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Gyro-Assisted Multi Terrain Rover

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Abstract: Rocker Bogie is a rover suspension system used in applications 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 differential chassis, which keeps the rover body balanced, enabling it to "rock" up or down depending on 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 that 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.

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 Chassis.
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. This paper presents the design and implementation of self-stabilizing dynamic mobile platform with 2-degrees of freedom on the rover. The self-stabilizing control system presented in this paper can be used in various medical, military applications and logistic devices and is objectively suitable for working in outdoor where the ground surface is not flat or uneven. The platform can freely rotate due to its mechanical structure within 2-degrees of freedom. The complete control system of stabilizing the platform has been designed on the Arduino UNO microcontroller. Longitudinal and lateral movements are controlled via servomotors for X and Y-axes. The algorithm has been developed to interpret the digital data from the gyroscope to the angular position of the system and applying complementary filter and proportional controller on it subsequently. The magnitude is then compared to a preset function to infer the angle of tilt of the platform. The tilting angle is then converted to rotation angle for the servomotors to act on.

Principle

The rocker-bogie design consisting of no springs and stub axles in each wheel which allows the chassis to climb over any obstacles, such as rocks, ditches, sand, etc. that are up to double the wheel's diameter in size while keeping all wheels on the ground maximum time. As compared to any suspension system, the tilt stability is limited by the height of the center of gravity and the proposed system has the same model of Rocker Bogie system. Systems employing springs tend to tip more easily as the loaded side yields during obstacle course. Dependent upon the center of overall weight, any vehicle developed on the basis of Rocker bogie suspension can withstand a tilt of at least 50 degrees in any direction without overturning which is the biggest advantage for any heavy loading vehicle. The system is designed to be implemented in low speed working vehicles such as heavy trucks, Bulldozers which works at slow speed of around 10 centimeters per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles.

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Schematic diagram

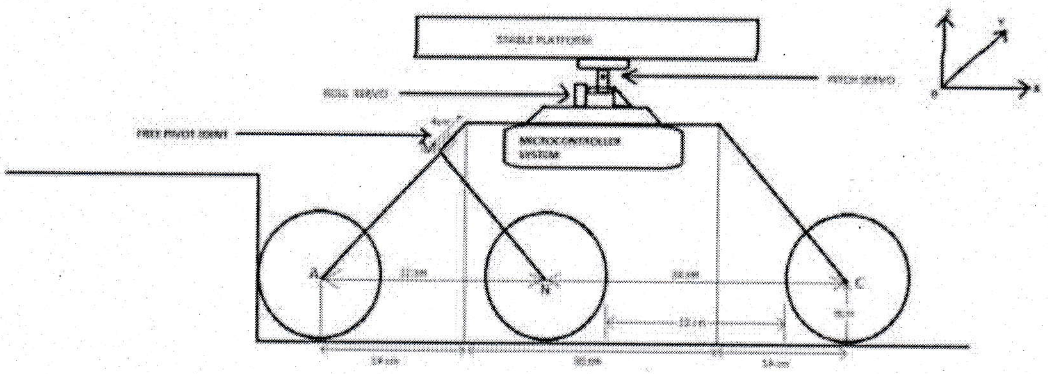

Fig 1: Schematic of multi-terrain rover

Observation

The main problem associated with current suspension systems installed in heavy loading vehicles rovers (including those with active and semi active suspension systems) is their slow speed of motion which derail the rhythm to absorb the shocks generated by wheels which remain the result of two factors. First, in order to pass over obstacles, the vehicle must be geared down significantly to allow for enough torque to raise the mass of the vehicle. Consequently, this reduces overall speed which cannot be tolerated in the case of heavy loading vehicles. Second, if the vehicle is travelling at a high speed and encounters an obstacle (height greater than 10 percent of wheel radius), there will be a large shock transmitted through the chassis which could damage the suspension or topple down the entire vehicle. That is why current heavy loading vehicles travel at a velocity of 10cm/s through uneven terrain. The software-based testing of rocker bogie suspension system describes the momentum and efficiency related utilities in cumulative manner.

Literature review and related work

Vladimír popelka proposed a method that reports on a particular solution build on the sensor MPU6050 and its parameters that can scan 6DOF (3 x 3 accelerometer + gyroscope). In real conditions this task is not trivial, since the signals of these sensors are quite noisy and influenced by other variables such as reaction speed, inertia, and accuracy of data interpretation, sensor drift and others. Self-stabilizing platforms can be of great use especially in the automotive, aviation, marine, robotics, aerospace as well as in everyday life.

Mohammad Mahad Nadeem, Sumair Ullah Khan and Danial Mazhar proposed a method on Self-Stabilizing Dynamic Mobile Platform where the design and implementation of self-stabilizing dynamic mobile platform with 2-degrees of freedom on a mobile platform using low-cost material. The self-stabilizing control system presented in this paper can be used in various medical, military applications and logistic devices and is objectively suitable for working in outdoor where the ground surface is not flat or uneven. The platform can freely rotate due to its mechanical structure within 2-degrees of freedom. The complete control system of stabilizing the platform has been designed on the Arduino UNO microcontroller. Longitudinal and lateral movements are controlled via servomotors for X and Y-axes. The algorithm has been developed to interpret the digital data from the gyroscope to the angular position of the system and applying complementary filter and proportional controller on it subsequently.

Shaocheng Qu proposed a method that deals with self-balancing and track-searching cart where the track-searching function is designed with the technology of System on a Programmable chip (SOPC). The system checks the inclination angle of a vertical axis on the cart, and the two wheels are driven respectively with different angels and speeds to keep the cart balanced.

Saugato dey, Souvik halder and M.P. Nanda Kumar proposed a method on Gyroscopic stabilization of two-dimensional gimbals platform using fuzzy logic control where the paper proposes an experimental analysis of the phenomena of stability of a two-dimensional gimbals structure platform using MEMS (Micro Electro Mechanical System) based gyroscopic sensor. Gyro is placed on the gimbal structure platform to measure the

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angular tilt. The proposed method uses fuzzy logic control technique to design the stabilizer. Two DC gear motors are used to control the azimuthal and pitch position of the structure. An H-bridge motor driving circuit is used to drive the dc geared motor. The random drift of MEMS Gyro data is eliminated by Kalman Filter.

Nitin Yadav, Balram Bhardwaj and Suresh Bhardwaj proposed a method on Rocker Bogie Suspension System and implement in front loading vehicles the front wheels are forced against the obstacle by the center and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle and obstacle overtaken. Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over

Abhisek verma, Chandrajeet Yadav, Bandana Singh, Arpit gupta, Jaya mishra and Abhishek saxena proposed a method on design of Rocker-Bogie Mechanism The term "rocker" comes from the rocking aspect of the larger link on each side of the suspension system. These rockers are connected to each other and the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the other goes down. The term "bogie" refers to the links that have a drive wheel at each end.

Methodology

In order to overcome vertical obstacle faces, the front wheels are forced against the obstacle by the center and rear wheels which generate maximum required torque. The rotation of the front wheel then lifts the front of the vehicle up and over the obstacle and obstacle overtaken. Those wheels which remain in the middle, is then pressed against the obstacle by the rear wheels and pulled against the obstacle by the front till the time it is lifted up and over. At last, the rear wheel is pulled over the obstacle by the front two wheels due to applying pull force. During each wheel's traversal of the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles center of gravity.

Design of rocker bogie

The important factor in manufacturing of rocker bogie mechanism is to determine the dimensions of rocker and bogie linkages and angles between them. The lengths and angles of this mechanism can be changed as per requirement. In the work aim is to manufacture the rocker bogie mechanism which can overcome the obstacles of 150 mm height (like stones, wooden blocks) and can climb over stairs of height 150 mm. Also, another target is to climb any surface at an angle of 45°. To achieve the above targets, the design of rocker-bogie model by assuming stair height 150 mm and length 370 mm. Using Pythagoras theorem, find the dimensions of the model. It has both angles of linkages of 90°.

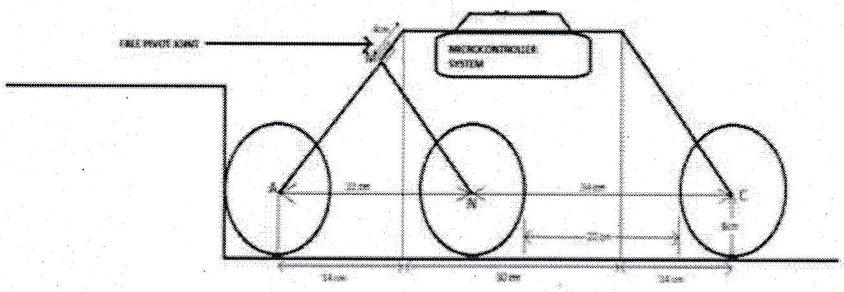

Fig 2: Schematic of Rocker Boogie

The main objective of this Rocker Bogie is to climb the stairs without overturning. To achieve proper stair climbing the dimensions of linkages should be proper. By assuming the stair height of 150 mm and length of 370 mm respectively the rover is designed. To climb the stairs with higher stability, it is required that only one pair of wheel should be in rising position at a time. Hence to find dimension of bogie linkages, first pair of wheels should be placed at horizontal position i.e. at the end of the rising level as shown in Fig.1. And second pair should be placed just before the start of rising level. There should also be some distance between vertical

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edge of the stair and second pair of wheel to striking of wheels. By considering all these design specifications the rover has to be constructed.

Schematic of self-stabilizing platform

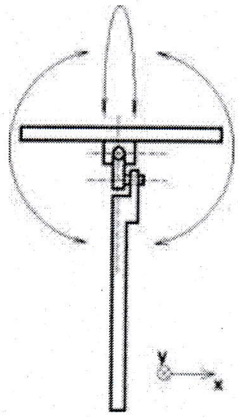

Fig 3: Sketch of platform with 2 DOF

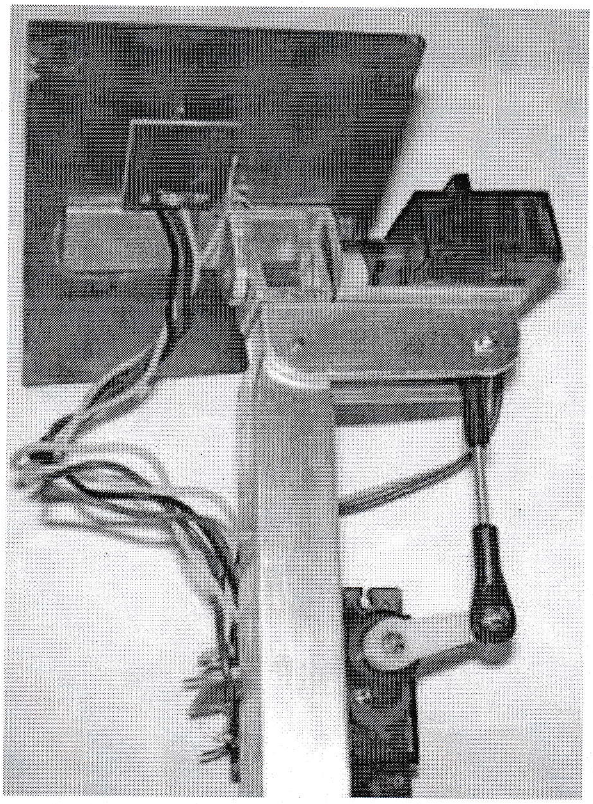

Fig 4: Real model of self-stabilizing platform.

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The design of the square-shaped self-stabilizing platform has each side measuring 15.3 inches at the front and back, 13.2 inches at the left and right with a height of 16 inches. The material used in the construction of the platform is wood, since it is inexpensive due to its lightweight and ease of drilling and attaching supports, as in the case of holding the servomotors. The self-stabilizing platform has been simply mounted on the mobile robot that has four tires.

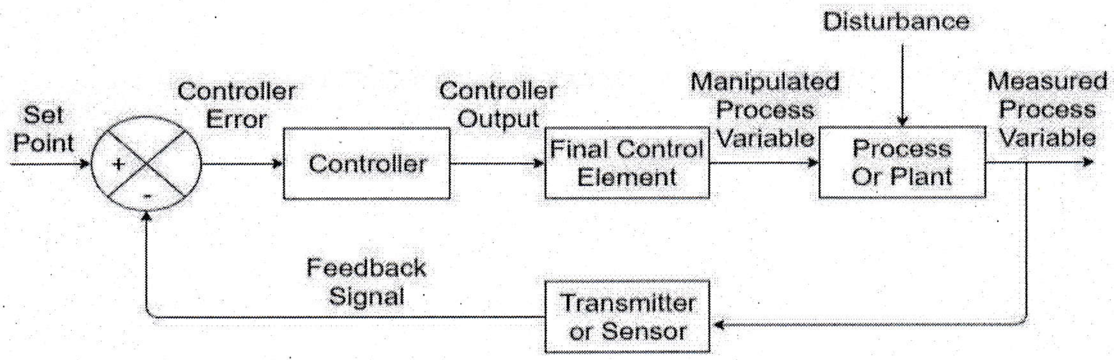
When the mobile robot starts to move on different plains, the self-stabilizing platform placed on it experiences translations and vibrations.
The system has 2-DOF (i.e. Pitch & Roll axes) which means it has 2-independent variables that outline its pose, that is orientation and function. Due to its physical isolation, the system has its own kinematics and is ideal as it allows the system to translate and allow the movement of the self-stabilizing dynamic mobile platform in the 2-DOF. Despite the restriction to just 2-degrees of freedom, the system works perfectly while maintaining the function and orientation of the stability of the self-stabilizing dynamic mobile platform.

Controller design

I. Strategy of execution:

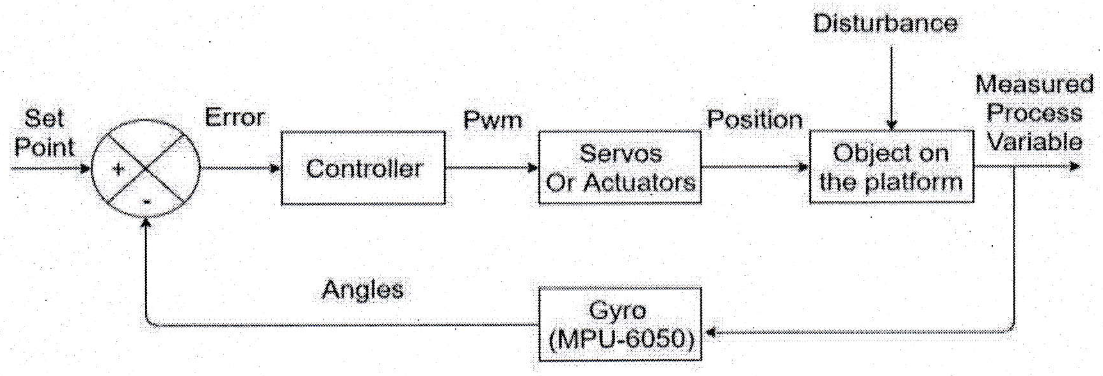
It is clear that every mechanism or actuator can enforce completely different movements, also as positioning itself in several angular tilts for configuration of the platform. Within the same means, it infers movements which are completely different for the manipulator. However, the management parameters of every manipulator can bear identical cycles.

II. Architecture of control system:



the basic control block diagram of a plant where the error in the system is removed through a controller. The desired value is set through a set point and the error is manipulated through the controller by mathematical representation.

III. Our control scenario:



In our project control scenario, the control block diagram follows the same pattern where the set point is set, which is 180 in our case. The error is computed in the controller through the reverse acting method and a PWM signal is sent to the actuators. The servos then rotate accordingly to the signal provided. When a disturbance is created to platform the gyro sensor sends feedback

Discussion

From the references Kalman filter algorithm produces estimates of the true values of sensor measurements and their associated calculated values. the hypothesis and production of the independent platform with standard parts are accessible with higher levelling of the supported masses the precision is increased because of the positioning errors of every motor is damped. the cart achieves both functions of self-balance and track searching. No matter what angles the frame of the cart are placed at, the cart drives the two wheels respectively with different speeds and directions and it will maintain balance with slight vibration at the range of + or - 10 degree after several adjustments. increasing the rocker-bogie mobility system in conventional heavy loading vehicle behavior when high-speed traversal is required increases in the stability margin and proved with valuable and profitable contrasting the SSF metric.

Conclusions

This work shows how rocker bogie system works on different surfaces. As per the different weight acting on link determines torque applied on it. By assuming accurate stair dimensions, accurately dimensioned rocker bogie can climb the stair with great stability. The design and manufactured model can climb the angle up to 45°. Also the model is tested for the Web cam with AV recording mounted on rocker bogie system and found satisfactorily performance obtains during this test camera has rotated around 360°. During stair climbing test for length less than 375 mm (15 inch) system cannot climb the stair. It can be possible to develop new models of rocker bogie which can climb the stairs having low lengths.

Results

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. contrasting the response of these two distinctive configurations of the rocker-bogie suspension against upcoming obstacles that can be present along the system generated obstacles and roadblocks. The rover provides stability at a comparatively low cost with a less complex system, & Higher leveling of the supported masses. Precision, because the positioning errors of every motor is damped.

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