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Intelligent Dual Axle Steering System (I-DAS)

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ABSTRACT: Nowadays, every existed vehicle mostly are using the two wheel steering system to control the movement of the vehicle whether it is front wheel drive, rear wheel drive or all wheel drive. But due to the awareness of safety, four wheel steering vehicles are being used increasingly due to high performance and stability that they bring to the vehicles. Already there are some commercial prototypes of such 4Wheel steering system, steer by wire systems and there's a lot of research, both academic and commercial in the field. The upgradations in this turf are exceedingly expected and favorable. For our engineering major project at Madhav Institute of Technology and Science, we chose to prepare a prototype to adapt a few new ideas in this field. We named this model as Intelligent Dual Axle Steering System (I-DAS). In this report, the performance of four wheels steered vehicle model is considered which is optimally controlled during a lane change maneuver in three type of condition which is low speed maneuver, medium speed maneuver and high speed maneuver. For parking and low-speed maneuvers, the rear Wheel steer in the opposite direction of the front wheels, allowing much sharper turns. At higher speeds, the rear wheels steer in the same direction as the front wheels. This results in more stability and less body lean during fast lane changes and turns because the front wheels don't have to drag non-steering rear wheels onto the path.

KEYWORDS: Steer-by-wire, oversteer, understeer, fishtailing, slip angle, microcontroller, ESC module

I. INTRODUCTION

A steer-by-wire system is an advance technology which aids the steering wheel to operate the turning of wheels without any physical connections with the steering wheel. The physical connection had been replicated by the electric motors for the precise and safe control of the steering wheels. This in turn has also helped in increasing the safety and steering performance of the vehicle. The method of adapting the change with different circumstances makes it more advance and reliable for the drivers with all set of driving experiences. A steer-by-wire 4WS system could be modified to reduce the steering effort. The absence of any physical connection makes the installation of Steering wheel to the either side easier and economic. Steer by wire is an advance technology in itself. We attempted to combine this technology with the concept of dual axle steering system. When the steering is applied to both the axles the problem of oversteer and understeer is solved at once. This fetches a lot of fertile promises in the advancement of steering systems.

Introduction to project

This project aims at developing a steer by wire Intelligent Dual Axle Steering System (I-DAS) which would cater to the needs of people. Steer by wire is the advancement in the field of automotive industries. This system is employed to improve steering response, increase vehicle stability while maneuvering at high speed, or to decrease turning radius at low speed.

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Problem in conventional steering system:-

1. Maneuvering long vehicles with conventional two wheel steering system is a tedious task at specifics such as parking and roundabouts.
2. The understeer or oversteer is a predefined set of values in a vehicle and does not vary along with the speeds and road conditions. But, at low speed corners, oversteer is favorable whereas at high speed corners understeer is desirable.
3. At high speed corners, there occurs a problem of fishtailing in conventional steering system, which is crucial as it will cause accident.
4. While lane changing in a two wheel steering system, it often produces yaw motion in the vehicle. Hence, directional stability of the vehicle is reduced.
5. At low speeds, wear of tyre occurs due increase in slip angle.

Solution:-

In Dual-axle steering systems, the rear wheels are steered by a computer and actuators. The rear wheels generally cannot turn as far as the front wheels. Some systems allow the rear wheels to be steered in the opposite direction as the front wheels during low speeds. This allows the vehicle to turn in a significantly smaller radius—sometimes critical for large trucks or tractors and vehicles with trailers.

As the name suggests, there are two steering mechanisms at two axles respectively without any mechanical link in between them. Forward axle steering system works as conventional steering system. For the control of the rear axle steering system, an induction motor with low rpm and high torque is installed. The direction of the rotation of that motor is decided as per the direction of rotation of front wheels and speed of the vehicle. At low speeds, the direction of rotation of both the motors is kept opposite to provide less turning radius, thus, eliminating the problem of maneuvering at low speed corners and tight parking spaces. While at high speed corners, the direction of rotation of motors is kept same but the rear wheels are allowed to rotate at half of the rotation of front wheels. This helps in increasing the directional stability at high speed corners.

II. REQUIREMENTS

1. Electronics Component.

1. Bluetooth module hc05-

The use of HC05 in our model is in slave configuration by factory reset.

It is being used to control the inputs of Arduino and hence controlling the speed and directions of motors via phone.

2. Arduino UNO-

Arduino UNO is a single board microcontroller with the processor of 16MHz ATmega328.

The UNO has its own memory, hence making the use of sensor modules easy or neglecting their redundant use.

3. Geared Servo Motors-

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. The use of servo motors in our model is to precisely control the direction of rack. The pinion is installed on the rotor of motor. Both the steering mechanisms are specifically actuated via servo motors.

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4. Geared DC motor-

A DC motor is rotary electrical motor that converts direct current electrical energy into mechanical energy. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

The use of DC motor in our model is to drive the vehicle, referencing the power house of the vehicle. Since the speed of DC motor can be manipulated using ESC modules, the use of DC is preferred.

5. A3144 Hall effect sensor-

The Arduino Hall effect sensor code can be used to detect a magnet and count the number of times it detects it. In HES, a thin strip wire of metal has a current applied along it. In the presence of a magnetic field, the electrons get deflected towards one side of metal strip and produce a voltage gradient.

The use A3144 in our model is to count the RPM of our wheel and hence sending the digital input to the Arduino.

6. Neodymium magnet-

The use of neodymium magnets in our model is to help the Hall Effect sensor in counting the rotation of wheel as the magnetic field gets disturbed by the rotation of wheel.

7. Resistors-

The use of resistors in our circuit is to provide a safe current to our driving motor.

8. Batteries-

The batteries that are being used in our model are zinc-carbon (6f22) batteries.

The model consumes two batteries, one to power the electrical motors, another to power the Arduino UNO.

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II. MECHANICAL COMPONENTS

1. Frame-

A vehicle frame, also known as its chassis, is the main supporting structure of a motor vehicle, to which all other components are attached, comparable to the skeleton of an organism.

2. Rack and pinion-

A rack and pinion is a type of linear actuator that comprises a circular gear (the pinion) engaging a linear gear (the rack), which operate to translate rotational motion into linear motion.

3. Tie Rods-

Tie rods connect either end of the steering rack to the steering knuckles on which the front wheels pivot when the steering wheel is turned.

4. Hubs-

In vehicles, the hubs are installed over the wheels to ensure their easy and safe rotation. One end of the hub is attached to the wheel and the other is connected with the axle.

5. Wheels-

A drive wheel is a wheel of a motor vehicle that transmits force, transforming torque into tractive force from the tires to the road, causing the vehicle to move.

6. Clamps and mountings-

The clamps are used to hold the motors and wires at their place. The mountings are used to ensure the perfect position required to mesh up with different gears.

III. DESIGN AND WORKING

1. System Overview

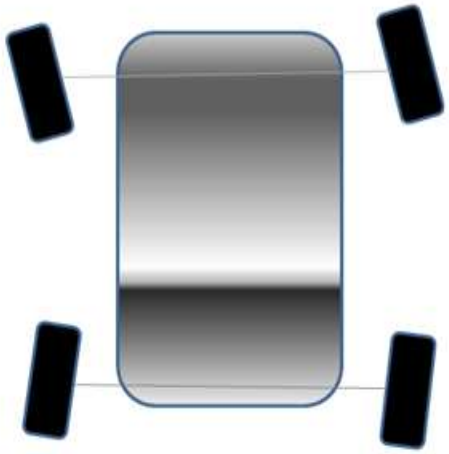
This model explains the practical application of the I-DAS which in turn can be adapted to the road vehicles as per the advancement in the technology. I-DAS solves the problem of rigidity in the steering module. It gives suppleness to the vehicle as well as the driver to choose between the different steering modes provided in the system.

The three Steering modes namely out-phase, neutral-phase and in-phase works inside the vehicle as per its speed and road condition and give better handling and assistance to the driver as a result.

The direction of the rotation of rear motor depends first on direction of rotation of front motor and speed of the driving wheels.

a. At low speed corners and in reverse gear (less than 35 kmph)

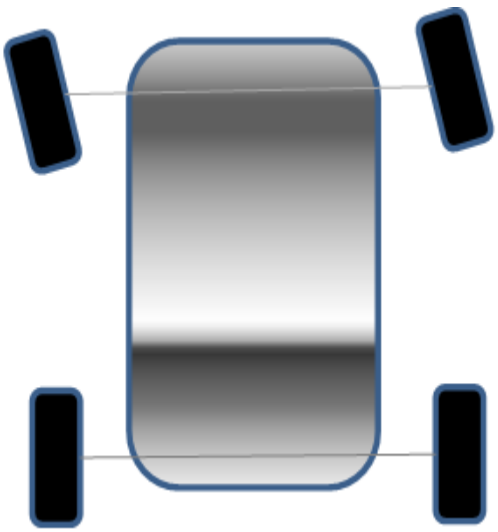
When the speed of the vehicle is less than 35kmph and it takes a turn, the rear wheel turns to the opposite direction, hence making the turning radius smaller. This is called anti-phase steering. This same loop gets activated when car is moving backwards. This helps in parking the vehicle at tighter places. The major benefit is the response of vehicle to the driver's input.



Anti-phase steering

a. At medium speed corners(35kmph-60kmph)

When the vehicle is in normal driving range, there is no such use of rear wheel steering system. Hence the loop gets deactivated when vehicle is moving in the speed range of 35kmph-60kmph. This is called neutral phase steering system. This facilitates in accomplishing a safe transition from oversteer to understeer or vice versa.



Neutral Phase Steering

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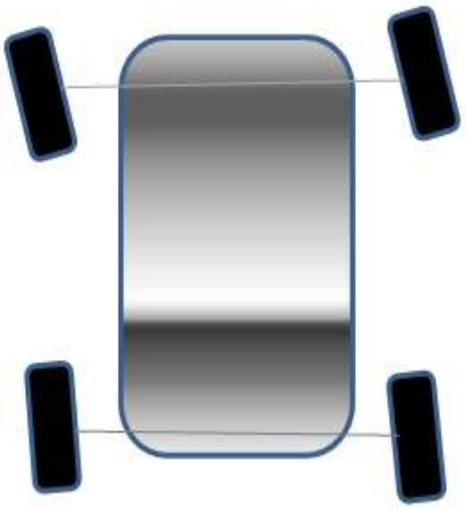
b. At high speed corners (greater than 60kmph)
Since at high speeds the stability of the vehicle becomes major concern, hence the loop allows the rear wheel to turn into the same direction as that of front wheels. This is called in-phase steering system. It helps in increasing the stability of vehicle by reducing the sensitivity of driving wheels.



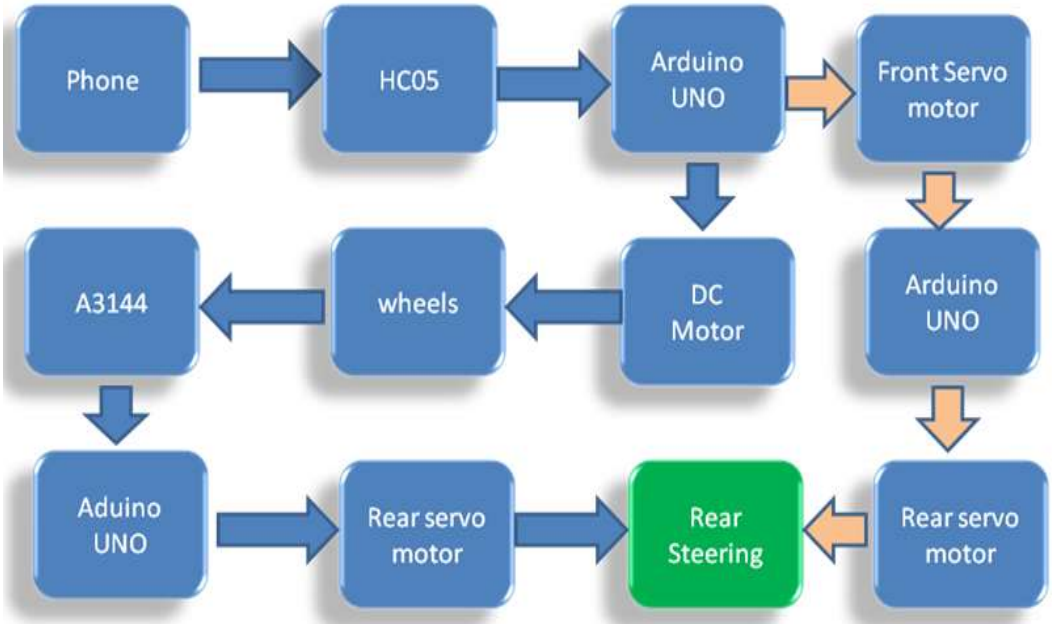
In-Phase steering

2. Working of model

In our model, we give power to the driving wheels and steering input via phone. The Bluetooth module Hc-05 with the factory reconfiguration, installed in the circuit receives the input and sends feedback to Arduino UNO. Thus receiving the signal Arduino converts the digital input into analogue. The converted digital input is then divided into two loops of settings. The first loop

Takes the acceleration input from the phone and is used to actuate the geared DC motor to deliver the power to the driving wheels. Now, the A3144 Hall effect sensor comes into role. With the help of neodymium magnet, HES detects the number of rotations of wheels and sends the feedback to the Arduino. The Arduino converts that input into speed with the help of some predefined codes. This input is now stored into the memory of microcontroller. The second loop takes the steering input given by the user and actuates the servo motor at the front wheel which in turn operates the rack of the front steering mechanism. Now, using the values of the parameters stored into the memory of microcontroller based on both the loops, rear servo motor will get actuated.

Flow Chart



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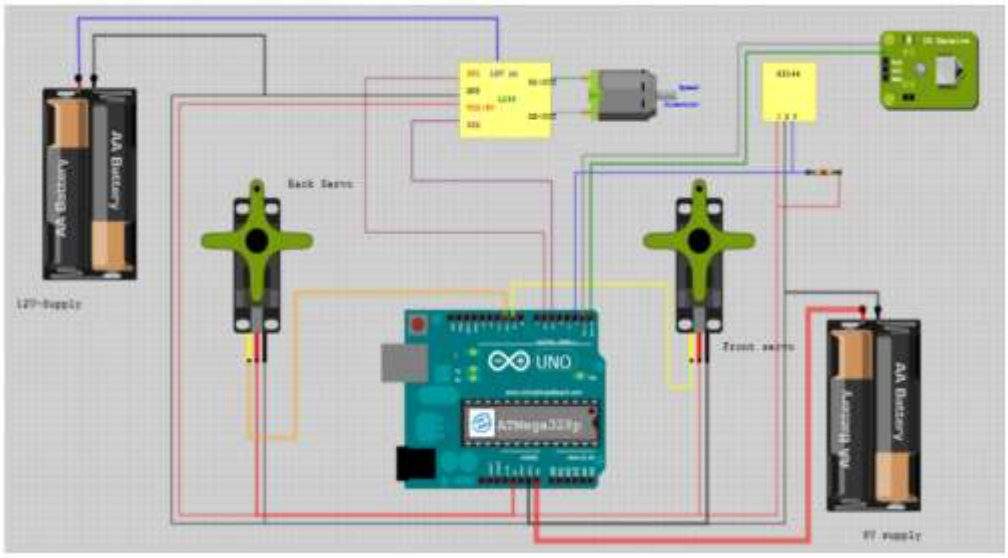
Circuit diagrams
Complete view



IV. CONCLUSION

The Intelligent-Dual Axle Steering system we build can be improved a lot, but the main problem seems to be with the choice of controllers and motors. For a future project, given better equipment, this system could be implemented in a small model car and can be used for control theory demonstrations. New control systems, such as state-space controls, can be implemented to enhance the performance of the system. This is just a prototype to demonstrate our approach to a new era of steering that is steering mechatronics

Although not in the near future, given enough resources, this system can be implemented in real road cars and perhaps be combined with regular steering to take advantage of the safety benefits of our system.

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