Self-Balancing Robot Using Raspberry Pi and PID Controller

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Abstract:- An In essence, a self-balancing robot is an inverted pendulum. If the center of mass is higher than the wheel axels, it can balance better. A higher center of mass translates to a higher moment of inertia, which translates to a lower angular acceleration. It functions like a self-balancing robot. The experiment necessitates the use of a Raspberry Pi and the L293D driver module. The robot's balance can be achieved with the aid of feedback and a correction factor. The feedback element is the component that informs the Raspberry Pi about the robot's current orientation. The experiment primarily employs a PID controller with gains Kp, Ki, and Kd. PID corrects the difference between the desired and real values. Error is the difference between input and output. By changing the output, the PID controller reduces the error to the smallest value possible. The current tilt of the robot is read by system dynamics and fed to the PID algorithm, which performs calculations to power the motor and hold the robot upright.

***Keywords*:-** *Self-Balancing Robot; Raspberry Pi; PID Controller; Robot; Feedback Element; Correction Factor.*

I. INTRODUCTION

As with the well-known small personal transporter known as the "Segway," the self-balancing robot stands on two wheels and maintains its balance without crashing. In recent years, self-balancing robots based on the inverted pendulum principle have become a common research subject. Since the mechanism is non-linear and fully unstable, an inverted pendulum is a difficult control issue. To compensate for the robot's angular displacement, an external force type motor is needed to keep it upright. A controller is the most critical component in stabilising the robot's system. A PID controller (proportional integral-derivative controller) is the most commonly used and simple controller, and it can be used to improve both transient and steady-state responses. With a high order and high external noise system, however, the PID controller is less powerful. This project shows how to control the angular speed of the motor to hold the robot upright using data from the accelerometer sensor to create a two-wheeled robot that can stand upright on its own. The aim of this research is to show that a PID controller with more controllability and adjustability outperforms a conventional PID controller. The research revealed the most suitable definition for implementing PID- on a real-world device.

1.1 Relevance

Several researchers have collaborated on the creation of a PID controller for the Raspberry Pi. The feedback (as an axis) from accelerometers is used to align the robot in three directions. We'll use the Raspberry Pi to create a PID controller. We present a self-balancing Robot to represent the controlling role.

1.2 Objective

Our main goal is to find a low-cost way to build a PID controller using the Raspberry Pi. To illustrate this controlling feature, we use a self-balancing robot. Here are some of the goals for the self-balancing robot:

- To get the robot to stand up in the shortest amount of time with the least amount of overshoot.
- To get the robot to roll along the horizontal a predetermined distance while remaining upright.
- To guide the robot so that it circles the corn. ers, if there is time.

II. LETERATURE REVIEW

Rajeshwari Madli [1] el al in “Automatic Detection and Notification of Potholes and Humps on Roads to Aid Drivers” Ultrasonic sensors are used to detect potholes and humps, as well as to determine their depth and height. Using a global positioning system receiver, the proposed system captures the geographical location coordinates of the potholes and humps. Flash notifications with an auditory beep are used to send out alerts.

Moazzam et al. [2] “Metrology and visualization of potholes using the microsoft Kinect sensor,” a low-cost model for analysing 3D pavement distress images has been proposed It employs a low-cost Kinect sensor that provides direct depth measurements, lowering computational costs. A RGB camera and an IR camera make up the Kinect sensor, which captures both RGB and depth data. To assess the depth of potholes, these images are analysed in the MATLAB environment by extracting metrological and characteristic features.

Youquan et al. [3] "A research of pavement potholes detection based on threedimensional projection transformation," created a model for detecting the three-dimensional cross section of a pothole in the pavement To capture the image of the pavement, the system uses LED linear light and two CCD (Charge Coupled Device) cameras. To determine the depth of potholes, it uses various digital image processing technologies such as image pre-processing, binarization, thinning, three-dimensional reconstruction, error detection, and compensation.

Orhan and Eren [4] "Road hazard detection and sharing with multimodal sensor analysis on smart phones," have proposed a project to identify road hazards using an Android platform. This proposed work is divided into three sections: sensing, analysis, and sharing. The sensing portion collects raw data from the accelerometer and synchronises it with the gui, allowing for easy access. The values obtained from the sensors are used to create analysis modules in the analysis component. The sharing aspect works like this: the built system is linked to the central application, from which it can interact directly with the social network.

Mednis et al [5] "Real time pothole detection using Android Smartphone's with accelerometers," Using an Android Smartphone with accelerometers, a real-time pothole detection model has been suggested. Modern Android smartphones have built-in accelerometers that detect acceleration and vibrations. Potholes are detected using accelerometer data. To locate potholes, different algorithms are used, such as Z-thresh, which measures the acceleration amplitude at the Z-axis, Z-diff, which measures the difference between the two amplitude values, STDEV (Z), which calculates the standard deviation of vertical axis acceleration, and G-Zero.

III. ARCHITECTURE AND IMPLEMENTATION

The key criterion of research is equilibrium with a two-wheeled robot. To achieve the task of balancing a two-wheeled robot, a microcontroller, DC motors, and inertial sensors will be used. In Figure 1, you can see a block diagram of the robot's structure design. A gyroscope and accelerometer sensors are used in the implementation of a balanced two-wheeled robot. IMU optical combination board sensor 6-degrees of freedom ITG 3200 / ADXL 345 was used as the sensor. A motor is a component that allows the robot to move in order to reach equilibrium. It is critical to choose a strong DC motor. The perfect DC motor is one that has a high torque and has quickly made the rounds of a two-wheeled robot system. This robot makes use of 12V DC motors. Raspberry Pi is an analogue and digital input/output controller. Raspberry Pi is a line of single-board computers with a small form factor. The Raspberry Pi is used as the key controlling device in this project. The self-balancing robot's motion control needs three states to be controlled: pitch, pace, and turn/yaw. A PID controller can be used to control each state. The cycles of speed and pitch are intertwined, with one pushing the other.

Using the Raspberry Pi 4 model, the proposed solution is used to perform PID controlling functions. The duty cycle output from the control system is sent to the motors via 12V, 16 KHz square pulses. The entire procedure is carried out at a frequency of 50 Hz. The robot is then moved around by wheels, which keep it balanced.

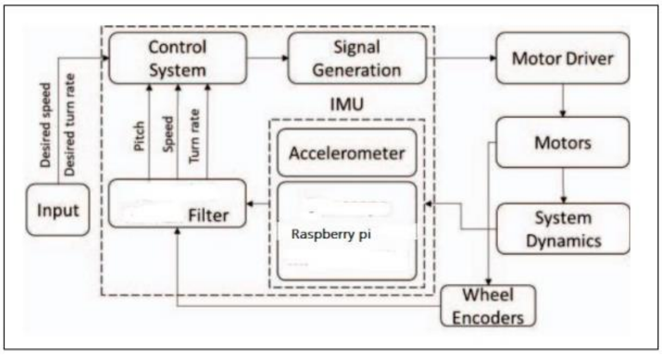

Fig -1: Block diagram of proposed system.

IV. CONCLUSIONS

The experimental results showed that using a cascaded PID control strategy in conjunction with a trajectory controller was effective in achieving autonomous motion. Error detection and overall device reliability have been achieved using PID controllers. Estimation noise is responsible for the high frequency low amplitude noise shown in the experimental response curves. Gear backlash causes the high amplitude disruption or oscillation at steady state, as previously described. The trajectory controller has demonstrated its ability to track a trajectory within reasonable error limits.

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