

Design and Creation of Four-wheel Non- interaction Navigation Machinery

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Abstract

Here we are trying to improve the steering mechanism, by rotating all 4-wheels to reduce the radius of rotation. This is a Mechatronics based project where different sensors and actuators has to employed. Electronic controller unit is going to be act as the vital element of this project through which the complete steering system has to be controlled. This electronic controller receives analog signal from the user and convert it into digital signal as an output. Through this project we would like to illustrate various modes of steering working behavior which will finally cause the vehicle to run under complete control of the user. "Two-wheel steering mechanism, four-wheel high-speed steering mechanism and four-wheel low speed steering mechanism" are few most commonly used mechanisms these days. These discrete modes of steering working mechanism are possible because of independent motors are going to be used here. Using various electrical, mechanical and electronics elements, we could get able to design and fabricate this 4-wheel noncontact steering mechanism.

Keyword: Sensor, Actuator, Electronic controller, steering mechanism, Wheel.

INTRODUCTION

The first model of automobile in mainstream with 4wheel steering was launched by an American company called hummer. The model was named E-Hum V. This model was launched in 2019. This was an electrical SUV. The model has been an instant success. The design and system of the vehicle was very cost intensive. With our project we have reduced the cost of the complete steering system which can help us to adapt the system in all vehicles. The racecars are evaluated on their dynamic performance, design process and solutions, and business concerns such as cost and marketability. In this highly competitive field teams must build an extremely agile and lightweight vehicle to succeed in the competition's tight autocross courses. Four-wheel steering is an advanced method of improving a car's handling capabilities and adding additional parameters for tuning the car's dynamic profile [1–

3]. The problem is to design a four-wheel steering system to go to Indian roads. There are many groups, and this paper will cover them in more detail. Majorly there are a few types of implementations which can be used to achieve 4-wheel steering, which are:

Hydraulic linear actuators, Electric linear actuators, linear actuators with tie rod, Electric motor-powered steering rack

Out of the above 4 types we have weighed in the pros and cons of each of them and then adopted the 4th one (Figures 1 to 4). The weighing in of the pros and cons will be seen in the thesis.

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Phases of 4 Wheel Steering Systems

The steering systems work on the following three phases:

1. Negative Phase
2. Positive Phase
3. Neutral Phase

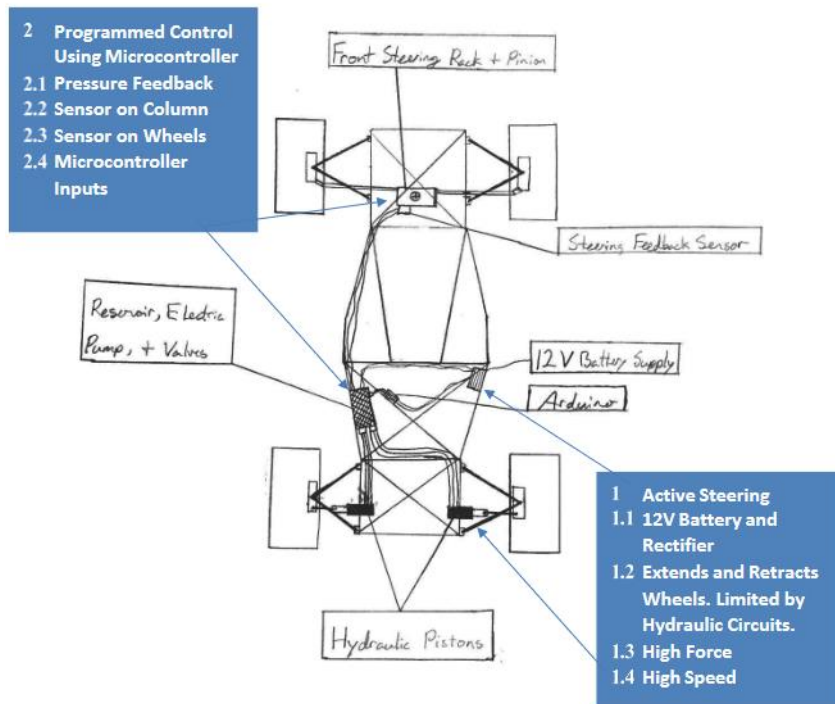


Figure 1. Hydraulic Powered Linear Actuators.

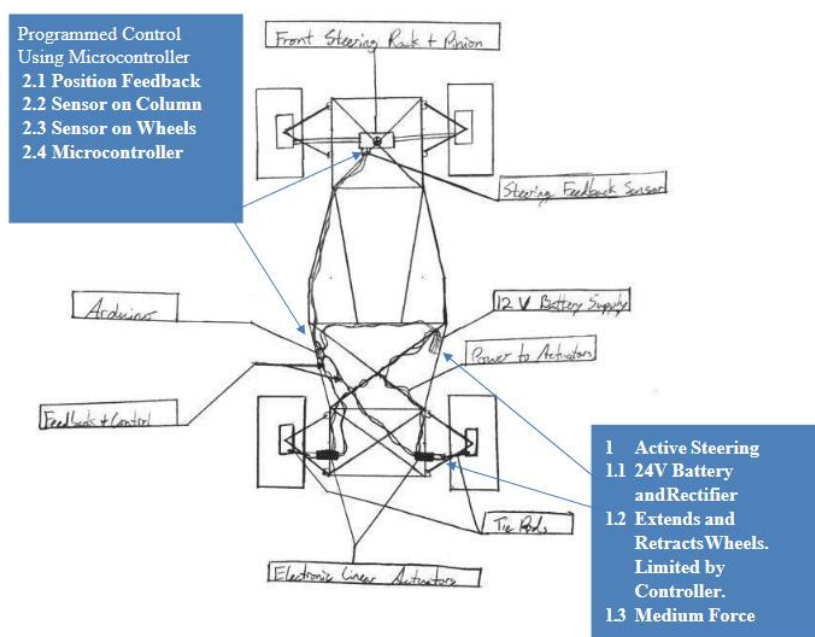


Figure 2. Electric Powered Linear Actuators.

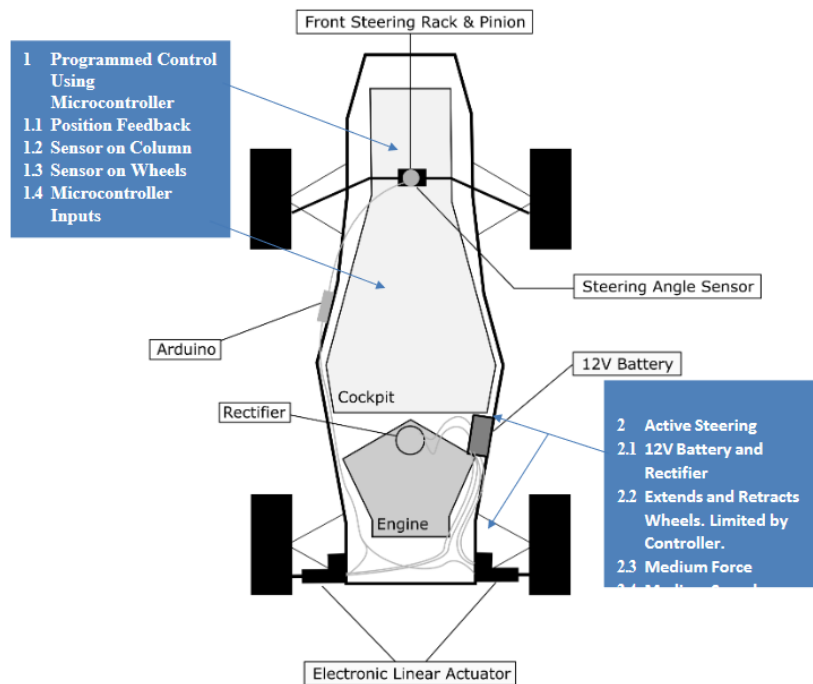


Figure 3. Linear Actuators without tie rod.

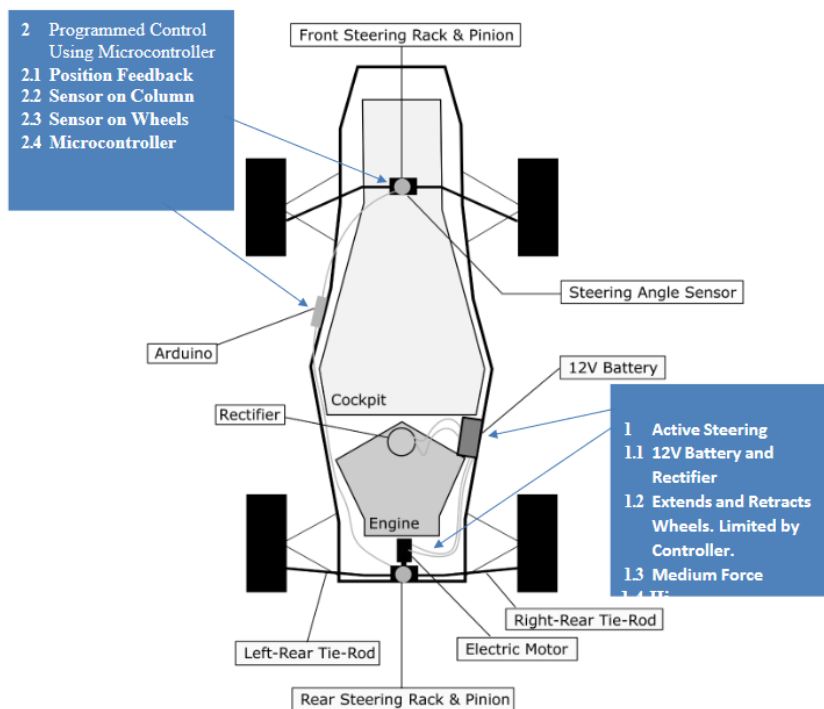


Figure 4. Electric Motor-powered Steering Rack.

This phase helps vehicles to steer into tighter parking spaces. On highways, it facilitates and stabilizes the vehicle's cornering and makes lane changes simpler and safer. Rear wheels revolve in the opposite direction from the front wheels when traveling at slower speeds. It's a bad time right now. The rear wheel stays straight or in neutral at a medium pace. The rear wheel turns in exactly the same manner as the front wheels when moving faster [4].

Negative Phase

The front and rear axles move in opposition to one another during the negative phase. The radius of curvature when turning decreases as both axles travel in opposing directions (Figure 5). This indicates that the car will require less space to park and will be useful in areas where vehicular traffic and parking are big issues [5–7].

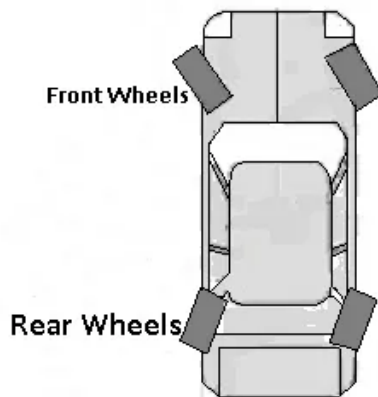


Figure 5. Negative Phase.

Neutral Phase

Only the front wheels run in either a right or left direction during the neutral phase, with the rear wheels acting as the front wheels' followers. This is the drive that all four wheels use daily. It is usually used at medium speed (Figure 6).

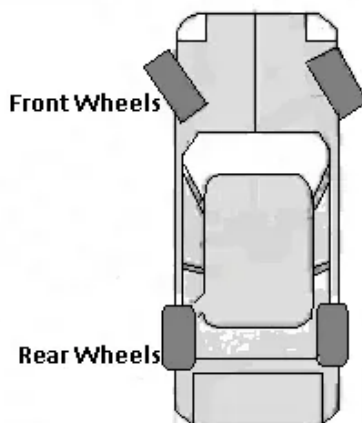


Figure 6. Neutral Phase.

Positive Phase

Both the front and rear axles move in the same direction relative to one another during the positive phase. During highway driving, the quadra steering system-equipped car can change lanes thanks to the motions of both the front and rear axles [8]. It is typically applied more quickly (Figure 7).

If we compare the Four-Wheel steering system to conventional Steering System, then in Four-wheel and two-wheel steering system, the car remains more efficient and stable on the cornering, better steering response and precision, high-speed straight-line stability and significant improvements in fast, easy, safe lane changing the drive. A lower speed and smaller turning radius lessen the risk of hitting any barriers [9].

One steering actuator may drive all four wheels thanks to its cutting-edge steering system innovation. The construction of a four-wheel, steerable power base with maximum flexibility, uncompromising static stability, front- and rear-wheel tracking, and exceptional obstacle climbing capacity will be made possible by the effective implementation of this feature. The 4WS's advanced system will function with the aid of microprocessors. The rear wheels' left and right turning is managed and directed by this system using an onboard computer.

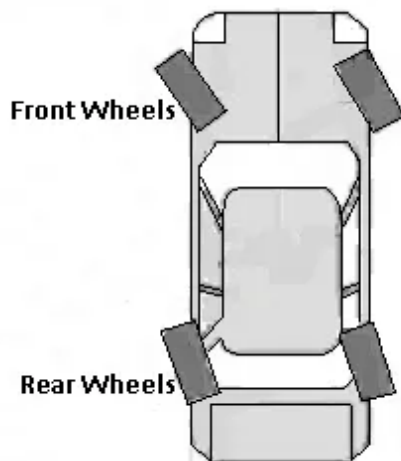


Figure 7. Positive Phases.

Compared to the traditional two-wheel steering system, four-wheel steering is better. The 4WS offer low-speed driving, extremely quick steering, lane-changing ability, straight-line support, and cornering ability. These devices are expensive and extremely sophisticated. Now, four-wheel steering systems are more expensive than traditional two steering systems. The popularity of four-wheel steering is rising, and more and more new vehicles are probably going to use it. The cost of four-wheel steering systems will decrease as they are installed in more vehicles [10–12].

Design Brief

We propose the design of a Four-Wheel Steering System (4WS) to improve the stability and performance of a vehicle. The technology will feature the conventional rack and pinion steering in the front, but it will also contain a semiconductor device that sends a signal to two linear actuators in the back to move the wheel hubs in response to the vehicle's speed. The 4WS system must be able to turn the rear wheels in both directions depending on the speed of the vehicle. To maintain stability during rapid bends, the rear wheels will revolve in the same direction as the front wheels. To enable a smaller turning radius at low speeds, the rear wheels will turn in the opposite direction from the front wheels. The linear actuators must be able to run on a 24 V battery and pull low currents around 4 amps or less. They must also be able to extend and retract over a range of approximately 2 to 4 inches and have fast enough travel speeds to prevent lagging between the front and rear wheels. A Fail-Safe system must be implemented to return the rear wheels to equilibrium if the system is to lose power or not function properly in order to maintain driver safety [13, 14].

DESIGNS AND ANALYSIS

The hierarchy of operational requirements that were taken from guide interviews and background research. The requirements were organized into five main requirements: active steering, electronic control, safe during operation, operating environment, and does not reduce performance. All other requirements were considered sub-requirements. The design requirements, shown above, were derived from the operational requirements [15]. Each number of operational sub-requirements was made into specific design requirements (Figures 8 to 12).



Figure 8. Chassis.



Figure 9. Final chassis.

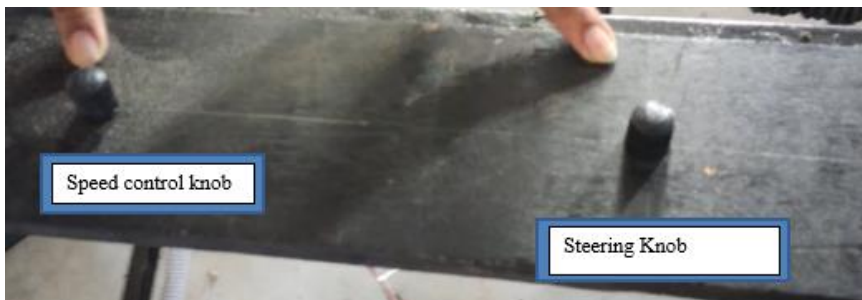


Figure 10. Steering module.

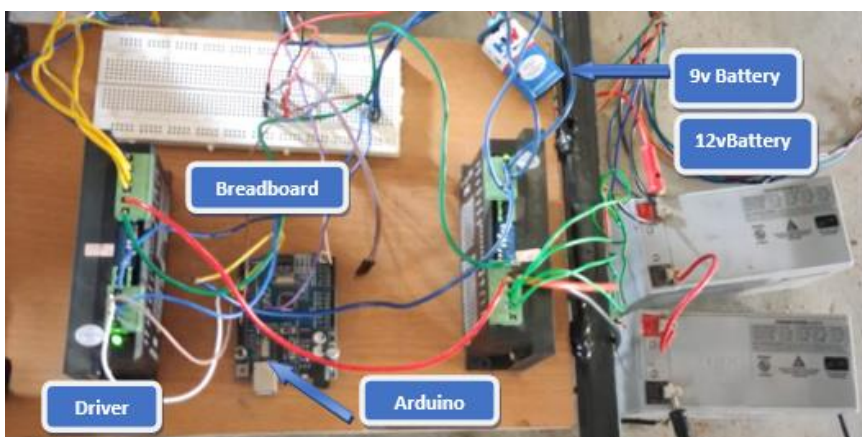


Figure 11. Arduino Case Fin.



Figure 12. Design Considerations.

Concept Selection Process

Preliminary analysis of each concept's physical feasibility based on design requirements, function allocation, and functional decomposition.

Hydraulic Actuator Concept

This system is composed of two hydraulic cylinders, a fluid reservoir, pump, control system with actuating valves, and hoses. Like the other steering layouts, this would use an Arduino controlled system. The 12V battery supply powers the hydraulic pump in this arrangement. The actuators push or pull on the uprights of the race car in order to steer the wheel in accordance with the front steering. This set-up uses no tie-rods so the actuators are sized such that they connect directly onto the frame and the other end to the upright. The Arduino uses a steering angle sensor as the input of the front steering to produce an output steering angle on the rear wheels. This program will also be a function of speed of the race car. This system would function ok in the car but be physically awful as an overall system. The hydraulic cylinders can exert forces way greater than what is necessary to turn the wheels and will have to be mounted specifically.

Electronic Linear Actuators with Tie-Rods Concept

This arrangement uses two E Automation Feedback Rod Linear Actuators combined with an Arduino for control and is powered by a 24V DC battery. The actuators push or pull on the uprights of the race car in order to steer the wheel in accordance with the front steering. This set-up uses tie-rods so the actuators will have to be specially mounted to the frame and the other end to a tie-rod that is connected to the upright. This introduces more weight to the system and different packaging in the rear of the race car. The Arduino uses a steering angle sensor as the input of the front steering to produce an output steering angle on the rear wheels. This program will also be a function of speed of the race car. This system works well with the race car and is much lighter than the hydraulic and rear steering rack concepts. Having the tie-rods may provide an easier connection to the uprights, but may

introduce complications in packaging of the rear of the car. A special mount will have to be created and attached to the frame in order to have the actuator sit the proper distance to extend and retract while turning the wheel. This extra linkage will create some extra factors into the programming of the Arduino in turning the wheel specific degrees in accordance to the front steering. The actuators run about 12000r/s a piece and can exert a force of 150lb at a speed of .5in/sec which is sufficient for turning the wheel in no excess of 6 degrees of steering [15]. The feedback provides exact location of the actuator arm so the Arduino knows its location at all times. These considerations were quantified in Table 1.

Table 1. Parts list.

S.N.	Part	Quantity	Part use
1	NEMA- 23, stepper motor 30kg cm	2	To position the rack and pinion
2	12V DC Battery	2	To power the stepper motor Page 64 of 71
3	Arduino Uno	1	To program and control the system
4	Electrical Wires	30	To provide connection between Arduino, battery and stepper motor
5	Bracket+ Stock coupling	2	To mount the stepper motor
6	Tires+ Drum	6	To give the car mobility
7	Axle	6	To mount the wheels
8	Rack and Pinion	2	To convert rotary motion to linear motion
9	Drivers dm542	2	To electronically control the direction and magnitude of rotation in stepper motor
10	Bearings	6	To mount axle on the wheel
11	Wheel mount	4	To introduce the turning members in the wheel.
12	Coupling	2	To connect the pinion to the motor
13	Breadboard	1	To provide easy connection between terminals
14	Potentiometer	8	To provide angular information from the user to Arduino
15	9 Volts Battery	3	To power the Arduino

Analysis

Analysis of Motor Specification

Motor power Specification 48W

Battery Specification at 24v dc supply Capacity 7Ah

No. of battery modules 1

Battery Efficiency 75%

Calculating Battery Backup Time

$$T = \text{Capacity} \times \text{Voltage} \times \text{No. of batteries} \times (\text{Battery Efficiency} / \text{Load in watts})$$

$$= 7 \times 24 \times 1 \times (0.75 / 48)$$

$$T = 2.62\text{Hrs}$$

Calculating Power Consumption (W)

$$W = I \times V \times (\text{sqrt. Of no. of batteries})$$

$$= 4 \times 24 \times 1$$

$$W = 96\text{W}$$

RESULT AND CONCLUSION

Result

We made a vehicle with the capability of steering all wheels with the help of a NEMA 23 stepper motor which is thus controlled with a Arduino. This Arduino takes signal from the user through a potentiometer. The code which is written for the Arduino takes the speed of the vehicle into consideration to decide the safest mode to achieve a turn in. This code is easily customizable and thus is adaptable to every user by themselves. We have taken an automobile battery to power the steering system which makes the vehicle more adaptable to the current vehicle. The method we created is incredibly affordable and versatile in design. As the battery is recharged by the alternator present in every vehicle thus the battery never run out of power. We can also run the system with the traditional system in case of failure of the electronic system. This provides a greater sense of adaptability to the customer and a sense of safety.

CONCLUSION

A 4-wheel steering system which can administer different modes depending upon the speed of the vehicle is very much useful in the modern world with the congested roads and small parking spaces. In this environment we can easily implement the 4-wheel steering system in a commercial space. Till now the system hadn't been implemented because of the tough implementation of electronic systems into the automobile sector being not reliable. But now we have a good way to implement this. Its maintenance cost is practically non-existent.

Future Scope

The use of present mainstream 4-wheeler automobile industry is completely void of any 4-wheel steering systems. With the aid of our method, this hole can be closed. We have yet to implement this system to a real-life vehicle. The following elements serve as a summary of the vehicle's potential future use: Implementation on a vehicle with a working engine.

1. A system with lower power consumption can be devised replacing the existent model.
2. Better sustenance of weight can be done with the help of transmission Hence, there is no doubt that the system is functional on itself but it has a long way to go before being implemented into the commercial space.

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