Gyro-Assisted Multi Terrain Rover

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Abstract - *Rocker Bogie is a suspension system used in rovers like Pathfinder, Curiosity etc. The specialty of this suspension system is that it does not have any Shock absorbers. The term "rocker" comes from the design of the differential, which keeps the rover body balanced, enabling it to "rock" up or down depending on the various positions of the multiple wheels. Bogie means links that has driven wheels at each end. This mechanism can climb obstacles like rocks which are more than twice or two times the diameter of the wheels while the all six wheels are in contact with the ground, whereas the other suspensions tilt stability is limited to center of mass. The project deals when this mechanism is fixed with auxiliaries like stable platform they can be used as cargo carriers which can climb the obstacles. These mechanisms can take a direct 55 degree climb without overturning.*

Keywords: Bogie, Rocker, Suspension system.

1. INTRODUCTION

The term “rocker” describes the rocking aspect of the larger links present each side of the suspension system and balance the bogie as these rockers are connected to each other and the vehicle chassis through a modified differential.

In the system, “bogie” refers to the conjoining links that have a drive wheel attached at each end. Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain. As accordance with the motion to maintain center of gravity of entire vehicle, when one rocker moves up-word, the other goes down. The chassis plays vital role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation. As per the acute design, one end of a rocker is fitted with a drive wheel and the other end is pivoted to a bogie which provides required motion and degree of freedom. Bogies were also quite commonly used on the trailers of semi-trailer trucks as that very time the trucks will have to carry much heavier load.

2. PREVIOUS WORK

Robotic systems have been developed to assist humans in various tasks and applications, either in industrial or domestic purposes. These systems are categorized into Unmanned Aerial Vehicles (UAV), Unmanned Ground Vehicle (UGV), Under Sea Vehicles (USV), space robots and medical robots [1, 2]. By having these systems, certain dangerous and incapable tasks could be done to replace humans mainly in monitoring, inspections, repairs, and maintenance at risks places such as nuclear plants, oil rigs, construction sites, and others. This paper discusses and reviews types of UGV particularly in its designs, features, and applications, which initially it was used for the planetary surface on a lander-style spacecraft [3]. Remote Overhead Extendable Robot (ROVER) is actually a term for a small-scale robotic UGV that had been built by NASA for space exploration designed to move across the surface of a planet. The popular rovers developed by NASA are Spirit and Opportunity that have been commissioned in Mars explorations [4]. Other than that, agile prototypes named The Light-weight Rover Unit (LRU) had been developed for autonomous planetary exploration purposes with relatively small in size [5].

As the results of successful robotic missions on Moon and Mars, future plans have been made for carrying out various activities and experiments. There are various tasks need to be done by the rover especially for atmospheric aspects like data supervision about air pressure, temperature climate and temperature [6].Ultra-wideband UWB wireless localization systems for highly precise applications. The problem addressed in the presented paper is enabling novel applications with autonomous UAV systems. The proposed system consists of Accelerometer, Gyroscope (MPU-6050), Optical flow sensor, Magnetometer, Ultrasound sensor, Pressure sensor, and GNSS receiver. The authors made experiments of simultaneous flight of three UAVs [7]. This study focus on the attitude estimation of the multi-rotor copter. It is difficult to obtain accurate attitude values due to the nonlinearity of this system as well as strong coupling.

Complementary filter algorithm is applied is used to solve this problem. The Inertial Measurement Unit (IMU) is used to estimate four-rotor helicopters attitudes using MPU-6050[8]. The paper proposes a simple open unmanned aerial vehicle platform. It's based on open-source flight controller used MPU6050 as a gyroscope and accelerometer. Experiments of the proposed system show that the multi-rotor copter can effectively control its flight [9]. Kalman filter is used in this paper to estimate the values of the data received from inertial measurement unit IMU and sensors like pressure sensor and MPU6050. this estimator provides smooth data for the flight controller which increase the stability of the copter as well as other features like hold altitude or auto-landing [10]. This paper presents the proposal of an aerial photography system depending on open-source flight controller. Each part used in this system is an open-source like ground station, flight controller, camera controller software, and system design. The experimental result shows that the low-cost UAV is

capable for photography applications. MPU6000/6050 used in the open source flight controller system [11]. The two-wheeled dynamic-balance robotic platform is based on the inverted pendulum model applied to mobile platform. The research on inverted pendulum has been matured and some successful achievements have been created over past years at home and abroad. JOE, from Swiss Federal Institute of Technology, designed by Felix Grasser and so on, was controlled by liner control theory which was based on state feedback control [12]. NBot, designed by David P.Anderson from South Methodist University, equipped some sensors such as tilt sensor (measure the tilt degree of barycenter) and encoder (capture the platform's location) [13]. JOE and nEot have something in common that they can't stand straightly by themselves. Segway was created by Dean Kamen and became a popular production. It has five\ gyroscopes and multiple microprocessors called brain of platforms. If one of the circuit boards is broken, the others will assume the tasks and protect the user from harm [14]. Yinliang from the Harbin Engineering University created a two-wheeled mobile platform. It can be divided into two parts: upper computer and the body of platform. They can swap data and command by wireless [15]. Free Mover was the achievements in scientific research from University of Science and Technology of China which combined the control theory and technology with the computer application [16]. Transportation and delivery systems used in service sectors like pharmaceutical and health care industries are now being automated. Research on control methods for complex and nonlinear mechanisms are hot topic [17].In this paper, the inverted pendulum, which is a classic nonlinear control experiment, is analyzed using MATLAB and Simulink's Sim Mechanics toolbox. Despite the advances in wheeled robotics, certain amount of vibrations and shocks are unavoidable. Hence, ensuring the safety of fragile goods that are being transported becomes more important as any delay or damage to goods can end up being very costly [18]. This paper aims to provide the design and implementation of a small scale working model of a self-balancing platform on a cart[19] that can be utilized to transport fragile materials across rough terrain and if developed on a larger scale can minimize these significant losses in maintaining balance. A multifunctional self-balancing mobile platform that was designed and implemented based on inverted pendulum model is studied [20]. A simple, convenient, stable and reliable, environment friendly platform controlled through intelligent automation is presented. The design of a two-wheeled balancing robot based on the concept of inverted pendulum [21] and implementation of PID control in developing a stable self-balancing platform on a mobile robot is analyzed [22], [23].

In MEMS vibratory gyroscopes, large power consumption stemming from the drive operation is an issue for wearable applications that call for longer battery life [24]. One solution is the CR method that uses free vibration for the drive[25]. So far, this approach is shown only for single-axis gyroscopes. This paper aims to apply the CR method to 3-axis TF gyroscope that possesses immunity for vibrations and shocks. Conventional TF gyroscope employs the anti-phase drive mode of two coupled masses [26]. This TF configuration, however, is not suited for CR when the resonant frequencies of in-phase and anti-phase are closely located. Even when the masses are released in anti-phase fashion, slight manufacturing asymmetry induces in-phase oscillation that makes a beat waveform the beat, the released mass will hit the stopper, resulting in waveform disturbance and physical damage [27]. The gyroscope contains 118 CR cells. Each CR cell has a parallel-plate capacitor formed by the 0V-biased mass electrode and a hold electrode. The catch operation is attained by applying a DC voltage to all the hold electrodes [25]. Majority of MEMS gyros function like Corilos vibratory gyros: as the inertial body (IB) performs oscillations about the drive axis (primary oscillations) and under the platform angular rate, Coriolis forces arouse IB oscillations about the sense axis (secondary oscillations). Currently, as MEMS gyro applications are diversified, more emphasis is put on vibration resistance. Using elastic systems with multiple IBs is an important trend in MEMS technology. In 2011, Ana log Devices presented its new four body MEMS gyro ADXRS646 with reduced sensitivity to linear accelerations and vibrations [29].

FLOWCHART OF MPU6050

The proposed system (Unified System) introduces a new method of balancing the platform using MPU which consists of both accelerometer and gyroscope, by maintaining the orientation of the MPU we can control the platform, the input is taken and arduino coverts the input to PWM output which in turn is received by the servo meter which maintains the platform in the opposite orientation of the MPU.

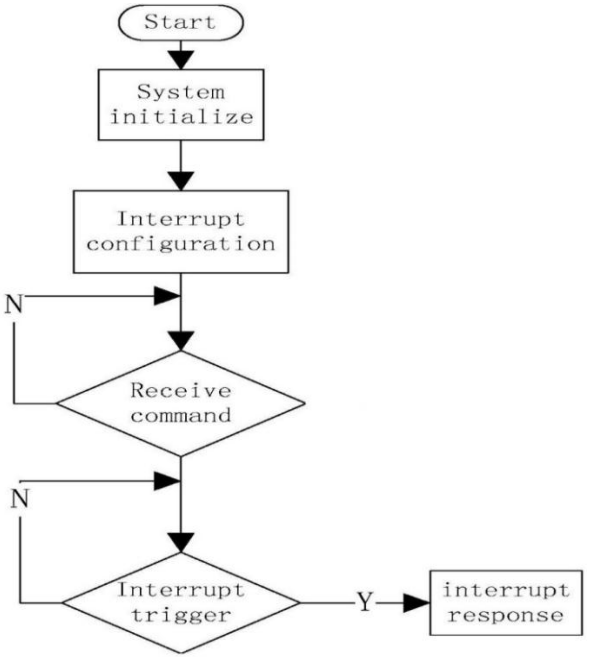

Fig 1: Flowchart of MPU6050

MPU is a six axis IMU sensor which means that it gives six values as output. Three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on MEMS (Micro Electro Mechanical Systems) technology. Both the accelerometer and the gyroscope is embedded inside a single chip. This chip uses I2C (Inter Integrated Circuit) protocol for communication. MPU consists of gyroscope and an accelerometer an accelerometer works on the principle of piezo electric effect. Here imagine a cuboidal box, having a small ball inside it, like in the picture above. The walls of this box are made with piezo electric crystals. Whenever you tilt the box, the ball is forced to move in the direction of the inclination, due to gravity. The wall with which the ball collides, creates tiny piezo electric currents. There are totally, three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y and Z axes. Depending on the current produced from the piezo electric walls, we can determine the direction of inclination.

Gyroscopes work on the principle of Coriolis acceleration. Imagine that there is a fork like structure, that is in constant back and forth motion. It is held in place using piezo electric crystals. Whenever, you try to tilt this arrangement, the crystals experience a force in the direction of inclination. This is caused as a result of the inertia of the moving fork. The crystals thus produce a current in consensus with the piezo electric effect, and this current is amplified. The values are then refined by the host microcontroller. Now check this short video that explains, how a MEMS gyroscope works.

FLOWCHART OF PROPOSED SYSTEM

The general operational flow of the Gyro assisted multi-Terrain Rover is described in this section. in the first the RC receiver and transmitter should be linked together by connecting the binding cable. The RC receiver is then connected to the motor-driver board which controls the speed of the motor.

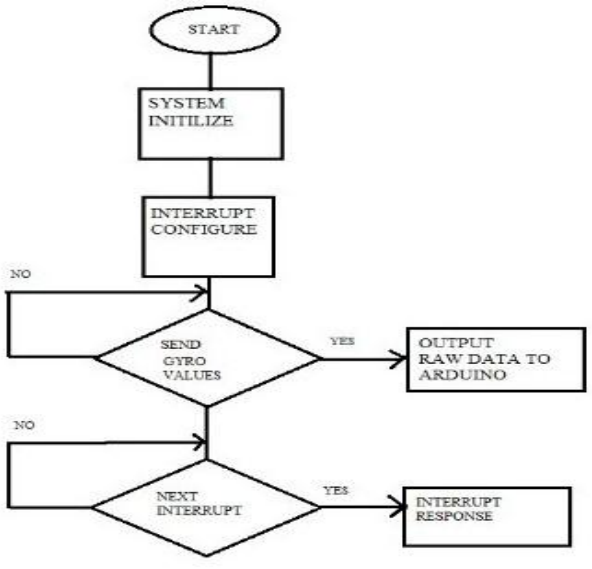

Fig 2: Flowchart for the proposed system

Once this procedure is completed successfully the microcontroller system in project Arduino UNO interfaced with MPU6050 is turned ON, Once the calibration procedure is completed we can start moving the Rover on rough terrain, The terrain causes the platform placed on the Rover to tilt, this variation changes the set orientation of the MPU which causes the Digital Motion Processor (DMP) to compensate the tilt,

It generates Raw values of Gyroscope in X,Y and Z axes which is given to the arduino to generate an appropriate PWM signal to control the servo motors in Roll and Pitch axes .this restores the original orientation of the platform and the Rover continues to move on the rough terrain and maintain the platform stable.

The proposed system can provide a stable platform for any device or object to be kept on top of it

Advantages of Proposed System include:

- Operate in rough roads and climb steps.
- Uniform distribution of payload over its 6 wheels at all times
- Reduce the main body motion by half, compared to any other suspension
- Maintains inertia of the payload platform.

Description of Components

A. Arduino Uno

Each of the 14 digital pins on the Uno can be used as an input or output, using pin mode, digital write , and digital read functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. In our project, the Arduino is used as the main microcontroller for calculation of units consumed and computation of the bill. It controls the entire metering and billing system. It also transmits the data such as consumed energy, generated bill and securityservices (Line ON/OFF).

B. Servomotor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor, although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. A servomotor is a closed-loop

servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft.

C. MPU6050

IMU sensors usually consists of two or more parts. Listing them by priority, they are accelerometer, gyroscope, magnetometer and altimeter. The MPU 6050 is a 6 DOF (Degrees of Freedom) or a six axis IMU sensor, which means that it gives six values as output. Three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on Micro Electro Mechanical Systems technology. Both the accelerometer and the gyroscope is embedded inside a single chip. This chip uses I2C protocol for communication.

D. Motor Driver Board

SmartDriveDuo10 has the specification of MDD10A which is able to drive two brushed motors bidirectionally at 10Amps each, plus additional smart features of MDS40A. The operation mode is configured by the DIP switch on MDDS10. The DIP switch configurations for commonly used modes are printed at the back of PCB. MDDS10 uses solid-state component-MOSFETs as H-bridge switching which offers faster switching time. And the MOSFETs are being switched at 16KHz for quiet operation

E. DC Motor

Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure.

F. Li-Ion Battery

The battery is a 12V 15000mah Li - ion Battery and it is specially designed for powering the system device which use 12V DC power. You can use this battery to power our powerful wireless transmitter, CCTV camera and so on. GPS Device LED Speaker Toy and Digital Products etc. Both can suitable for your need.

G. RC Transmitter

The FlySky FS-i6 2.4G 6CH PPM RC Transmitter With FS-iA6B Receiver. This is a great entry-level radio for those just starting in the field of drones flying due to the ease of use of this product and an impressive list of features for a first-time radio. FlySky FS-i6 2.4G 6CH PPM RC Transmitter is a 6-channel telemetry 2.4GHz transmitter that uses the reliable Automatic Hopping Digital System (AFHDS) and includes such features as digital trims, backlit LCD screen, and simple programming.

3. RESULT

After the realized fabrication of rover, the results has been generated and analyzed which comparing the disturbances in the rover's Centre of mass in its operations. The rover provides stability at a comparatively low cost with a less complex system, & Higher leveling of the supported masses. The dynamic stability platform consists of the upper platform (small wooden plank), which controlled, based on disturbance and intermediate top servo lying across the bottom servo. The MPU-6050 is placed just below the top platform through which the tilt angle is being measured. It provides stability at a comparatively low cost with a less complex system. The rocker bogie suspension is capable of climbing over obstacles such as rock and gravel and can climb over heights of 12 cms. it can be operated via RC controller from a range of 500mts. the run time of the system can be increased by increasing the battery capacity.

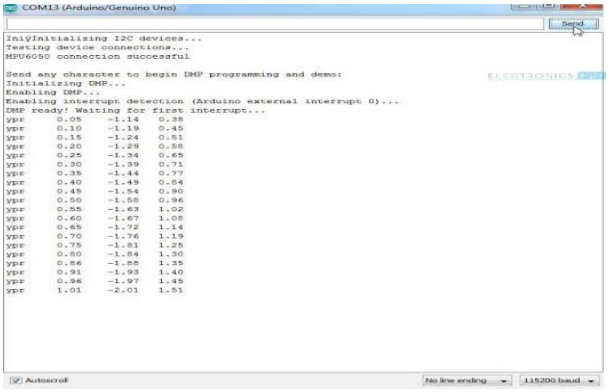

Fig 3. Values in serial Monitor

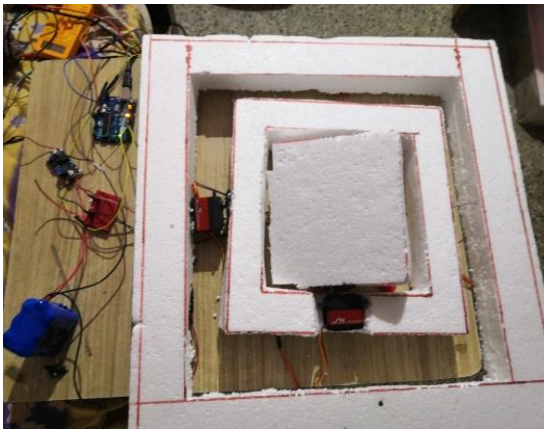

Fig 4. Self-stabilizing platform

Fig 5. Rocker boogie Suspension

4. CONCLUSION

The proposed design of the rocker-bogie mobility system helps in conventional heavy loading vehicle behavior when high-speed traversal is required. . In future, if the system installed in heavy vehicles and conventional off-road vehicles, it will definitely decreases the complexity as well as power requirements to retain bumping within it The dynamic self-stabilization mobile platform has been designed at low cost equipment, and software. The platform is designed utilizing economical materials, Styrofoam, Arduino, MPU-6050, & two servos. The complete low-cost design and implementation of a self-stabilizing dynamic mobile platform has been discussed to balance the object placed on the platform in dynamic conditions.

5. REFERENCES

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