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Automotive Bot

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ABSTRACT

A bicycle can be turned into an automotive bot, which can stabilize itself and navigate itself to the intended destination. There are two theoretical methods by which a two wheeled vehicle oriented in tandem can be stabilized: dynamic stabilization and control moment gyroscope (CMG) stabilization. Dynamic stabilization utilizes tactical steering techniques to trigger a lean in the vehicle in the intended direction for balancing, while CMG stabilization employs the reactive precession torque of a high-speed flywheel about an axis that will act to balance the vehicle. Of these two, CMG stabilization offers greater advantages for static vehicles. The conceptual stage paper proposes that the technology which was used in the auto driven cars can be successfully implemented to a highly unstable form through auto stabilization by one of the above two methods. The bike can easily navigate with the help of radar and map technology. The radar sonar system detects possible collisions and avoids them through intelligent form of cruise control that slows down and speeds up automatically to keep pace with the vehicle in front of you.

Keywords: Flywheel Balanced Bicycle, Gyroscopic effect, 3 axis-accelerometer, Auto obstruction detector

I. INTRODUCTION

A History of Autonomous Stabilization Attempts at autonomous stabilization of inherently unstable vehicles have dated back to the early 20th century. In 1905, Louis Brennan built a Gyroscopic Monorail that utilized a CMG system controlled by passive actuation of several mechanisms and mechanical sensors designed to respond to the monorail's tilt orientation. The monorail successfully executed test runs carrying 50 passengers along a circular path; however, due to the limited accuracy of sensors and robust controllers at that time it was more practical to employ inherently stable two rail systems.

In 1909 and 1911 similar projects where endeavored by Scherl and Shilovsky. Shilovsky's gyrocar was a two wheeled vehicle with the wheels oriented in tandem. The gyrocar was capable of being manually stabilized via a clutch activated CMG system, requiring the human passenger to actuate the clutch appropriately to gimbal the CMG's flywheel. Lack of sensors for accurate angular position, velocity, and acceleration feedback limited the autonomy of these early attempts. Today, much progress has been made in sensor technology, motor technology, control methods, and autonomous controllers making the use of a CMG stabilized 2-wheeled vehicle more practical. In the advent of computer aided programs and microcontrollers, more research has been conducted on the self stabilization of bicycles. Bicycle dynamics and control have been investigated in detail. A very well-known self -balancing robot bicycle, Murata Boy, was developed by Murata in 2005. Murata Boy uses a reaction wheel inside the robot as a torque generator, as an actuator to balance the bicycle.

High end companies are experimenting on the automotive bot technology for two wheelers and still they are in the incubation stage and finds no luck in developing one. Studies in dynamic stabilization where the bicycle is actively steered to induce leans that oppose the bicycle's instabilities while moving forward at a constant velocity; however, this attempt fails at stabilizing a static bicycle, a difficult task for human riders, because the passive gyroscopic stabilizing effect produced by the angular momentum of the bicycle's wheels is absent. A few different approaches have been pursued to achieve static stabilization, the most notable of which include: adding a rotor mounted on the crossbar mounting a pendulum to balance the tilting force , and using the precession effects of a gyroscopic actuator.

A. Existing Technology for Cars

1. Object Detection:

Google's driverless car uses a lot of very advanced hardware. It needs to be able to detect and avoid obstacles, as well as understand if an object is a curb, a pedestrian or cyclist. Google's driverless car uses a host of detection technologies such as sonar devices, stereo cameras, lasers and radar15.The Velodyne 64-beam laser (LIDAR – light detection and ranging) mounted on the roof of the Google car is at the heart of its object detection. It measures the distance between the vehicle and object surfaces facing the vehicle by spinning on its axis, changing its pitch and taking 1.3 million readings per second. The laser has a 360-degree horizontal field of view, a 30-degree vertical field of view and a maximum distance of 100 meters. The radar has a horizontal field of view of 60 degrees for the near beam and 30 degrees for the far beam, as well as a maximum distance of 200 meters. Based on this information, the Google car adjusts the throttle and brakes continuously to prevent an impact. It is essentially an adaptive cruise control. The sonar has a 60-degree horizontal field of view for a maximum distance of 6 meters. The stereo cameras have an overlapping region with a 50-degree horizontal field of view, a 10-degree vertical field of view, and a maximum distance of 30 meters. Both the radar and sonar sensors have a narrow field of view; therefore, the car knows things are about to get messy if another vehicle crosses both beams. This signal is used to swerve the vehicle or apply the brakes. Google mounts regular cameras around the exterior of the car in spaced-out pairs. The overlapping fields of view create a parallax not unlike your own eyes that allow the system to track an object's distance in real time. As long as it has been spotted by more than one camera, the car knows where it is. These stereo cameras have a 50-degree field of view, but they are only accurate up to about 30 meters15.

2. Ultra-Precise Map:

Google has built the entirety of California's road system (about 172,000 miles) in software, along with accurate simulations of traffic, pedestrians and weather. Google has built the data the cars need to process by mapping each road that the cars will drive on by ultra-precise digitization of the terrain. Google's software integrates all the data from these remote sensing systems (~ 1GB per second) to build a map of the car's position. Its algorithms then process data based on observing deltas.

Mapping of the terrain in which the car drives is done in "real-time" as opposed to using the "delta" approach that Google is taking, starting with pre-mapped routes and terrain information. The following sections cover some interesting technologies available, illustrating the incremental approach to self-driving cars by auto manufacturers.

***3. Lane Change Assist*:**

This driver assistance system consists of two radar units. The devices are invisibly mounted in the corners of the rear bumper. One sensor operates as system master; the second unit is configured as slave. By using a private data link, the data of both radars are combined in a sensor data fusion-tracking algorithm.

4. Parking Assist:

Fully Assisted Parking Aid is now available in Ford. It can now park cars in tight spaces and back into perpendicular and angled parking spaces. When the car finds a suitable spot, it alerts the driver, who can stay in the car or get out and use a remote to finish the parking job. The car then backs itself into the parking space.

5. Adaptive Cruise Control:

Adaptive cruise control (ACC) is an intelligent form of cruise control that slows down and speeds up automatically to keep pace with the car in front of you. A small radar unit behind the front grille or under the bumper measures the distance. Some cars employ a laser while others use an optical system based on stereoscopic cameras. ACC is ideal for stop-and-go traffic and rush hour commuting that swings from 60 mph to a standstill. Regardless of the technology, ACC works day and night but its abilities are hampered by heavy rain, fog or snow. In an autonomous driving car, ACC needs to track not only the car in front but also the cars in adjacent lanes in case a lane change becomes necessary.

II. METHODOLOGY

A. Auto Stabilizing

The bicycle needed to be able to stand on its own and ride without tilting to either side. There are two theoretical methods by which a two wheeled vehicle oriented in tandem can be stabilized: dynamic stabilization and control moment gyroscope (CMG) stabilization

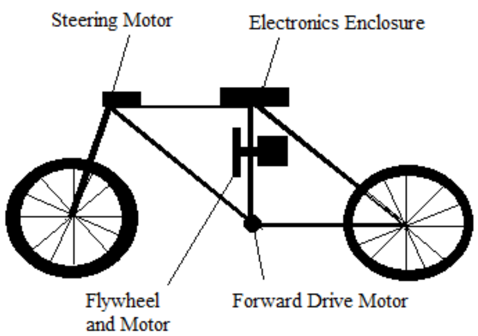
1. Control Moment Gyroscope (CMG):

CMG stabilization employs the reactive precession torque of a high-speed flywheel about an axis that will act to balance the vehicle. Of these two, CMG stabilization offers greater advantages for static vehicles.

1.1 Description of system:

In order to meet the design requirements, potential designs for controlling the balance of the bicycle were developed and will be explained in this section. The method is described below with particular attention given to how well they meet the selection criteria: physical complexity, power requirements, programming code complexity, ease of turning/steering, math complexity, deviation from a straight line, cost, and closeness to resembling a bicycle.

The level of difficulty is related to the number of motors and sensors required, the reaction time required, and starting and stopping. Finally, power requirements include the battery necessary to provide the system with 10 continuous minutes of power supply (the original power supply requirement; it has now been changed to 5 minutes). The required battery is dependent on the weight of the model, number of motors needed for that design, and the torque demanded of the motor(s) for the control system.



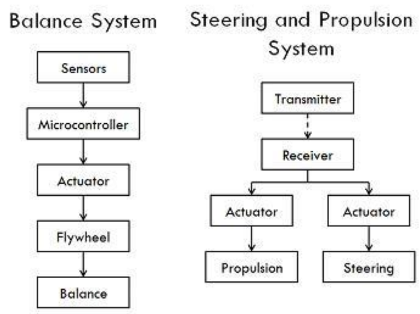
The flywheel design employs a flywheel which rotates about an axis parallel to the bicycle's frame. This design models the bicycle as a pendulum with a fixed pivot where the bicycle wheels meet the floor. As the bicycle begins to fall to one side, a motor mount to the bicycle exerts a torque on the flywheel, causing a reactionary torque on the bicycle, which restores the bicycle's balance.

The flywheel design has several advantages. This design is very stable: the bicycle can balance even in a stationary position. The mathematical model of this system is the least complex of the considered designs. Due to the simplicity of the design, the model would most likely be the closest to reality. Because of the relative math simplicity and the ease of starting and stopping, the controller would be relatively straight forward to implement. This design would also allow the bicycle to travel in a relatively straight line with only small deviations.

One of the main disadvantages of this design is that it does not likely permit easy steering, especially for higher speeds, considering that the PID gains will be optimized for straight-line travel. In addition, the frame would have to be altered, causing the design to look less similar to a bicycle than others do.

1.2. Control Overview:

The control of the bicycle is divided into two parts: balancing controlled by a microcontroller and steering and propulsion remotely controlled by an operator. The two control systems are described in further detail below, and the entire system is illustrated in a fig.



The AT mega 16 (the selected microcontroller) reads the output of the accelerometer and the gyroscope via the 12-bit analog-to-digital converter, and interprets the resulting values as a measurement of the bicycle's tilt angle. The measured angle is implemented into a PID algorithm, and outputs a corresponding voltage to the motor controller. The motor controller then outputs a voltage to the DC motor, which is geared down, and ultimately actuates the flywheel. A torque is exerted on the flywheel, and a reaction torque is exerted on the bicycle. This means in all aircraft with exception of agricultural and small general aviation airplanes, where the installation of a movable landing gear would increase the costs beyond the requirements of the aircraft category. Landing gear extraction is a primary operation and always its actuation has high redundancy.

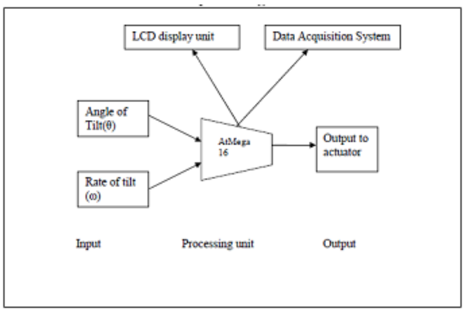
1.2.1 Microcontroller Unit :

The microcontroller selected to control the balance of the bicycle is the AT mega 16. The processing unit used is Atmel ATMega16 microcontroller unit which is a versatile EEPROM. It has four I/O (Input / Output) ports, onboard ADC (Analog to Digital Converter) and PWM (Pulse Width Modulation) outputs for motor control. It can be programmed easily with minimum hardware requirements, which make it extremely popular in robotics applications. Here it performs the following functions:

- ✓ ADC conversion of outputs of Rate Gyro and Accelerometer.
- ✓ Processing the input signals
- ✓ Periodic recalibration of gyro
- ✓ Display of angle & other data.
- ✓ Control of actuator unit

Fig. ATMega16

In this paper, a high speed flywheel with a single DOF gimbal is used to induce the torque that will counteract the moment due to gravity applied on the bicycle when it deviates or tilts from its semi-stable, vertical position. By applying a gimbal torque to a spinning flywheel, a simultaneous, amplified reactive torque is generated about an axis orthogonal to both the flywheel's gimbal axis and spin axis. This controllable reactive torque can be oriented to act about the axis that will balance an unstable bicycle.



1.2.2 ANGLE SENSOR:

Tilt sensing is the crux of this project and the most difficult part as well.

- ✓ Triple Axis Accelerometer ADXL335
- ✓ Dual Axis Gyroscope IDG500

To measure the bicycle's tilt angle, it is better to use an accelerometer and a gyroscope, and to combine them using a complimentary filter. Integrating these two sensors proves useful when calculating the bicycle's tilt angle. Accelerometers may be used to measure the angle with respect to gravity directly, but they are highly susceptible to noise.

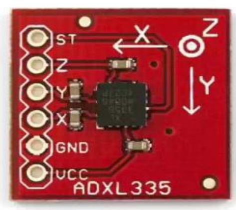


Fig. Triple Axis Accelerometer ADXL335

Gyros are less susceptible to noise, but they measure angular velocity. As a result, the gyro output must be integrated in order to obtain a measurement of angular position. This integration yields an error known as drift, a drawback of the gyro. Integrating both sensors allows one to easily combine the output of each sensor in order to obtain a more accurate angle reading. This is accomplished through the implementation of a filter, which combines the advantages of each sensor and eliminates the drawbacks of each sensor.

1.2.3 Actuator unit

As the bicycle tilts, we need to apply a restoring force to return the robot to vertical position. A reaction wheel pendulum model is followed for the balancing purpose. The components used are:

- ✓ High torque 24V DC motor
- ✓ A metallic reaction wheel
- ✓ Motor driver L293D

To supply sufficient power to the flywheel, a fairly powerful motor and a gear reducer are required. In order to choose the motor, the designed frame and layout of components, as well as the calculations to model a simple inverted pendulum, can be inputted to a MATLAB simulation using Simulink. This simulation allowed the team to determine the power, torque and velocity that the motor needed to supply. To meet these requirements, we use High torque 24V DC motor.

The capacitor connected across the motor charges and discharges during the on and off time respectively, thus behaving like an integrator. The torque generated by the motor is a function of the average value of current supplied to it. It seems to be obvious that once we have angle we can rotate the flywheel with acceleration proportional to it, but that will not do the job. If that is done what actually will happen is that when there is a tilt the bike will cross the mean position and reach the other side till the same tilt angle. To fix this we need some kind of algorithm that can damp this periodic motion and make it stable at the mean position after some time. This is where PID (Proportional Integraland Derivative) Controller comes to use.

2. Dynamic Stabilization

Dynamic stabilization utilizes tactical steering techniques to trigger a lean in the vehicle in the intended direction for balancing.

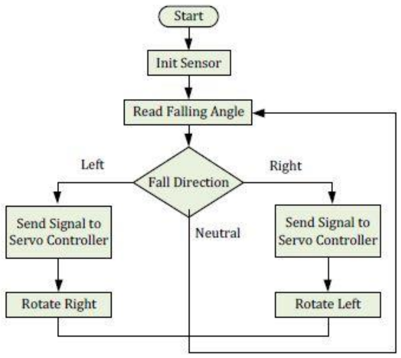
2.1 Description of system

Main components in proposed system are mainly divided into following section:

- ✓ Sensor-based-bicycle-state detection.
- ✓ PID controller for logic processing.
- ✓ Servo controller based bicycle handle controlling.

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer. In proposed system it will help to get the travelling motion and also falling angle.

Figure describe the technique which can be used to balance the bicycle. Even when staying relatively motionless, a rider can balance a bicycle by the same principle. While performing a track stand, the rider can keep the line between the two contact patches under the combined center of mass by steering the front wheel to one side or the other and then moving forward and backward slightly to move the front contact patch from side to side as necessary. Forward motion can be generated simply by pedaling. Backwards motion can be generated the same way on a fixed-gear bicycle. Otherwise, the rider can take advantage of an opportune slope of the pavement or lurch the upper body backwards while the brakes are momentarily engaged.



2.2 Balancing proposed technique

Proposed system is mainly a wireless controlled two wheel bicycle with inbuilt capability to balance itself while driving at particular speed. To achieve this with machine learning phase and embedded system we are proposing the system. This proposed system aimed to make a bicycle bot, powered by an electric motor, which could balance by itself and move along a particular path. The primary aim was to make the cycle balance on its own by controlling its handle.

B. Vehicle detectors

The collision of the vehicle can be avoided through sensor technology. There is a wide range of sensor technologies available for vehicle detectors. Some of the most common and some developing technologies are described in this section.

1. Video Image Processors

A video image processor (VIP) is a combination of hardware and software which extracts desired information from data provided by an imaging sensor. This imaging sensor can be a conventional TV camera or an infrared camera. A VIP can detect speed, occupancy, count, and presence. Because the VIP produces an image of several lanes, there is potential for a VIP to provide a wealth of traffic information such as vehicle classification and incident detection. A VIP generally operates in the following manner: the operator selects several vehicle detection zones within the field of view (FOV) of the camera. Image processing algorithms are then applied in real time to these zones in order to extract the desired information, such as vehicle speed or occupancy. Advantages of VIPs are that they are mounted above the road instead of in the road, the placement of vehicle detection zones can be made by the operator, the shape of the detection zones can be programmed for specific applications, and the system can be used to track vehicles. Disadvantages are the need to overcome detection artifacts caused by shadows, weather, and reflections from the roadway surface. The disadvantages can be overcome through design and installation of the hardware and design of the software algorithms.

2. Infrared Detectors

There are two types of infrared (IR) detectors, active and passive. Active infrared sensors operate by transmitting energy from either a light emitting diode (LED) or a laser diode. An LED is used for a non-imaging active IR detector, and a laser diode is used for an imaging active IR detector. In both types of detectors the LED or laser diode illuminates the target, and the reflected energy is focused onto a detector consisting of a pixel or an array of pixels. The measured data is then processed using various signal-processing algorithms to extract the desired information. Active IR detectors provide count, presence, speed, and occupancy data in both night and day operation. The laser diode type can also be used for vehicle classification because it provides vehicle profile and shape data. A passive infrared system detects energy emitted by objects in the field of view and may use signal-processing algorithms to extract the desired information. It does not emit any energy of its own for the purposes of detection. Passive infrared systems can detect presence, occupancy, and count. Some of the advantages of infrared detectors are that they can be operated during both day and night, and they can be mounted in both side and overhead configurations. Disadvantages are that infrared detectors can be sensitive to inclement weather conditions and ambient light. The choice of detector materials and construction of the system, as well as sophisticated signal processing algorithms, can compensate for the disadvantages.

3. Ultrasonic detectors

Ultrasonic detectors have not become widely used in the United States, but they are very widely used in Japan. Japan uses ultrasonic detectors in traffic applications as much as the U. S. uses inductive loop detectors in traffic applications. There are two types of ultrasonic sensors available, presence-only and speed measuring. Both types operate by transmitting ultrasonic energy and measuring the energy reflected by the target. These measurements are processed to obtain measurements of vehicle presence, speed, and occupancy. The advantages of ultrasonic are that they provide all-weather operation, do not need to be approved by the FCC, and provide fixed or portable mounting fixtures above the road. Their disadvantages include their need to be mounted in a down-looking configuration as perpendicular as possible to the target (as opposed to side mounting), a difficulty in identifying lane-straddling vehicles and vehicles traveling side by side, and susceptibility to high wind speeds. Some of these disadvantages may be compensated for through more sophisticated data processing techniques.

4. Microwave/Millimeter wave radar

Microwave detectors have been used extensively in Europe, but not in the United States. They operate by measuring the energy reflected from target vehicles within the field of view. By processing the information received in the reflected energy, the detectors measure speed, occupancy, and presence. Some of the advantages of microwave detectors are that they are a mature technology because of past military applications, they detect velocity directly, and a single detector can cover multiple lanes if it is placed properly and appropriate signal processing techniques are used. In addition, FCC approval is not required if it operates in the X-band or Ku-band, and the output powers are within specified limits. Some of the disadvantages are unwanted vehicle detection based on reception of sidelobe radiation, and false detection due to multipath. Most of these disadvantages can be overcome, in whole or in part, through proper placement of the detectors, signal processing algorithms, and antenna design.

III. CONCLUSION

This paper is highly concentrated on the bicycle using reaction wheel pendulum. Tilted information to roll axis is attained through the sensor integration of complementary filter between gyroscope and accelerometer. The simplest structured PID controller has been applied to roll direction joint. As future works, robust controller for the roll axis to minimize external disturbances effects, and S curved trajectory are under research. Sustainable and practical personal mobility solutions for campus environments have traditionally revolved around the use of bicycles, or provision of pedestrian facilities. However many campus environments also experience traffic congestion, parking difficulties and pollution from fossil-fuelled vehicles. It appears that pedal power alone has not been sufficient to supplant the use of petrol and diesel vehicles to date, and therefore it is opportune to investigate both the reasons behind the continual use of environmentally unfriendly transport, and consider potential solutions. The research seems to have immense scope due to the fact that even the high end companies are still at the incubation stage in this technology due to lack of practicability.

IV. ACKNOWLEDGEMENT

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