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Design and development of an adjustable suspension system

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Abstract —***This project focuses on the design, development and evaluation of an adjustable vehicle suspension system. This system is aimed to improve vehicle performance on all terrain conditions from rough to flat surfaces. In this system we are using rack and pinion mechanism and electronic mechanism (sensor, receiver, and microcontroller). The modifications allow the upper links of the suspension system to change vertical position on-the-fly, to meet operator preference. The position change alters suspension geometry and therefore the performance characteristics of the vehicle; specifically the anti-squat which impacts vehicle sag and therefore traction. Thus, traction is directly controlled through adjustments to the suspension system. Future applications of this design are expected to improve the performance characteristics of vehicles of all sizes, ranging from mobile robots to automobiles. In addition to scalability, the advantage of our design is the on-the-fly adaptability, which enables adjustments in suspension performance for the terrain or obstacle being traversed through rack and pinion mechanism.***

Keywords-Adjustable suspension, Ultrasonic sensor, rack and pinion, ARDUINO microcontroller etc.

I. INTRODUCTION

In 2008, 58% of all Sport Utility Vehicle (SUV) passengers involved in rollover accidents were fatally injured (Administration, 2008). In addition, in 2010 rollover accidents accounted for 35% of all vehicular occupant fatalities (Administration, 2010). The risk of rolling over is largely affected by a vehicle's suspension system and how it counteracts external forces while the vehicle is in motion. Although, suspension systems have made significant progress to better mitigate the risk of rollovers, these accidents still occur frequently and are incredibly dangerous to vehicle occupants. That's why in this project focuses on a rack and pinion mechanism system that will utilize semi active technology allowing the operator to adjust the geometry of the suspension using an interface.

Altering the geometry of the suspension system significantly impacts more than just the stability of the vehicle. It also affects the behavior of the entire vehicle and how it will respond to different surfaces and maneuvers. This adjustability is expected to allow for the system to be used in a variety of scenarios that will far exceed the state of the art in suspension systems today. To alter the geometry of the suspension system, we utilize mechanisms to power instantaneous and independent motion in the system. The position change of the rack and pinion system, as a result of the motion, occurs in the vertical direction with respect to a predetermined origin.

This allows the operator to adjust the system geometry to improve the efficiency and stability of the vehicle on a variety of terrains. An improved suspension system that effectively provides instantaneous adjustable would have potential in a plethora of fields and scenarios. This system could be used to improve performance and efficiency in drag racing, rock climbing, desert racing, military vehicles and more. In addition, the system would not be limited to strictly passenger vehicles; it could also improve the performance of mobile robots, toys, or any mechanical system that requires a suspension for its functionality. Thus, this suspension design is expected to make broad contributions far beyond our goal of improving vehicle safety.

II. LITERATURE REVIEW

A. Rezanoori et.al. Says in the paper "Development of active suspension system for a quarter car model using optical incremental encoder and ultrasonic sensors" that Nowadays in the industrial world, quality factors are the reasons of growth and survival of an automotive unit. Suspension system as an effective part of vehicle can achieve two factors, "safety" and "convenience". It plays an important role in the quality of the car. Therefore, it is necessary to carry out an analysis and evaluation of how the suspension system responds in different vehicles under various conditions whilst improving vehicle quality. Considering the power units and automotive vehicle production capacity in developing countries, the need of a vehicle with features such as durability and accuracy as suitable standard for passenger vehicles was felt. This paper describes the development of a new system able to predict and scan road profile and its condition. Vehicle equipped with this predictor technology use measurement sensors such as Ultrasonic and Optical Incremental Encoder.

Alessio Carullo et.al. Says In the paper "An Ultrasonic Sensor for Distance Measurement in Automotive Applications" that ultrasonic sensor that is able to measure the distance from the ground of selected points of a motor vehicle. The sensor is based on the measurement of the time of flight of an ultrasonic pulse, which is reflected by the

ground. A constrained optimization technique is employed to obtain reflected pulses that are easily detectable by means of a threshold comparator. Such a technique, which takes the frequency response of the ultrasonic transducers into account, allows a sub-wavelength detection to be obtained.

Xing Xu et.al. Says in the paper "Dynamic Ride Height Adjusting Controller of ECAS Vehicle with Random Road Disturbances" that the ride height control system is greatly affected by the random road excitation during the ride height adjusting of the driving condition. The structure of ride height adjusting system is first analyzed, and then the mathematical model of the ride height adjusting system with the random disturbance is established as a stochastic nonlinear system. This system is decoupled using the differential geometry theory and stabilized using the Variable Structure Control (VSC) technique.

Dionisio Andújar et.al. Says in the paper "An Ultrasonic System for Weed Detection in Cereal Crops" that Site-specific weed management requires sensing of the actual weed infestation levels in agricultural fields to adapt the management accordingly. However, sophisticated sensor systems are not yet in wider practical use, since they are not easily available for the farmers and their handling as well as the management practice requires additional efforts. A new sensor-based weed detection method is presented in this paper and its applicability to cereal crops is evaluated. An ultrasonic distance sensor for the determination of plant heights was used for weed detection.

III. PROPOSED MODEL

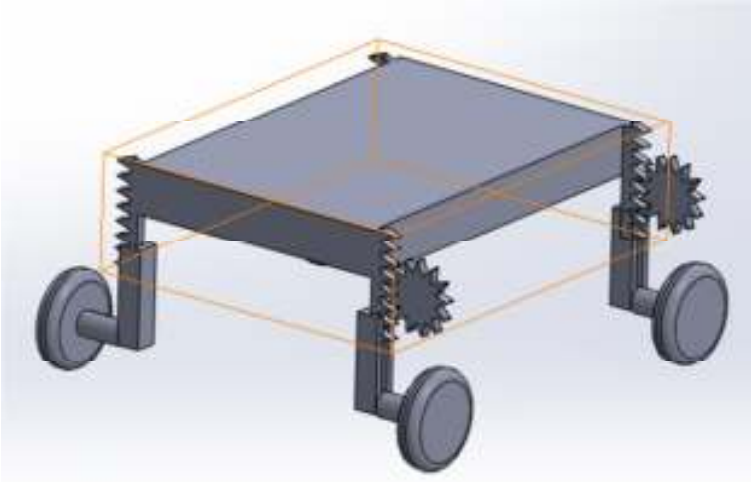

Figure 1. Proposed model

III. COMPONENT DETAILS

1. ARDUINO UNO MICROCONTROLLER

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free (currently for Mac OS X, Windows, and Linux).

Figure 2. ARDUINO UNO microcontroller

Features:

- ATmega328 microcontroller
- Input voltage - 7-12V
- 14 Digital I/O Pins (6 PWM outputs)
- 6 Analog Inputs
- 32k Flash Memory
- 16Mhz Clock Speed

2. ULTRASONIC SENSOR

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

This is the HC-SR04 ultrasonic ranging sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit. There are only four pins that you need to worry about on the HC-SR04: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground).

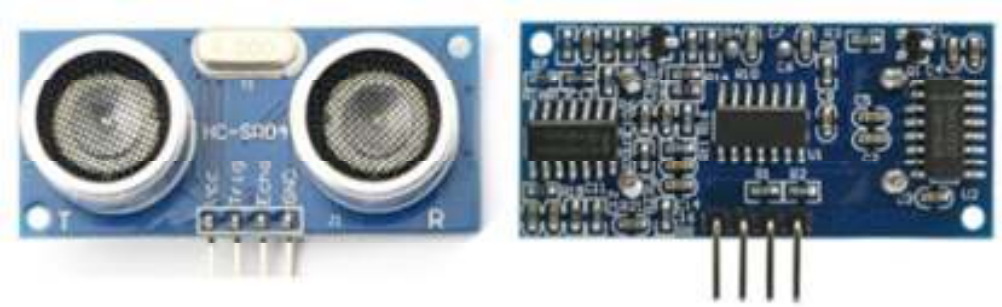

Figure 3. Ultrasonic sensor

Features:

- Operating Voltage: 5V DC
- Operating Current: 15mA
- Measure Angle: 15°
- Ranging Distance: 2cm - 4m

3. CHASSIS

The frame is made up of wooden plank of 5 mm thickness. The rectangular dimensions of frame are 350mm*200 mm

4. DC MOTOR

60RPM 12V DC geared motors for robotics applications. Very easy to use and available in standard size. Nut and threads on shaft to easily connect and internal threaded shaft for easily connecting it to wheel.

Figure 4. 12 V DC motor

Features

- 60RPM 12V DC motors with Gearbox
- 6mm shaft diameter with internal hole
- 125gm weight
- 1.5 kgcm torque
- No-load current = 60 mA(Max), Load current = 300 mA(Max)

5. WHEELS

Robotic tyre with 70mm x 20mm size suitable for 6mm shaft motors.

Figure 5. Ultrasonic sensor

Specifications:

- 70 mm Diameter
- 20 mm Width
- Hole Diameter 6.1 mm
- Screw for fastening on motor shaft

6. RACK AND PINION

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.

IV. ADVANTAGES AND APPLICATIONS

ADVANTAGES:

- Mechanism (rack and pinion) cost is low.
- Ride and handling are met effectively and safely.

APPLICATIONS:

- Any vehicle(four wheeler

V. CONCLUSION

This project focuses on the design, development and evaluation of an adjustable vehicle suspension system. This system is aimed to improve vehicle performance on all terrain conditions from rough to flat surfaces. In this system we are using rack and pinion mechanism and electronic mechanism (sensor, receiver, and microcontroller). This allows the operator to adjust the system geometry to improve the efficiency and stability of the vehicle on a variety of terrains. An improved suspension system that effectively provides instantaneous adjustable would have potential in a plethora of fields and scenarios. This system could be used to improve performance and efficiency in drag racing, rock climbing, desert racing, military vehicles and more.

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