Project Topic:

Inverted Pendulum

Abstract

An inverted pendulum is a pendulum that has its center of mass above its pivot point. It is often implemented with the pivot point mounted on a cart that can move horizontally and may be called a cart and pole as shown in the photo. Most applications limit the pendulum to 1 degree of freedom by affixing the pole to an axis of rotation. Whereas a normal pendulum is stable when hanging downwards, an inverted pendulum is inherently unstable, and must be actively balanced in order to remain upright; this can be done either by applying a torque at the pivot point, by moving the pivot point horizontally as part of a feedback system, changing the rate of rotation of a mass mounted on the pendulum on an axis parallel to the pivot axis and thereby generating a net torque on the pendulum, or by oscillating the pivot point vertically. A simple demonstration of moving the pivot point in a feedback system is achieved by balancing an upturned broomstick on the end of one's finger. The inverted pendulum is a classic problem in dynamics and control theory and is used as a benchmark for testing control strategies.

The inverted pendulum is a classic problem in dynamics and control theory and is widely used as a benchmark for testing control algorithms (PID controllers, state space representation, neural networks, fuzzy control, genetic algorithms, etc.). Variations on this problem include multiple links, allowing the motion of the cart to be commanded while maintaining the pendulum, and balancing the cart-pendulum system on a see-saw. The inverted pendulum is related to rocket or missile guidance, where the center of gravity is located behind the center of drag causing aerodynamic instability. The understanding of a similar problem can be shown by simple robotics in the form of a balancing cart. Balancing an upturned broomstick on the end of one's finger is a simple demonstration, and the problem is solved in the technology of the Segway PT, a self-balancing transportation device.

In the standard Inverted Pendulum system, a linear actuator consisting of a belt drive and dc motor is used to stabilize the vertical angular position of an inverted pendulum connected to a cart. Angle conversion of the Inverted Pendulum is performed using rotary encoder/potentiometer and the analog to digital converter of the Arduino Uno. Additionally, a digital Proportional Integral Derivative control algorithm is presented that addresses the issues of sample time, derivative kick, on-the-fly tuning and reset windup.