A Review on Various Methods for Self-Balancing of Electric Two - Wheeler

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Abstract - *In this paper, we are going to deal with the self-balancing of the two -wheeler. Two -wheelers are owned by most of the population as it is more economical and feasible than cars. However, compared to cars, two -wheelers are challenging to balance, especially at low or zero speed, which is the most crucial factor is concerned with the safety of the rider. However, if we can achieve the aspect of a two -wheeler which is as safe as a car, but at a low price, then every average person will purchase it and will have a safer means of transportation. For increasing safety factor in two -wheelers, we can use the gyroscope; the gyroscope is the rotating mass that can change the bike's orientation as per the requirement. This gyroscope is mounted on the two -wheeler chassis at the centre of mass; sensors, motors and battery are also used for balancing purposes. This self-balanced two - wheeler can be easily handled by handicap peoples and even by children as they can automatically balance themselves without the rider's efforts. Moreover, as this two -wheeler runs on a battery, it does not cause any pollution.*

Keywords: *Self-Balancing, Gyroscope, Electric Vehicle.*

Introduction

Motorcycles are one of the most commonly used modes of transportation. It has been popular due to its fuel efficiency, Durable, compact design, and attractive look. Various innovative ideas are introduced for motorcycle such as electric bikes, Self-balancing vehicles, Solar -powered bikes, etc. Different Papers are published for these different innovative ideas. Some of the papers show the working and mathematical modeling of the vehicle, some Simulations of the working model, and some show a Graphical representation of the frequency phase diagram of bike steering.

Some of these papers and their reviews are as follows:

1. Design, development and analysis of self-balancing electric bike [1] (IJSER © 2018) ISSN 2229-5518 Summary:

There are numerous ways to design an efficient self-balancing bicycle, using a control moment gyroscope (CMG), mass balancing, steering control, and reaction wheel. Based on previous research, CMG usage is the suitable choice since it can produce a large amount of torque, it has no ground reaction forces, and the system can be stable even when the bicycle is stationary. CGM method can provide ample torque, but the energy consumption of CMG is very high because the flywheel is spinning all the time. The Centre of mass location and the Gyroscopic effect of its wheels were the team's main challenges.

2. Self-Stabilizing Bike using Gyroscope [2] (IJRET volume: 06, issue: 11) ISSN 2321-7308 Summary:

It is a common information known to everyone that a bike needs support in a standstill condition. Therefore, Gyroscopes can help the bike to balance itself. In this paper working of the gyroscope has been explained. The various components used in CMG are also informed in this research paper, and the working of CMG for stabilizing the two-wheeler is also explained.

3. Survey on Self Balancing Two Wheel Electric's prototype [3] (IJERGS volume: 05 issue: 5) ISSN 2091-2730 Summary:

The deployment of electric vehicles in vast quantities can be viewed as a carbon -free transportation sector. This paper presents the results of an exploratory survey on the market for electric self-balance bikes. This research work demonstrates the remarkable use of the balancing bike for the people whose concern is safety and people with specific disabilities. The main components for self-balancing are a gyroscope, three -axis accelerometer and PID controller for logic processing. Research also quantifies the market for electric bikes in the transportation sector as compared to conventional vehicles. It is clear from our research that there must be a cheap and alternative way of transportation in urban and rural areas, which is an advance and comparatively cheaper than current conventional vehicles.

4. A Self-Balancing Performance Comparison of Three Modes of Handle Electric Motorcycles [4] (IEEE©2015) 978-1-4799-6649-3 Summary:

This Research paper deals with self-balancing to handle an electric motorcycle. In this, we go to study about the comparison of the performance of the three kinds of steering working modes (1) Single -phase mode (SPM), which means only the front steering rotating; (2) Anti phase model (APM), the front and rear steering rotate in the opposite direction; (3) In phase model (IPM), the front and rear steering rotate in the same direction. With these three steering modes, experiments are formed from which we can conclude that: The SPM has the best self-balancing stability. Its speed can be controlled by the rider's feet impractical application. The APM only has the fastest turning performance. IPM could not keep self-balancing after 10 seconds. The IPM possesses both stability and flexibility, but its speed is not easy to be controlled. The electric motorcycle posture can be measured by using an inertial measurement unit (IMU) sensor. The IMU sensor contains a3 -D accelerometer, a 3 –D angular rate sensor, and a3 -D magnetometer.

5. Full -Speed Self-Balancing Electric Motorcycles Without the Handlebar [5] (IEEE©2016 volume: 63, issue: 3) Summary:

In this paper, a novel handlebar -free self-balancing electric motorcycle is studied; by controlling the steering, the motorcycle can self-balance by keeping its wheels swaying. A brief comparison of the three modes are discussed here; the three modes for steering are (1) Single -phase model (SPM), (2) Anti phase model (APM), (3) In phase mode (IPM). Two modes of steering are combined here to achieve a full -speed self-balancing motorcycle: Single -phase model (SPM) and in -phase mode (IPM). Two different phase models were applied in zero/low speed and average/high speed: IPM stabilizes at zero or low speed, and SPM stabilizes at medium or high speed.

6. Design and Development of a Self-Balancing Mono Wheel Electric Vehicle [6] (IJAREEIE volume: 06 issue: 05) ISSN 2278-8875 Summary:

In this paper, a single Wheel Hover-board is discussed. This vehicle balances on a single wheel and operates according to the driver's inclination (forward and backwards). PID Controller with IMU Sensor is used for balancing purpose. The PID Controller senses the platform's inclination against the ground level and computes the control variables for counteracting the fall by providing sufficient counter -torque. The platform stays parallel concerning the ground. The internal Combustion engine has 27% efficiency, and fossil fuel resources are depleting, whereas a General Electric gas turbine at a thermal electric power plant achieves ~66% efficiency; therefore, electric vehicles are more suitable. 7. Self-balancing Two -wheel Electric Vehicle (STEVE)

7. (ISMA13©2013) 978-1-4673-5016- 7/13/$31.00 Summary: Self-balancing two -wheel electric vehicle (STEVE):

STEVE is an applied research project to design, analyze and construct an electric vehicle with two parallel wheels similar to SEGWAY. Mechanics of STEVE included two coaxial wheels connected with two gearboxes and motor assembly. STEVE utilizes the physical laws of mechanical, electrical, fluid, and thermodynamics. It provides the mathematical analysis for the modeling of Steve with and without rotation on a flat surface. Gyro -meters and accelerometer are used to provide orientation.

8. A Study on Self-Balancing Electric Motorcycles with Two -Wheel Steering [8] (IEEE©2014) 978-1-4799-4598-6/14/$31.00 Summary:

A study on a self-balancing electric motorcycle with two -wheel steering: This paper studies the controlled balancing of an electric motorcycle with its wheels swaying by introducing three kinds of self-balancing structures. a) Kinematics and Dynamics: Models of kinematics and dynamics of the motorcycle are provided to prove the relation between the motorcycle's circular motion around its radius and wheelbase. This paper provides the nonlinear dynamics of the two-wheel steering structure. b) Master Operator System: Master operator is used for a driver with two motors, one for control of speed and the other for controlling the motorcycle's direction. c) Posture Controller Design: Two kinds of steering motions are considered to simplify the motorcycle control strategy in the posture controller system.

Methodology

Many researchers have done their research in the field of a self-balancing two-wheel vehicle. Different people have used different approaches for stabilizing the two wheelers. One of the well -known examples is the selfbalancing robot bicycle Murata Boy, developed by Murata in 2005. This self-balancing robot bicycle uses a reaction wheel inside the robot as a torque generator and as an actuator to balance the bicycle. The reaction wheel is nothing but a spinning mass, and its axis is fixed to the bicycle, and its speed is increased or decreased to generate a reaction torque around the spin axis which will balance it. Reaction wheels are simple in structure and are less expensive compared to the other momentum exchange actuators. The reaction wheel's advantages are low cost, simplicity, and the absence of ground three reactions. Its disadvantages are that it consumes more energy and cannot produce large amounts of torque. We have studied other balancing two -wheelers, such as mass balancing, steering control, reaction wheel, and gyroscope. Gyroscopes are suitable for balancing purpose as it does not require ground reaction and produce large amounts of torque. Compared to reaction wheels, gyroscopes are relatively lightweight, and they can generate higher torque levels per unit kg. Significant torque amplification and momentum storage capacity are two essential properties of the gyroscope. The gyroscopes are rotating masses that provide orientation to two -wheelers as per requirement. This gyroscope is mounted on the centre of mass of the two -wheeler, and it is connected to the motor, which will provide momentum to the mass. A light motor is also connected to the gyroscope to provide a tilting motion when required. When the two -wheeler is unbalanced and titling in one direction, the sensors measure the tilt angle with the velocity and acceleration of the vehicle and transfer it to the microcontroller. Later, the microcontroller will activate the motor which will tilt the rotating mass according to the bike tilting velocity and acceleration. This tilting motion to the rotor will produce an anti-torque to the bike's tilting motion, which will oppose the bike inclination and keep the bike in a stable vertical position. As the gyroscope is a heavy mass, it will indeed affect the design of the two -wheeler. Therefore, for balancing the two -wheeler, we have to keep some factors in consideration, such as the centre of mass should be low, vibrations induced due to the motor should be minimal, and the wheels should be aligned with the shaft axis.

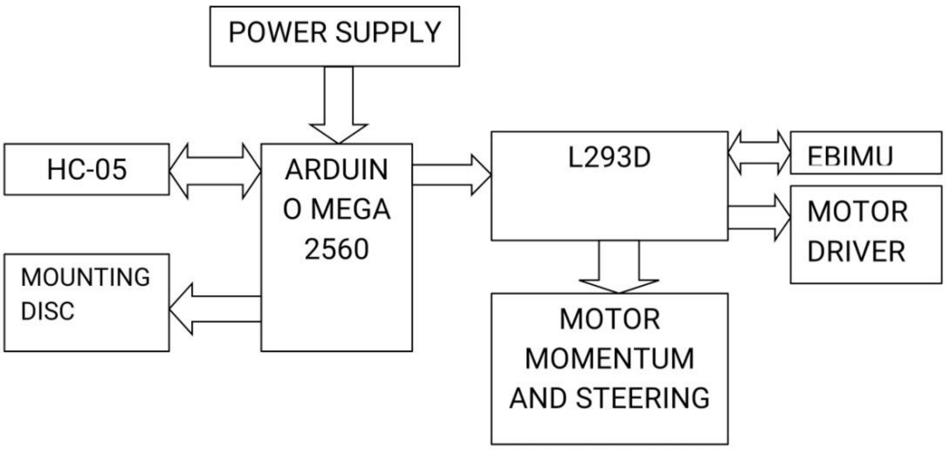

Fig -1: Working Block Diagram

The control flow block diagram shows that the first data from an android phone is sent through the Bluetooth kit to Arduino. The Arduino then drives the wheel controller, which activates the motor driver circuit and the sensor. Thus, the motor controls the orientation of the rotating mass, and other motors provide momentum to it.

Results and Discussion

Balancing two -wheeled vehicles were always challenging tasks for controllability, even for a normal human being. In this paper, we have studied self-balancing techniques and found an effective one. Some techniques for balancing are Reaction wheel, mass balancing, steering control, and gyroscope. In balancing a bicycle with the reaction wheel's help, the reaction wheel is nothing but a flywheel that rotates about an axis parallel to the bicycle frame, which is connected to a motor. When a bicycle is titled on one side, the motor exerts a torque on the flywheel, generating a counter torque on the bicycle and stabilizing itself. However, it has disadvantages, it does not provide easy steering, especially at high speed, and it also consumes more energy and generates less torque.

Another method is steering control, where a controller controls the amount of torque applied to the steering handlebar to balance the bicycle. This consumes less energy, but it requires ground reaction and cannot handle the significant tilting angle disturbance. The energy consumption of steering control is low, but it cannot balance the bicycle at low forward velocity. Mass balancing is simple, yet it produces less amount of torque. Whereas in a gyroscope even the rotating mass weighs more and it produces a large amount of torque lighter than the reaction wheel, storage of momentum is significant, and no ground reaction is required. Gyroscopes are used in inertial navigation systems such as Hubble telescope, inside the steel hull of submerged submarines and gyro theodolites to maintain tunnel mining direction. Comparing these four balancing methods, we can say that the gyroscopic effect is best and suitable for stability and controlling steering wheels. In the gyroscope, the rotating mass will change the orientation of the two -wheeler based on the inputs. Anyone can operate the self-balanced two - wheeler using a gyroscope; children, older people and physically challenged people can ride on this two -wheeler. It gives a safe ride at any speed, and when the bike is at rest, we do not need a stand to support the bike.

Conclusion

Thus, we have studied different research papers on different systems for balancing the two wheeler vehicle. Gyroscope (without Arduino), gyroscope with Arduino, IMU are the different systems for balancing of two wheeler vehicle studied in those research papers. We have studied mathematical modeling, kinematics and dynamics, different operating systems, and posture -recognition systems in these papers. Furthermore, we are researching a better power management system and power-train mechanism to produce high torque with less energy consumption.

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