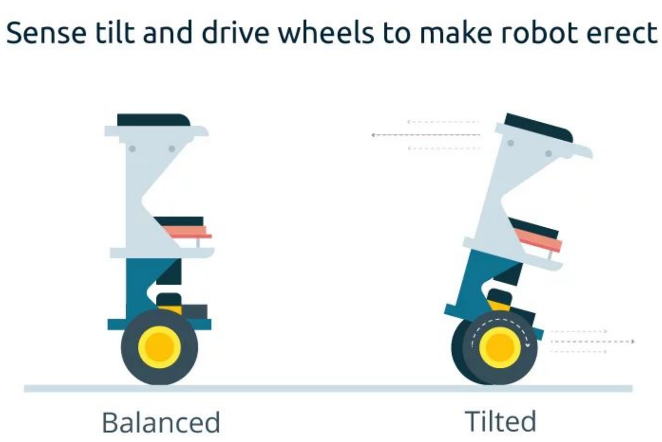
The following equipment will be required to assemble our self-balancing robot:

- Arduino Microcontroller (x1)
- Stepper Motor (x2)
- Motor Drivers (x2)
- Accelerometer & Gyroscope Module (x1)

- Wheels (x2)
- Battery
- Angle Brackets, Rods and Nuts

Background

The self-balancing robot is similar to an inverted pendulum. Unlike a normal pendulum which keeps on swinging once given a nudge, this inverted pendulum cannot stay balanced on its own. It will simply fall over.



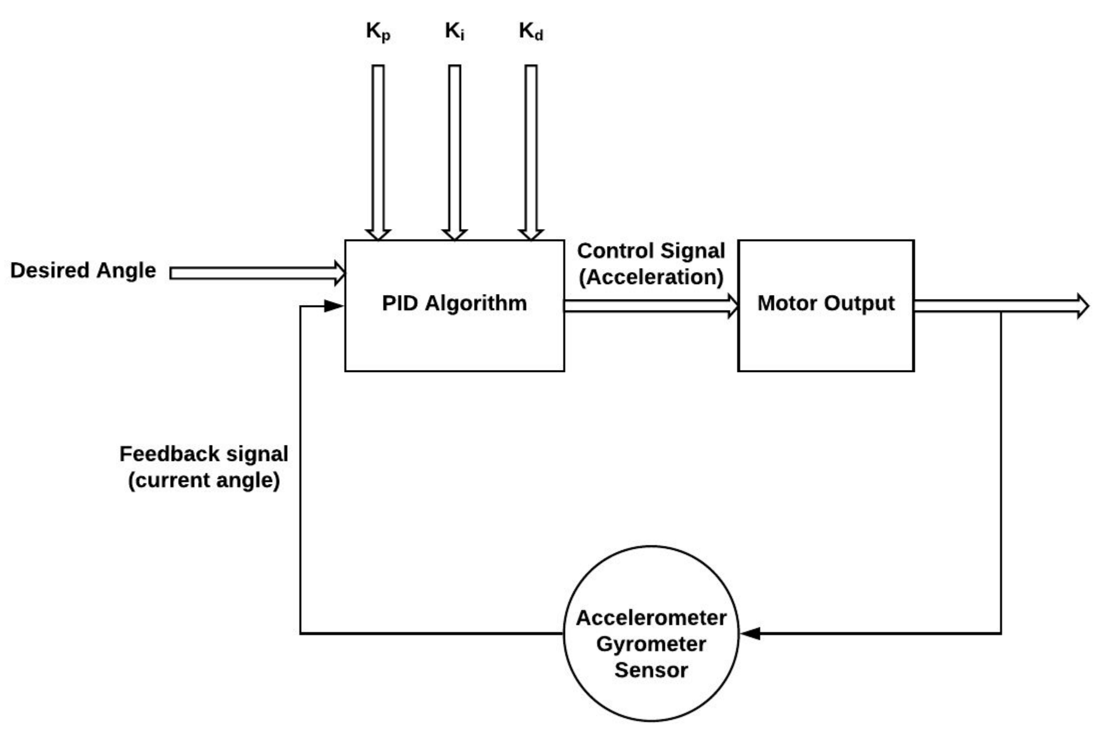
To prevent the robot from falling, the wheels have to move in a way which counters the applied force. In this regard, knowing the tilt angle is imperative. There are a wide array of sensors that can be used, such as inclinometers, light sensors, accelerometer or gyroscopes. However, each of these sensors have their shortcomings; the inclinometer takes a long time to converge to the angle it is currently at, light sensors are highly susceptible to background noise (ambient light and the reflective index of the surface it is operating in), gyroscopes have a bias and accelerometers are relatively noisy. We will use accelerometer and gyroscope for this project.

Methodology

To fulfill the purpose, the following method will be used:

- Derive dynamical equations based on the theory of the inverted pendulum
- Form transfer functions for the angle deviation, ψ, and position, x
- Find a controller that can control these two conditions
- Design a circuit
- Interface motors and sensors with the microcontroller
- Designing a chassis and assembling

Block Design



The basic idea behind a PID controller or algorithm is to read a sensor, then compute the desired actuator output by calculating proportional, integral, and derivative responses and summing those three components to compute the output.