International Journal of Research in Engineering, Science and Management
Volume-2, Issue-12, December-2019
www.ijresm.com | ISSN (Online): 2581-5792

AutOCR: Automatic Obstruction Clearing Robot

Tanmoy Das[1], Swapnil Sambhav[2], Rahul Yadav[3], Pushkar Kumar[4], Rahul Singh[5], Suraj Yadav[6]
[1,2,3,4,5]*UG student, Department of Mechanical Engineering, Asansol Engineering College, Asansol, India*
[6]*Assistant Professor, Department of Mechanical Engineering, Asansol Engineering College, Asansol, India*

***Abstract*: The aim of our project is to design a robot which helps the vehicle to maneuver around and/or over obstacles. The working is based on principle of gyroscopic precession. The Robot uses two gyroscopes mounted on the frame, which can be activated according to our requirement. By providing spin and precession to the gyroscopes in a controlled way it is possible to create a couple on the vehicle such that the vehicle is able to maneuver over obstacles. Cost effective microcontroller is used to provide controlled motion to the Robot. For spin motion brushless DC motor can be used and for precession motion stepper motor or a high torque motor with encoder can be used.**

***Keywords*: Gyroscope, Couple, Torque induces Precession**

1. Introduction

Gyroscopes are common in many of today's applications from the biggest aircrafts to the smallest consumer electronic devices. However, gyroscopes are primarily used as sensors in navigation and/or to make devices aware of their orientation. But this Robot takes a different approach and uses gyroscopes to directly influence the orientation of a vehicle. When an object rotating about an axis is applied with external torque along a direction perpendicular to the rotational axis, the precession occurs. This kind of precession is called torque induced precession. Our aim is to use this precession motion to maneuver over obstacles.

2. Working Principle

A. Precession

Precession is a change in the orientation of the rotational axis of a rotating body. In an appropriate reference frame it can be defined as a change in the first Euler angle, whereas the third Euler angle defines the rotation itself. In other words, if the axis of rotation of a body is itself rotating about a second axis, that body is said to be processing about the second axis. A motion in which the second Euler angle changes is called nutation. In physics, there are two types of precession: torque-free and torque-induced, out of which the type of precession we used in our project is torque induced precession.

B. Torque Induced Precession

Torque induced precession also called gyroscopic precession is the phenomenon in which the axis of a spinning object describes a cone in space when an external torque is applied to it. The phenomenon is commonly seen in a spinning toy top, but all rotating objects can undergo precession. If the speed of the rotation and the magnitude of the external torque are constant, the spin axis will move at right angles to the direction that would intuitively result from the external torque.

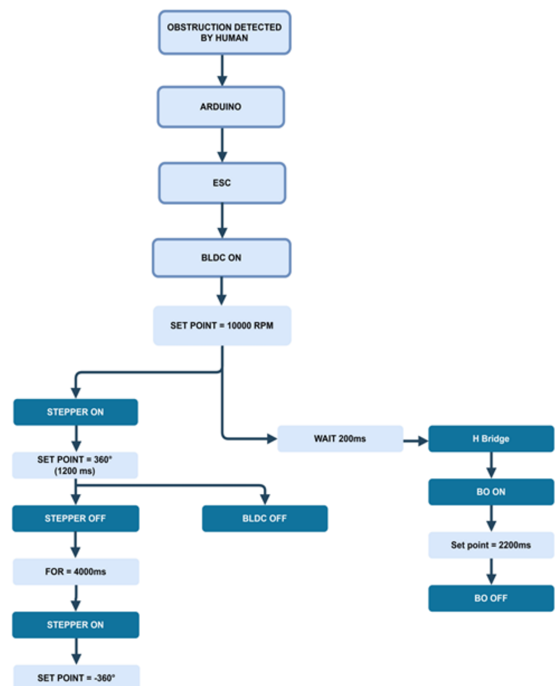

Fig. 1. Working

C. Euler Angles

The Euler angles are three angles to describe the orientation of a rigid body with respect to a fixed coordinate system. They can also represent the orientation of a mobile frame of reference in physics or the orientation of a general basis in 3-dimensional linear algebra. The geometrical definition demonstrates that three composed elemental rotations are always sufficient to reach any target frame. Three Euler angles area as follows:

- Ψ - about z axis (1st Euler angle)-couple.
- Θ - about new y axis (2nd Euler angle)-precession.
- Φ - about new x axis (3rd Euler angle)-disc rotation.

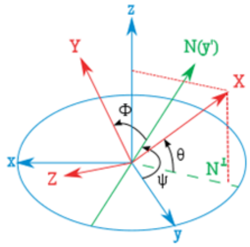

Fig. 2. Projections of X axis after three Euler rotations

3. Components

The Obstruction Clearing Robot consists of various components such as reacting wheel, various types of motors along with electronic component such as speed controller, microcontroller, connecting cables and H- bridge motor driver.

A. Reaction Wheel

Reaction Wheel is a vital part of a gyroscope. It is simply a solid structure with most of its mass accumulated at its periphery to provide high moment of inertia.

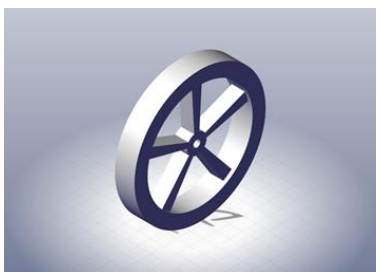
Fig. 3. Reaction wheel

B. Motors

Motor is used to convert electrical energy into rotational kinetic energy following various governing laws. We used three types of motors in our project i.e. BLDC Motor, BO motor and Stepper motor.

1) BLDC Motor

A Brushless DC (BLDC) motor is also referred to as an electronically commutated motor. There are no brushes on the rotor and commutation is performed electronically at certain rotor positions.


Fig. 4. BLDC Motor

2) BO Motor

A BO (Battery Operated) light weight DC geared motor which gives good torque and rpm at lower voltages. This motor can run at approximately 200 rpm when driven by a single Li-Ion cell. Great for battery operated light weight robots. It can do reverse and forward directions.

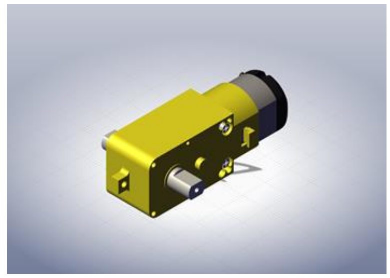
Fig. 5. BO Motor

3) Stepper Motor

A stepper motor, also known as step motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

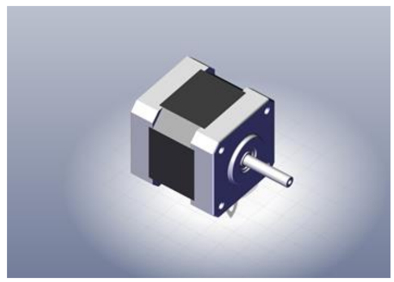
Fig. 6. Stepper motor

C. Electronic speed control

An electronic speed control follows a speed reference signal (derived from a throttle lever, joystick, or other manual input) and varies the switching rate of a network of field effect transistors (FETs). By adjusting the duty cycle or switching frequency of the transistors, the speed of the motor is changed. The rapid switching of the transistors is what causes the motor itself to emit its characteristic high-pitched whine, especially noticeable at lower speeds.


Fig. 7. ESC

D. Microcontroller

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

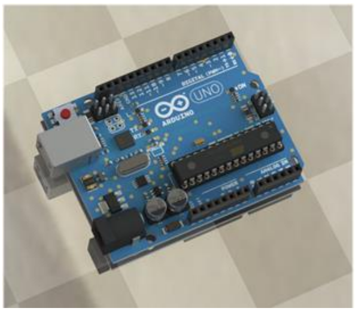

Fig. 8. Arduino

E. H-bridge motor driver

The L298N is an integrated monolithic circuit in a 15- lead Multi watt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

Fig. 9. L298N

F. Circuit diagram

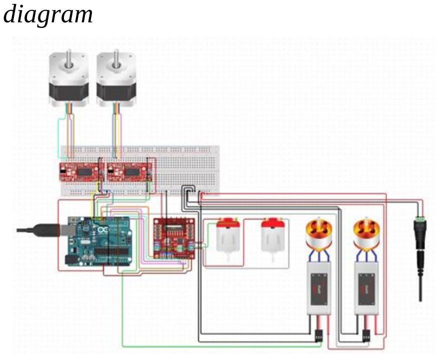

Fig. 10. Circuit diagram

G. Rendered image of model

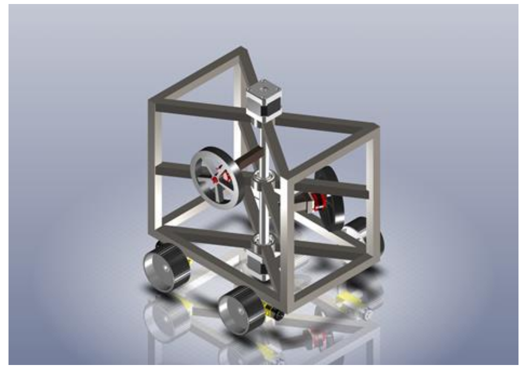

Fig. 11. CAD Model

4. Calculation

A. Couple Calculation

- M (mass of disc at outer periphery) = 370.25 g
- 0uter radius =5 cm
- Inner radius =4 cm
- N_d (velocity of disc in rpm) = 10000
- N_p (velocity of precision in rpm) = 50

Gyroscopic couple due to one disc, $C_d = I\ \omega_d\ \omega_p$

r (Mean radius of disc) = (outer radius-inner radius)/2

= (5-4)/2 = 4.5cm

Here, I = moment of inertia of disc = mr^2 =25 * (4.5)2

=7497.56 g/cm^2

ω_d = angular velocity of disc = $(2\pi/60) * N_d$

=> $(2\pi/60) * 10000 = 1047.2$ rad/s

ω_p = angular velocity of precision = $(2\pi/60) * N_p$

=> $(2\pi/60) * 50 = 5.235$ rad/s

So, $C_d = I\ \omega_d\ \omega_p$ = (7497.56 * 1047.2 *5.235)

= 24666 kg cm^2/s^2

Now, L (length from disc to precision axis) = 14.5 cm

Force = (Cd /L) = (24666/14.5) = 1701.103 Kg cm/s^2

= 17.01 N

Lifting Force = 1701.103 * 2 = 34.02 N

Lifting mass = (F/g) = (34.02/9.8) =3.47 kg

B. Maximum power consumption

2 * Bldc Motor = 5A *2 = 10A

2* Stepper Motor = 1.6A * 2 = 3.2A

4* Bo Motor = 0.2A * 4 = 0.8A

1* Microcontroller = 0.04A* 1 = 0.004A

Total = 14.04A

Maximum Power Consumption = 14.04 * 11.1 = 155.84 W

5. Use

a) The robot can be used in rough terrain where it is difficult for normal wheeled robot to move.

b) More sophisticated and energy efficient version of these robot can be used for planetary exploration.

c) This system can be used in vehicles by using their flywheel as the disc of gyroscope and using an external source for precession.

6. Future scope

a) Disc material can be optimized by using alloys like nickel tungsten alloy, nickel iron alloy etc.
b) By maximum the spin rpm, the size robot can be minimized which can open door to making of new miniaturized robot.

7. Conclusion

The report deals with a robot whose objective is to maneuver over obstacles such as pits, valleys etc. by toppling itself from front and then from backwards. This toppling is achieved by torque developed due to gyroscopic couple. To achieve precise motion of disc and precession, popular and low cost microcontroller like Arduino is used. H bridge motor driver in combination with Arduino is use to provide precise locomotion to the robot during maneuvering.

References

[1] MIT Open Courseware - Precessional Angular Velocity and Titled Gyroscopes.
[2] Teodorescu, Petre P (2002). Mechanical Systems, Classical Models: Volume II: Mechanics of Discrete and Continuous Systems. Springer Science & Business Media. p. 420.
[3] Boal, David (2001). "Lecture 26 – Torque-free rotation – body-fixed axes".
[4] Schaub, Hanspeter (2003), Analytical Mechanics of Space Systems, AIAA, pp. 149–150.
[5] Magic car; Sean Ong Mechatronics Project MAGIC Sean Ong; May 8, 2012 EGGN 521.
[6] Circuito Io, https://www.circuito.io/