Design of Two Wheel Self Balancing Robot Using PID Controller

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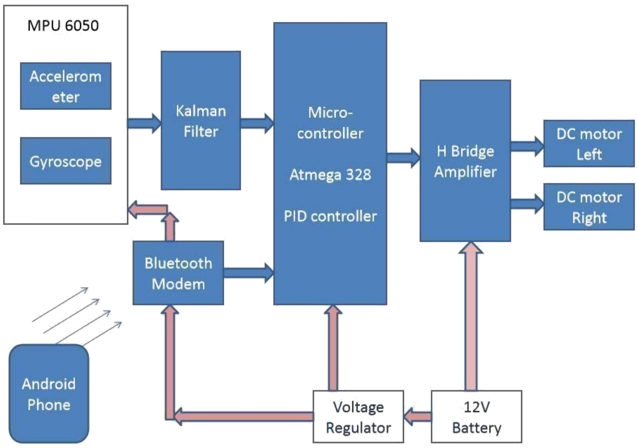
***Abstract*—In this project is to design and implementation of PID based two wheeled self-balancing robot to solve the inclination angle problem to balance the movement of robot and to implement in real time. We are designing the code and implement an efficient self-balancing PID algorithm using the embedded controller and to implement in real time. Accelerometer is fitted on the robot to measure the angle of tilt during load imbalance. It gives a summary of the work done in the fields of mechanical design, electronics, software design, system characterization and control theory. This wide array of fields necessary for the realization of the project holds the project up as a leading example in the field of mechatronics. Here special focus will be on the modelling of the robotic system and the simulation results of various control methods required for the stabilization of the system.**

Keywords—Self Balancing; PID; Accelerometer

I. INTRODUCTION

The research on a two-wheel inverted pendulum, which is commonly known as the self-balancing mobile robot, has gained momentum over the last decade in a number of robotic laboratories around the world. This is shown by a rapid increase in the number of journal papers, research projects and

theses on the subject, which have been dealing with similar projects. The principles of operation of such a robot are also used in a commercial electric transportation vehicle called Segway. The self-balancing mobile robot on two wheels, called Tilter, works on the principle of an inverted pendulum.The robot is inherently unstable and without external control it would roll around the wheels' rotation axis and eventually fall. Driving the motors in the right direction returns the robot to the upward position. Although the robot is inherently unstable, it has several advantages over the statically stable multi-wheeled robots – since it has only two wheels (two points touching the ground) it requires less space; since it is based on dynamic stability (it constantly needs to correct its tilt angle to remain stable) it exhibits improved dynamic behaviour and mobility. This additional manoeuvrability allows easy navigation on various terrains, turning sharp corners (it can turn on the spot) and traversing small steps or curbs. The stages in the project realization are explained in the following text. The first part deals with the mechanical structure of the robot containing the explanation about how it differs from that of classical mobile robots. In the second part, the selected electronic components, and the design of electrical circuits and printed circuit boards are explained. The next part gives an overview of the system modelling which was built by reference to the controller design and the estimator design. The last part deals with the software implemented in the robot, the computer and the cell phone.



BLOCK DIAGRAM OF SELF BALANCING ROBOT

II. DESCRIPTION

A. MPU 6050

Here IMU sensor used is MPU-6050.This chip contains a 3-axis gyroscope and 3-axis accelerometer. This makes it a "6 degrees of freedom inertial measurement unit".

Accelerometer - Gives the components of acceleration(g) along its three axis. - More sensitive and noisy data.

Gyroscope- Gives the components of angular velocity along its three axis. -Less sensitive but its output gets DRIFTED along with the time.

B. Kalman Filter

The Kalman filter is a set of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error. The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modelled system is unknown. The filter is used in control engineering to remove measurement noise that can affect the performance of system under control. It also provides an estimate of the current state of the process or system. The Kalman filter is a tool that can estimate the variables of a wide range of processes. In mathematical terms we would say that a Kalman filter estimates the states of a linear system. The Kalman filter not only works well in practice, but it is theoretically attractive because it can be shown that of all possible filters, it is the one that minimizes the variance of the estimation error.

C. PROPORTIONAL INTEGRAL DERIVATIVE CONTROLLER

Since we're not taking the integral into account, our algorithm is actually called a PD-controller algorithm. It is a loop where we take a measure, and compare it with what we want. We then apply an operation then repeat.

We need to take care, so that the responses our robot does is not too strong. This is called overshooting. However, if the response is too weak, the robot will spend too much time before it is positioned correctly – and this leads to it moving too much on the floor. Ideally, we want the robot to move as little as possible on the floor, while at the same time not oscillating due to overshooting.

Proportional – (present error) The present error is the amount of tilt that the robot has. It is supposed to have a tilt of 0°. If it is tiled by 10°, the error is -10.

Integral – sum of accumulated errors

The sum of errors accumulated. For the self balancing robot, this value is zero.

Derivative – expected future error

The error we expect to have on the next iteration of this algorithm. The current tilt may be 10°, and we may be expecting it to become 11° on the next iteration. The algorithm takes this into account when it decides how much force to apply on the wheels.

D. DC Motor

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

III. CONCLUSION

As performance limits in mobile robotics are increasing, dynamic effects are becoming ever more important.Self Balancing System could balance in limited conditions without much complex circuits.One of the major limitations was the sensing of balance. The time taken to attain the stable position is done within limited time and accuracy after the load is being placed. Because of the need to use the knowledge in fields of mechanics, electronics, programming and control, this project is extremely interdisciplinary and as such one of the most representative mechatronic problems. Further work will include increasing the level of autonomy of the robot by adding a vision system,thus allowing the robot to avoid obstacles. Segway and ball bot are applications of self-balancing to achieve higher speeds.

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