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SELF BALANCING ROBOT CONTROLLED BY BLUETOOTH MODULE

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ABSTRACT

To make a robot that can balance on two wheels. There will be only one axle connecting the two wheels, and a platform will be mounted on that. There will be another platform above it. The platform will not remain stable by itself. The functioning of the device is to balance the platform using distance sensors as Gyroscope sensor (Gyro MPU6050) and to maintain it horizontal. Firstly to just balance the robot on its two wheels,if the platform inclines, then the microcontroller (in this case, an Arduino Nano) will send signals to motors such that motors will move forward or backward depending on the inclination direction and extent. Balance of the robot was achieved by using a Proportional-Integral Derivative (PID) controller with inputs from a gyroscope and accelerometer. Stepper motors were used to maneuver the robot. A two wheeled self-balancing robot builds upon the inverted pendulum principle, if F is the force applied, φ is the angle from the equilibrium. When a tilt from the equilibrium occurs the motors will generate a torque that drives the wheels in the same direction as the tilt. The wheels will move the same distance as the centre of gravity in order to maintain balance. In order to achieve forward movement, the angle set point will be increased, changing the equilibrium point. A self-balancing robot is creating a robot that is a replica of a human body. Traditional robots consisted of four wheels, were easily stabilized, and were comparatively bigger in size. A traditional robot uses four wheels and four motors for movement, while a self-balancing robot uses only two wheels and motors for movement. A very famous application of the self-balancing robot is the Segway. Segway has been readily available on the market since 2011 and is also termed a "human transporter". It isused mostly to cover shorter distances.

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It has also become great consideration as a research entity because of the unstable character of the system. The two-wheel self- balancing robot is based on the fundamental principle of Inverted pendulum. Inverted pendulum has many practical applications such as human walking robots, missile launchers, earthquake resistant building design etc. Development of control system for atwo-wheel self-balancing robot has been a huge area of research for the past few years. This is mainly due to its nonlinear dynamics. It became an important test platform for the design and development of missiles, automobiles, space crafts, robots.

Keywords: Robot, Gyroscopesensor, ArduinoNano, Blue Tooth Module.

INTRODUCTION

Self-balancing robots are a topic of curiosity amongst students, robotics addicts, and hobbyists around the world. The fascinating aspect is the fact that it is a naturally unstable system. The project presents an attempt on developing an autonomous self- balancing robot. A key element in maintaining the robot in the upright position is estimation of the tilt angle. For this, the Kalman Filter has been implemented and tested to fuse data from a gyroscope and an accelerometer. In addition, the methodology in which the hardware was chosen and put together has been justified. Then the software development and challenges in the implementation of the Kalman Filter have also been explained. Project report details the development of a self-balancing robot controlled by a Bluetooth module. Implementation of the robot's hardware and software, including theselection of appropriate components and the programming of the microcontroller. The robot is equipped with an accelerometer and a gyroscope to measure its orientation and aPID controller to adjust its motor speed and maintain balance. The Bluetooth module is used to receive commands from a mobile device and control the robot's movement. The report includes detailed explanations of the design and implementation process, as well as the results of testing and future directions for improvement. Overall, this project demonstrates the feasibility and potential of using Bluetooth technology to remotely control self-balancing robots.

LITERATURE REVIEW

Conducting literature review prior to begin a research project is vital in Understanding two wheels balancing robot control technique, as this will supply the researcher with much needed additional information on the methodologies and technologies available and used by other research counterparts around the world. This chapter provides a condensed summary of literature reviews on key topics related to balancing a two-wheeled robot.

J.A. BORJA et al [2020] this paper presents low cost, two-wheels self-balancing robot for control education powered by stepper motors developed at the University of Seville. This design improves a previous model based on DC motors that has been used for the last five years in different courses in which students learn electronics, computer programming, modelling, control and signal processing by means of the construction and control of this robot. The new design improves the performance and reduces the total price of the device.

C.GONZALEZ et al [2017] Arduino based low-cost self-balancing robot developed at the University of Seville for control education. The main idea is that the students can learn electronics, at the University of Seville for control education. The main idea is that the students can learn electronics, computer programming, modelling, control and signal processing by means of the construction and control of this robot. The resulting model is a multivariable unstable nonlinear system with non-minimum phase zero. Experimental results obtained by students of the University of Seville are included to demonstrate possibilities of prototype. This paper presents an experimental, Arduino based, low-cost self-balancing robot as an educational control system. This system has been the diploma thesis of two students (Croche, A. (2014) and Gonzalez, C. (2016)) but in future courses building and controlling the proposed robot will be included as part of the curriculum of control and robotics courses

OBJECTIVES

Balancing: The primary objective of a self-balancing robot is to maintain its balance while in motion. This is accomplished by continuously adjusting the robot's center of gravity using feedback from sensors such as accelerometers and gyroscopes.

Wireless Control: The use of Bluetooth technology allows the robot to be controlled wirelessly from a smartphone or other Bluetooth-enabled device. This can provide greater flexibility and convenience compared to a wired control system.

Stability and Precision: A self-balancing robot should be stable and precise in its movements. This requires accurate sensor data and precise control algorithms to ensure the robot moves in the desired direction and at the desired speed.

Maneuverability: Depending on the specific application, a self-balancing robot may need to be able to maneuver in tight spaces or navigate complex environments. This requires a combination of agility, speed, and control.

User Experience: The overall user experience is an important objective for any robot. This includes factors such as ease of use, reliability, and responsiveness to user input. Bluetooth

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control can provide a user-friendly interface for controlling the robot and receiving feedback on its status.

Hardware Components

GYROSCOPE SENSOR

The gyroscope sensor is used to measure the angular velocity of the object. The 3-axis gyroscope sensor can find the orientation and rotation of the person in all three directions with respect to gravity. This provides an angle value ɵ which is then used to indicate the position of the person during fall. An accelerometer sensor is used to measure the acceleration or motion of the human body. A tri axial accelerometer measures the acceleration in all 3 axes x, y and z respectively. The accelerometer sensor provides a parameter value for measuring the person motion. Both these sensors are used for Fall detection.

Fig. 1 Accelerometer and gyroscope.

The ADXL345 is a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface. The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic accelerationresulting from motion or shock. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes less than 1.0°. Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion by comparing the acceleration on any axis with user-set thresholds. Tap sensing detects single and double taps in any direction. Freefall sensing detects if the device is falling. These functions can be mapped individually to either of two interrupt output pins. An integrated memory management system with a 32-level first in, first out (FIFO) buffer can be used to store data to minimize host processor activity and lower overall system power consumption. Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

WHERE TO USE HC-05 BLUETOOTH MODULE

The **HC-05** is a popular module which can add two-way (full-duplex) wireless functionality to your projects. You can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop. There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of

USART at 9600 baud rate hence it is easy to interface with any microcontroller that supports USART. We can also configure the default values of the module by using the command mode. So, if you looking for a Wireless module that could transfer data from Your computer or mobile phone to microcontroller or vice versa then this module might be the right choice for you. However, do not expect this module to transfer multimedia. Mode where the default device settings can be changed. We can operate the device in either of these two modes by using the key pin as explained in the pin description. It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP). Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCUas shown in the figure below

HOW TO USE THE HC-05 BLUETOOTH MODULE

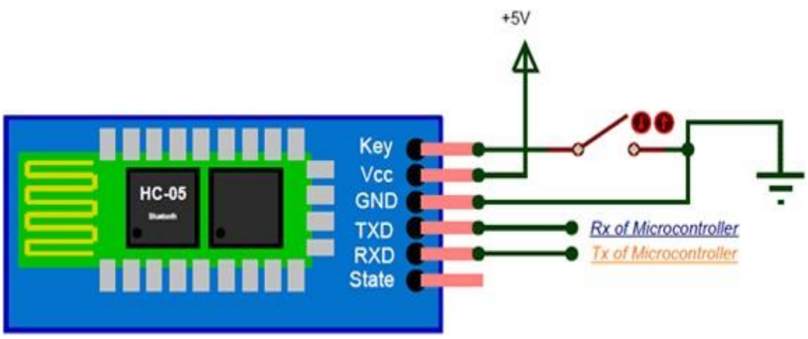

Fig. 2 HC5 Bluetooth Module.

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MOTOR DRIVER

The motor driver ICs are available at low cost and they are easy to execute in terms of design to progress the whole circuit design time. The selection of the drivers can be done based on the motor ratings like voltages and current. The most popular motor driver like ULN2003 is used in non-H-bridge based applications. It is suitable for driving the stepper motor. This driver includes a Darlington pair that can handle the max current up to 500mA and the max voltage up to 50VDC. The **stepper motor driver circuit** is shown below.

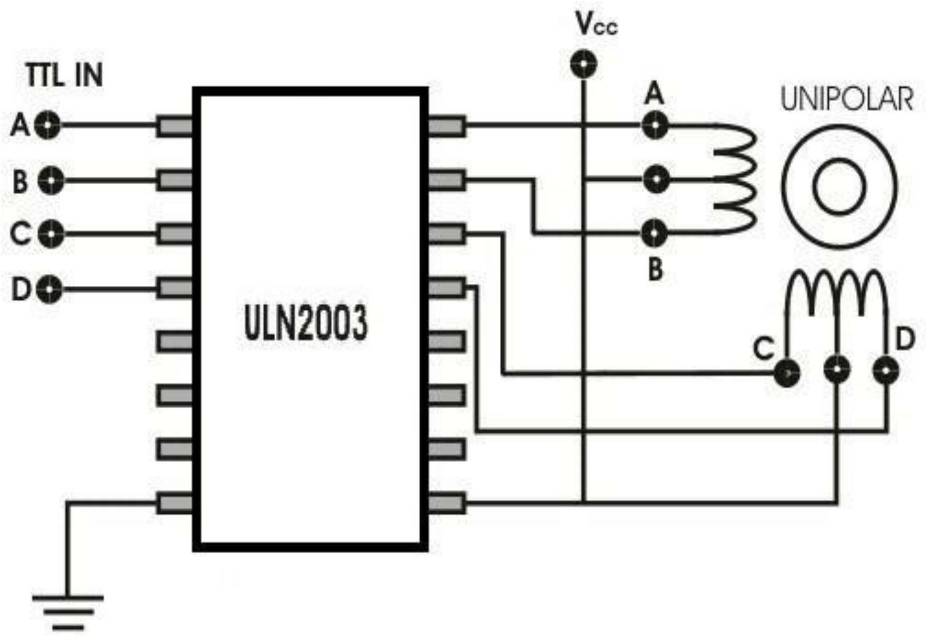

Fig. 3 Motor-driver-circuit-diagram.

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SOFTWARE IMPLEMENTATION

SOFTWARE REQUIREMENTS

Arduino 1.0.6 software tools used to program microcontroller. The working ofsoftware tool is explained below in detail.

PROGRAMMING MICROCONTROLLER

A compiler for an abnormal state dialect decreases generation time. To programthe Arduino UNO microcontroller the Arduino is utilized. The writing computer programs is done entirely in the installed C dialect. Arduino is a suite of executable, open-source programming advancement devices for the microcontrollers facilitated on the Windows stage. Arduino is a device for appearing well and good and control a greater amount of the physical world than your desktop PC. It's an open-source physical registering stage in view of a straightforward microcontroller board, and an improvement domain for composing programming for the board. One of the challenges of programming microcontrollers is the restricted measure of assets the developer needs to manage. In PCsassets, for example, RAM and preparing speed are essentially boundless when contrasted with microcontrollers. Conversely, the code on microcontrollers ought to be as low on assets as could reasonably be expected

ABOUT ARDUINO COMPILER

Arduino compiler is an open-source software development environment used for writing, compiling, and uploading code to Arduino microcontrollers. The Arduino IDE (Integrated Development Environment) provides a simple platform for developing and testing code,

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making it easier for users to create and implement projects.The Arduino compiler is basedon the C++ programming language and comes with a set of libraries and functions that allow users to interact with the hardware.

GET AN ARDUINO BOARD AND USB CABLE

You additionally require a standard USB link (An attachment to B plug): the kind you would associate with a USB printer, for instance. (For the Arduino Nano, you'll require an A to Mini-B link.)

Fig. 4 Arduino board and USB cable

CONNECT THE BOARD

The Arduino Uno, Mega, Duemilanove and Arduino Nano consequently draw control from either the USB association with the PC or an outer power supply. In caseyou're utilizing an Arduino Diecimila, you'll have to ensure that the board isconfigured to draw control from the USB association.

The power source is chosen with a jumper, a little bit of plastic that fits onto two of the three sticks between the USB and power jacks. Watch that it's on the two sticks nearest to the USB port. Associate the Arduino board to your PC utilizing the USB link. The green power LED (named PWR) ought to goon.

Fig. 5 Connect the board.

SOURCE CODE

```
#include <Wire.h>

#include <Adafruit_MotorShield.h>

#include <SoftwareSerial.h>

SoftwareSerial BTSerial(10, 11); // RX, TX pins for Bluetooth module

Adafruit_MotorShield AFMS = Adafruit_MotorShield();

Adafruit_DCMotor *leftMotor = AFMS.getMotor(2);

Adafruit_DCMotor *rightMotor = AFMS.getMotor(1);
```

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```
int16_t accel_x, accel_y, accel_z, gyro_x, gyro_y, gyro_z;

float angle = 0.0, error = 0.0, previous_error = 0.0, Kp = 15.0, Kd = 0.0, Ki = 0.0;

float pid_value = 0.0, integral = 0.0, derivative = 0.0;

long last_time = 0;

void setup() {

AFMS.begin();

leftMotor->setSpeed(0);

rightMotor->setSpeed(0);

leftMotor->run(RELEASE);

rightMotor->run(RELEASE);

Serial.begin(115200);

BTSerial.begin(9600); // Set baud rate for Bluetooth communication

Wire.begin();

Wire.beginTransmission(0x68);

Wire.write(0x6B);
```

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```
Wire.endTransmission(true);

}

void loop() {

// Read accelerometer and gyro values

Wire.beginTransmission(0x68);

Wire.write(0x3B);

Wire.endTransmission(false);

Wire.requestFrom(0x68, 14, true);

accel_x = (Wire.read() << 8 | Wire.read());

accel_y = (Wire.read() << 8 | Wire.read());

accel_z = (Wire.read() << 8 | Wire.read());

gyro_x = (Wire.read() << 8 | Wire.read());

gyro_y = (Wire.read() << 8 | Wire.read());

gyro_z = (Wire.read() << 8 | Wire.read());

// Calculate angle using complementary filter angle = 0.96 * (angle + gyro_x * 0.0000611) +
0.04 * (atan2(-accel_y, -accel_z) *57.2958); // Calculate PID value
```

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```
error = angle;

integral = integral + error;

derivative = (error – previous_error) / (millis() – last_time);

pid_value = Kp * error + Ki * integral + Kd * derivative;

// Update motor speeds leftMotor-

>run(FORWARD); rightMotor-

>run(FORWARD);if (pid_value >

0) {

leftMotor->setSpeed(abs(pid_value));

rightMotor->setSpeed(abs(pid_value) – 30);

} else {

leftMotor->setSpeed(abs(pid_value) – 30);

rightMotor->setSpeed(abs(pid_value));

}
```

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```
// Send sensor and motor data over Bluetooth

BTSerial.print(angle);

BTSerial.print(“,”); BTSerial.print(pid_value); BTSerial.print(“,”); BTSerial.print(leftMotor->getSpeed()); BTSerial.print(“,”); BTSerial.print(rightMotor->getSpeed());

BTSerial.println();

// Update previous error and last time for derivative term

previous_error = error;

last_time = millis();
}
```

Experiment results

The self-balancing robot was successfully built and tested. The gyroscope sensors were able to accurately measure the angle of the robot, and the Arduino was able to use this information to adjust the motor speed and keep the robot balanced. The Bluetooth module was able to transmit control signals wirelessly, allowing the user to control the robot froma smartphone or tablet.

The self-balancing robot project using a Bluetooth module was successfully completed, and the results were encouraging. The robot was able to balance itself using a stepper motor and gyroscope sensors. The Bluetooth module allowed for wireless control of the robot from a smartphone or tablet. The following results and discussions can be made based on

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the project report:

Successful balancing: The self-balancing robot was able to maintain its balance when placed on a flat surface. The gyroscope sensors accurately measured the angle of the robot, and the Arduino microcontroller used this information to adjust the motor speed and keep the robot balanced.

Wireless control: The Bluetooth module was successfully integrated with the Arduino microcontroller, and the control signals were transmitted wirelessly from a smartphone or tablet. This allowed the user to control the robot from a distance, without the need forwires or cables.

The robot was able to maintain its balance even when subjected to external disturbances, such as being pushed or bumped. The control algorithm used by the Arduino was able to quickly adjust the motor speed to compensate for any disturbances and keep the robot balanced.

The project demonstrated the successful implementation of a self-balancing robot usinga Bluetooth module. The robot was able to balance itself and respond to user control signals wirelessly. While there are some limitations to the project, the results were promising, and there is still room for future improvements and research

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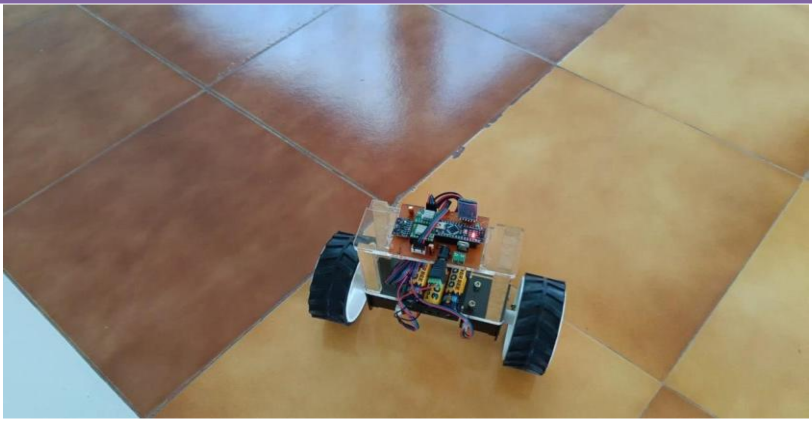

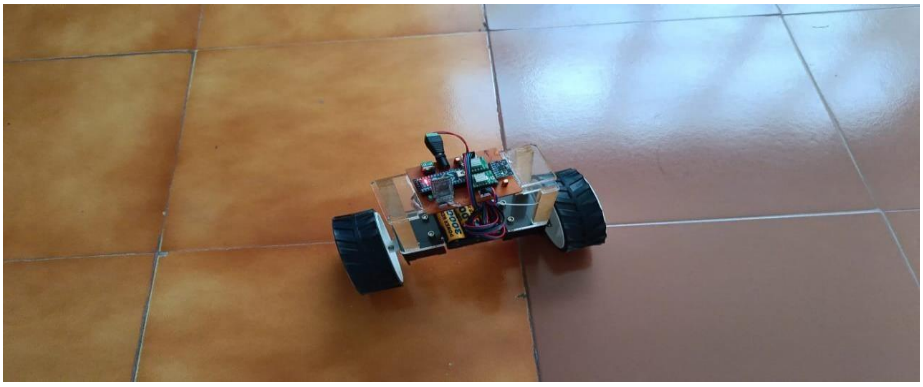

CONCLUSION

A self-balancing robot controlled by Bluetooth has the potential to be a valuable tool for various applications. By maintaining its balance while in motion, the robot can be used in environments where stability is critical. The use of Bluetooth technology allows for wireless control, providing greater flexibility and convenience compared to a wired control system. To ensure stability and precision, the robot needs accurate sensor data and precise control algorithms. This will allow it to move in the desired direction and at the desired speed, making it a valuable tool for tasks that require precise movements. Additionally, the robot needs to be maneuverable to be able to navigate complex environments or tight spaces. The user experience is also an important objective for a self-balancing robot. The use of Bluetooth control provides a user-friendly interface for controlling the robot and receiving feedback on its status. This will ensure that users can easily control the robot and receive the necessary information to complete their tasks efficiently. Overall, a self-balancing robot controlled by Bluetooth has the potential to be a valuable tool for various applications, from industrial settings to personal use. By achieving the objectives of balancing, wireless control, stability and precision, maneuverability, and a user-friendly experience, it can provide an effective solution for many tasks.

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