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Self-Balancing Robot

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Abstract— **A self-balancing robot is a type of robot that can balance itself on two wheels, without falling over. These robot use combination of sensors, motors, and control algorithm to maintain their balance and stability. Self balancing robot involves measuring the tilt and angle of the robot using an accelerometer and gyroscope sensor. The robot must constantly adjust its center of gravity to stay upright and work smoothly.**

I. INTRODUCTION

Robot is a automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner. By extension, robotics is the engineering discipline dealing with the design, construction, and operation of robots. The first robotics vision programs, pursued into the early 1970s, used statistical formulas to detect linear boundaries in robot camera images and clever geometric reasoning to link these lines into boundaries of probable objects, providing an internal model of their world.

Robots can be autonomous or semi-autonomous and range from humanoids such as Honda's Advanced Step in Innovative Mobility (ASIMO) and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, medical operating robots, patient assist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots.

Self-balancing is the premise of robot standing, while standing is a necessary condition for robot motion. How to keep the balance and resist the external disturbance is the key point of the research of the two-wheeled self-balancing robot. Self-balancing algorithms include traditional, modern and intelligent control algorithms. The modern control theory is mainly focused on the multi-variable and strong-coupled nonlinear system which can not be solved by using the traditional control theory. PID control algorithm in the classical control theory are tested in the two-wheeled self-balancing robot. Simulation experiments are carried out on the aspects of balance control, position control and speed control using PID.Inverted Pendulum application are plenty; for example the human body is an inverted pendulum balancing the upper body around our ankle joints in every step. Segways, making use of bodily movements for steering, have emerged on the market. In common, these applications share that their centre of mass is located above their pivot points, thus requiring active control in order to balance.

II. LITERATURE SURVEY

- Boubaker, Olfa (The inverted pendulum: A fundamental benchmark in control theory and robotics) International conference on education and e-learning innovations. IEEE 2012. In this paper, it has been shown that the inverted pendulum system is a fundamental benchmark in education and research in control theory. The particular interest of this application lies on its simple structure and the wealth of its model. The richness of the model has illustrated its usefulness to illustrate all emerging ideas in control theory and integrate trendy technologies and challenging applications in robotics.[1]

- An, Wei, and Yangmin Li. (Simulation and control of a two-wheeled self-balancing robot.) IEEE International Conference on Robotics and Biomimetics (ROBIO). 2013. A two-wheeled self-balancing robot is a special type of wheeled mobile robot, its balance problem is a hot research topic due to its unstable state for controlling. In this paper, human transporter model has been established. Kinematic and dynamic models are constructed and two control methods: Proportional-integral-derivative (PID) and Linear-quadratic regulator (LQR) are implemented to test the system model in which controls of two subsystems: self-balance (preventing system from falling down when it moves forward or backward) and yaw rotation (steering angle regulation when it turns left or right) are considered.[2]

- Unluturk, Ali, Omer Aydogdu, and Ufuk Guner (Design and PID control of two wheeled autonomous balance robot.) International Conference on Electronics, Computer and Computation 2013. In this study, a two-wheeled autonomous balance robot has been designed and implemented practically. A visual computer

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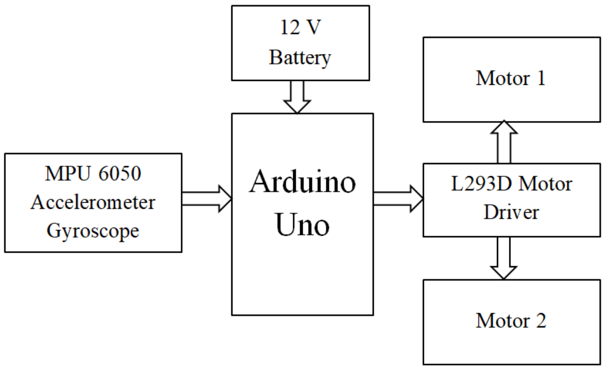
interface based on Qt-Creator has been created. The computer interface, different control algorithms can be performed on the robot easily, control parameters can be set up online, filter algorithms in various structures can be tried and the reaction of these changeable values to the system can be observed. The effects of some controllers such as Proportional (P), Proportional-Integral (PI), Proportional-Integral-Derivative (PID) on developed robot have been viewed successfully.[3]

III. METHODOLOGY



Block Diagram

The working of self-balancing robot is very simple the robot takes the reading from the MPU6050 the reading like the tilting angle, acceleration, velocity and motion of the robot which is then analyzed by the micro-controller present on the Arduino UNO for better stabilization and to keep the robot upright without being able to fall over. If the tilting angle is more at forward direction the Arduino controls the speed of the motors through L298N motor driver which also helps in maintaining the position of the robot without falling it. This process continuously happens until the robot is turned off. The robot is powered by the 12V battery which helps in providing the sufficient energy throughout the circuit. Two DC motors are being used in the robot that is why it is called two wheeled self-balancing robot.

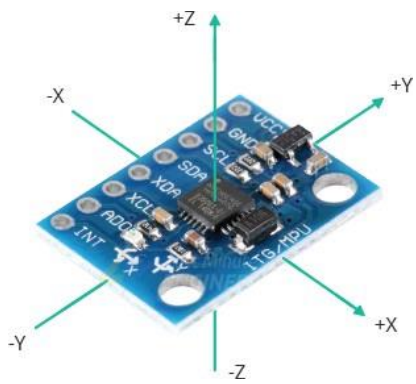
First reading is the angle as resulted from gyroscope(β1) integration. Accelerometer gives the second reading. For instance when the output of gyroscope is null(0), angle will converge to that of the result given by accelerometer(β2). If the value of 'α' is very small the output angle will not trust the reading from the accelerometer and eventually it will trust the gyroscope. In order to control the speed at which wheels should pivot,PID (proportional integral derivative), which is a control loop feedback mechanism largely used in control systems, is used. This concept is mainly used for calculation of 'error' value. Here firstly the measured and desired set points are calculated; the difference is obtained for further calculations. The proportional(P) term which is derived from PID is based on the current angle difference from Zeroth Point. The integral(I) term derived from the PID relies on the current angle difference or error(e(t)) from point zero which is then multiplied by the gain, and subsequently accumulated over time. The integral control also contributes in balancing the robot if it is moving. The derivative (D) term which is derived from PID is the current rate of rotation. In order for the robot to balance properly the hardware/physical orientation of the robot plays a vital role. In other words the centre of gravity of the robot should be balanced. The PID constants i.e., kp, kd and ki can be determined by trial and error method.

IV. HARDWARE COMPONENTS

1. ARDUINO :

Arduino is an open source and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs.

2. MPU6050 IMU:



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It is an Inertial measurement Unit commonly known as IMU, which is used to measure gravitational acceleration and rotational velocity. It is a 6-axis sensor module which contains 3-axis accelerometer and 3-axis gyroscope integrated on a single chip. It is basically used to determine the exact location of the robot in 3-dimensional space. The outputs of the gyroscope are defined in degrees per second. Hence in order to get the angular position integration of the angular velocity is needed. Gravitational acceleration can be measured by the Accelerometer along the 3 axes and thereby by using some sort of math we can calculate the sensor position. So by combining the accelerometer data values and gyroscope data values we can get very precise information defining orientation of sensor.

3. L293D Motor Driver:

This module is used to drive DC motors. As the module uses dual H-bridge drive, it is possible to drive two motors at the same time. It supports driver voltage from 5v to 35v.

V. RESULT

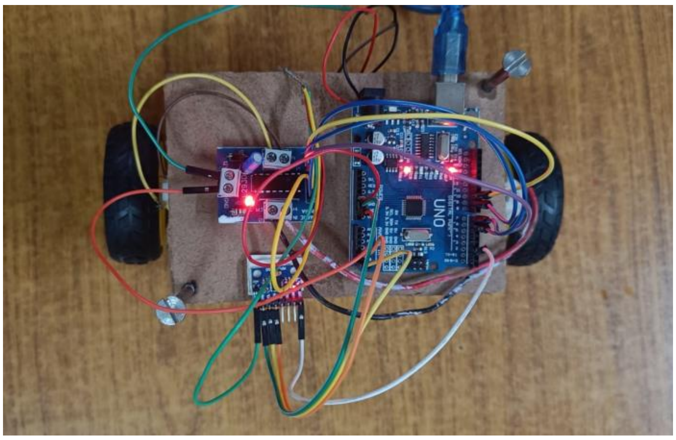
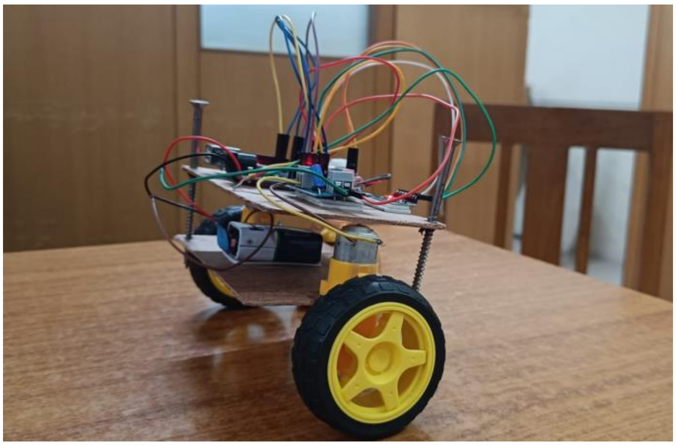


fig.(a)



CONCLUSION

In this project we were able to implement a self-balancing robot by using PID tuning method. The bot balances itself effectively while leaning in forward or backward directions by the implementation of a closed loop algorithm. The performance can be further improved by enhancing the precision of motor speed readings, thereby improving stability. Also by installing a Bluetooth module or some wireless technology it is possible to create a remote controlled prototype, increasing its array of applications. The above mentioned features can be used as a modification to the existing system while designing a more efficient system in the future. These robots can be used for smart gardening purposes; autonomous trolleys in malls, hospitals and airports; an intelligent robot for various purposes Currently popularized as “Segways”, these machines are mostly used for travel and tourism purposes and by private security services. It has been put to use by a range of private and military organizations since its invention.

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fig.(b)

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