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FABRICATION OF SWERVE STEER WHEEL DRIVE

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Abstract - In standard 2 Wheel Steering System, the rear set of wheels are always directed forward and do not play an active role in controlling the steering, thus it results increasing turning radius. While in 4 Wheel Steering System, the rear wheels do play an active role for steering and help to decrease the turning radius. Vehicle parking and driving in city conditions with heavy traffic in tight spaces, driving would be very difficult due to larger wheel base and track width. Hence there is a need of a mechanism that can decrease the vehicle's turning radius. We have developed an innovative 4 wheel steering design to implement a mechanism that can be used for high speed lane changing, crab steer, parallel parking depending upon the conditions of turning and lane changing with respect to front wheels, by using motors. Swerve drive, in which the car can move in any direction and independently translate its chassis orientation .so it is used rather than others drive.

The aim of this project is to conceive and design an ideal mobile platform, in terms of maneuverability, motion control simplicity, improved efficiency, platform stability. The term mobile platform is in reference to any type of a ground vehicle or robot, varying from a small powered wheel chair platform to a larger passenger transportation vehicle. A comparison is finally made to similar wheel designs, to show why the suggested design is preferable over the other designs.

Key words: Turning radius, swerve drive, chassis orientation, and maneuverability.

1.0 Introduction

One of the most common types of steering used for robot chassis is skid-steering. In a skid-steering system, the left wheels and right wheels on the robot are driven separately. Figure 1 shows a diagram of a skid-steering system. To drive straight, both sides rotate at the same speed. To turn, one side must drive faster than the other. Skid-steering is often used because it provides high maneuverability at low speeds and is easy to implement. Skid steered robots are able to turn about the center of their chassis by driving the left and right wheels in opposite directions.
One of the main drawbacks to skid steering is that the wheels must slide along the driving surface during turns. This induces drag, which causes the robot to waste energy. We believe that it is possible to design a steering system that has the low speed maneuverability of skid steering and does not cause wheel slipping. To avoid wheel slipping, we look to the principle of Advance steering called swerve drive.

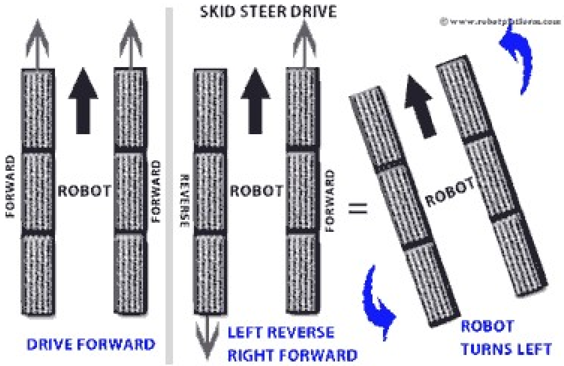

Figure 1: Skid steering system

1.1 Swerve drive

Swerve drive can be used for any drive train in which all drive wheels are steered as shown in figure 2. For this forum, the definition will be restricted to drive trains where all drive wheels are independently driven and steered. It is a holonomic drive train in which the robot can move in any direction and independently translate its chassis orientation. In FRC circles, swerve drive can be used for any drive train in which all drive wheels are steered. For this forum, the definition will be restricted to drive trains where all drive wheels are independently driven and steered. It is a holonomic drive train in which the robot can move in any direction and independently translate its chassis orientation.

1.2 Benefits of swerve drive

(a) Agility - A true 2-d drive train in which drive direction may be divorced from chassis orientation.
(b) Traction - In contrast to other holonomic drive systems, high traction wheels may be employed without negative consequence, furthermore drive force may be vectored in any desired direction.
(c) Flexibility - With the drive direction and power controlled independently to each wheel by software, multiple drive modes, including game-specific drive modes, become possible.
(d) Minimal steering hysteresis - There is almost no need to overcome static friction in steering.

Figure 2: Swerve drive

2. Literature Review:

For ease of quick reference the literature review is presented in the form of a table as shown in table:2

Table 2: Literature Review

AUTHOR	TITLE	WORK DONE	PUBLISHER
Jungmin Kim, Seungbeom Wo o, Jaeyong, Kim Joocheol Do, Sungshin Kim.	Inertial navigation system for an automatic guided vehicle with Mecanum wheels	AGV (automatic guided vehicle) with Mecanum wheels.	International Journal of Precision Engineering and Manufacturing March 2012, Volume 13, Issue 3, pp 379–386
Douglas Ollerenshaw and Mark Costello.	Simplified Projectile Swerve Solution for General Control Inputs	Swerve response of fin and spin stabilized projectile control mechanism	Journal of Guidance, Control, and Dynamics, Septembe r, Vol. 31, No. 5 : pp. 1259-1265
GUAN Shengwen1, LI Yongkui2, HU Yanqing2.	Design of Automatic Drive Farm Wheel Testing Vehicles	GPS-navigation wheel testing vehicles with mechanical system	Cnki journal
Arun Singh, Abhishek Kumar, Rajiv Chaudhary, R. C. Singh	Study of 4 Wheel Steering Systems to Reduce Turning Radius and Increase Stability	4 wheel steering a mechanism with changing in-phase and counter-phase steering of rear wheels depending upon the conditions of turning and lane	International Conference of Advance Research and Innovation (ICARI-2014)
Saket Bhishikar, Vatsal Gudhka, Neel Dalal, Paarth Mehta, Sunil Bhil, A.C. Mehta.	Design and Simulation of 4 Wheel Steering System	4 wheel steering a mechanism with changing in-phase and counter-phase steering of rear wheels depending upon the conditions of turning and lane	International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 12, June 2014
F.G. Pin, S.M. Killough	A new family of omnidirectional and holonomic wheeled platforms for mobile robots	omnidirectional capability for mobile robot platforms	IEEE Transactions on Robotics and Automation (Volum e: 10, Issue: 4, Aug 1994)

3.0 Issues and challenges involved in present work

(a) The major issue today in any vehicle is identifying the more turning radius of normal steering and Jerks in sudden turning of vehicle.
(b) The steering system should be selected according to the need and application.

(c) The swerve drive is selected because it satisfies the problems faced during the turning of wheels.

4.0 Scope and Objectives of present work

The main scope of present work is, to investigate the problems of normal steering, skid steering, Ackermann steering. The objective of improving the steering response, increase vehicle stability while maneuvering at high speed, or to decrease turning radius at low speed platform stability etc.,

5.0 Formulation of the problem

360 rotating of individual wheels are not obtained in normal steering system. The turning radius of normal steering is low. Hence swerve steering mechanism is used in rovers to have maneuverability and moving the wheels according to desire of driver. The rovers and robots need the wheels to move in 360 of rotation during obstacle or stuck in sand. The vehicle faces more problems in parallel parking. Swerve steering found its most widespread use in robots, where maneuverability in small arenas is critical, and it is also popular in army surveillance and industry.

6.0 Present work

The present work is split into the following modules:

1. Studying pros and cons of different drives.
2. Selecting the drive which is used for surveillance purpose.
3. Installing the swerve drive in surveillance vehicle operated with wireless system.

6.1 Studying props and cons of different drives.

Drives	Advantages	Disadvantages
Tracks (Differential Drive)	Good mobility for rough terrain, Low ground pressure	Complex mechanism, high power usage when turning
Skid Steer 4 wheel	Very simple, high weight capacity	High power usage, requires skidding/slipping
Differential drive 2 wheel + Passive Caster(s)	Easy	Lower weight designs, less precise controls. Bad for obstacles/bumps
2 wheel + 1 Powered Steering Caster	Easy mechanical, powered steering wheel for control	Lower weight designs, potentially a lot of weight on steering wheel.
2 wheel (Seaway Drive)	Easy mechanical, fun!	Not dynamically stable
Ackerman Steering	Wheels do not need to slip to turn. Fixed rear wheels makes control geometry easier.	Increased motor count

Rear wheel forklift steering	Tight maneuverability, good if weight is on front wheels	Less responsive than Ackerman, unstable at "high" speeds
Independent all wheel steering	Lot of flexibility for motion	Complexity of mechanism and large number of motors. More coordination needed for turns.
Rocker Bogie / Body Averaging	Helps body average the chassis to minimize pitch. Allows all wheels to maintain ground contact while distributing the weight.	Mechanical complexity

6.2 Selecting the drive which is used for surveillance purpose.

By observing the advantages and disadvantages of different drives we selected a used for any drive train in which all drive wheels are steered. It is a holonomic drive train in which the robot can move in any direction and independently translate its chassis orientation. In this steering system, all wheels turn at the same time when the driver steers. The wheels are swerve drive is steered by a computer and Joy sticks. Mobile platform is reference to any type of the ground vehicle or robot, varying from a small powered wheel chair platform to a larger passenger transportation vehicle. Flexibility with the drive direction and power controlled independently to each wheel by software and multiple drive modes can also increase scope of the swerve drive in the robot manufacturing industry.

6.3 Installing the swerve drive in surveillance vehicle operated with wireless system.

The swerve drive is installed in surveillance vehicle by using of different gears like driven and drive gear. The driver gear is attached to motor which input is obtained by Ir-circuit. This I-r circuit is controlled by joy sticks and work upto range of 15 meters. The surveillance camera is operated by using mobile app which is able to turn round and can move up and down .The advantage of camera is used to take videos and photos for future use. Surveillance camera is the monitoring of the behavior, activities, or other changing information, usually of people for the purpose of influencing, managing, directing, or protecting them. This can include observation from a distance by means of electronic equipment. Surveillance is used by governments for intelligence gathering, the prevention of crime, the protection of a process, person, group or object, or the investigation of crime see in figure 3

Figure 3: Surveillance camera

7.0 Experimental Work

The experiment is split into following modules

1. Fabricating the swerve drive with individual 360 rotating of wheels
2. Calculating the rotation of driver and driven gear

7.1 Fabricating the swerve drive with individual 360 rotating of wheels

(a) Making of mobile platform

The wooden platform of 30 X 35 cm is polished and the driven gear of 55 mm, driver gear of 21 mm are arranged as shown in figure 4.In this 11 driven gears, 2 driver gears and 2 idler gears are to be fixed. Marking of the centers of gears on platform is done. The holes are drilled for installing shafts in it.

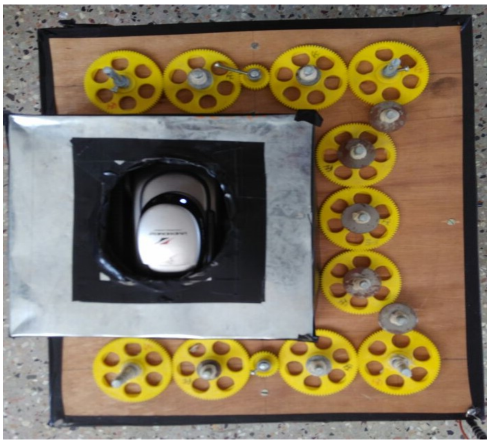

Figure 4: Representation of the all type of gears in swerve steer drive

(b) Installing shafts which are meshed with motor and wheels

The 4 shafts are inserted in driven gears at four edges of platform perpendicularly. These shafts are attached with the wheels and motor as shown in figure 5.The wooden blocks are used for supporting purpose. The gears are installed according to the marking as shown in figure 4 without contact loss. The gears are used instead of chains because of exact transmission of velocity. The motor is attached with the wheels parallel and perpendicular to shaft. The 4 driven gear and shafts are tightened with screws. The power to each wheel is obtained which is attached through Ir circuit to move vehicle for ward and back ward.

(c) Arranging motors to driver gear and incorporating surveillance camera

The motors are attached to driver gear and to Ir circuit .The Ir circuit will receive the actuate signals from joy sticks operated by user .These signals make motor to rotate according the input. By this driver gear is moved which makes driven gear to rotate and thus rotating shafts to rover move left or right. The surveillance camera is installed on mobile platform operates by using mobile app. The installation of any spy tool can be achieved.

Figure 5: Shafts and Motor installation

7.2 Calculating the rotation of driver and driven gear

Table 2: Specification of dc motor

DC supply	4 to 12V
RPM	100 at 12V
Total length	46mm
Motor diameter	36mm
Motor length	25mm
Brush type	Precious metal
Gear head diameter	37mm
Output shaft, Centered Shaft diameter:	6mm
Motor weight	100gms
Shaft length	22mm
Gear head length	21mm

Table 3: Specification of gears

Total number of teeth in driver gear	30
Total number of teeth in driven gear	85
Diameter of driver gear	21mm
Diameter of driven gear	55mm

Formulae

Angular speed of driver gear (ω_1) = $\frac{2\,\Pi\,N}{60}$

Where,

N = speed in rpm,

The angular speed and number of teeth ratio relation $\frac{\omega 2}{\omega 1} = \frac{T1}{T2}$

Where,

ω_1 = angular speed of the driver gear,

ω_2 = angular speed of the driven gear,

T_1 = number of teeth of driver gear,

T_2 = number of teeth of driven gear.

Angle turn through driver gear = $\frac{\text{length of arc of contact} \times 360}{\text{circumference of pinion}}$

Where,

Circumference of the pinion = $\Pi\,D_1$,

D_1 = diameter of the pinion.

Angle turn through the driven gear = $\frac{\text{length of arc of contact} \times 360}{\text{circumference of large gear}}$

Where,

Circumference of the gear = $\Pi\,D_2$,

D_2 = diameter of the gear.

Current produced by the batteries (I) = $\frac{V}{R}$

Where,

V = voltage of the batteries in volts,

R = internal resistance of the batteries ohm.

Power input to the motor (P_{in}) = $I^2 R$

Where,

I = current by produced by the batteries in Ampere,

As we know that power output (P_{out}) = $T \times \omega$

Where,

T = torque in N-m,

ω = angular speed of the motor in rad/sec.

Power input to the drive gear (P_{in}) = $\frac{2\,\Pi\,N\,T}{60}$

Evaluation

Total number of teeth in driver gear (T_1) = 30,

Total number of teeth in driven gear (T_2) = 85,

Diameter of driver gear (D_1) = 21 mm,

Diameter of driven gear (D_2) = 55 mm,

Speed of motor (N) = 100 rpm.

Therefore,

Angular speed of driver gear (ω_1) = $\frac{2\,\Pi\,N}{60}$

$$= \frac{2 \times 3.14 \times 100}{60}$$

$$= 10.41 \text{ rad/sec.} \qquad \text{(i)}$$

As we know from the angular speed and number of teeth ratio relation $\frac{\omega 2}{\omega 1} = \frac{T1}{T2}$

$$\frac{\omega 2}{10.41} = \frac{30}{85}$$

$$\therefore \quad \omega_2 = 3.674 \text{rad/sec}$$

Note: From diameter ratio; the value will be same.

Let θ_1 and θ_2 are the angle rotation of the driver and driven gears.

Note :- As the swerve drive is rotated 360 degrees, among 360 degrees we take the driver gear is rotated 45 degrees and we calculate the angle of rotation of driven gear

So angle turn through driver gear = $\frac{\text{length of arc of contact} \times 360}{\text{circumference of pinion}}$

Or length of arc of contact = $\frac{\frac{21}{2} \times 2\,\Pi \times 45}{360}$

$$= 8.24 \text{ mm.}$$

Angle turn through the driven gear = $\frac{\text{length of arc of contact} \times 360}{\text{circumference of large gear}}$

$$= \frac{8.26 \times 360}{2\Pi} \times \frac{2}{55}$$

$$= 17.1°$$

∴ we can conclude that the angular speed of the drive gear is more than driven and when the pinion gear rotates with an angle of 45° then the driven gear rotates with 17.1° which is less than the drive gear.

For the Battery and Motor:

Voltage produce by batteries (V_b) = 36 volt,

Internal resistance of the batteries (r) = 6 Ω (i.e each battery having 1.5Ω when it is fresh), Speed of the motor (N) = 100 rpm,

Current by produced by the batteries in Ampere (I) = 6 Ampere.

So, current produced by the batteries (I) = $\frac{V}{R}$

$= \frac{36}{6}$

= 6 Amperes.

Power input to the motor (P_{in}) = $I^2 R$

Where,

I = current by produced by the batteries in Ampere,

= 36 × 6
= 216 watt

As we know that power output (P_{out}) = T × ω

Where $P_{in} = \frac{2 \Pi N T}{60}$

Or $216 = \frac{2\Pi \times 100 \times T}{60}$

Or T = 20.63 N-m.

∴ Angular speed (ω) = 10.41 red/s (ii)

∴ From equations (i) and (ii) we conclude that angular speed of driver gear and power output are equal

8.0 Results and discussions:

Parameters	Values
Angular speed of driver gear (ω_1)	10.41 rad/sec.
Angular speed of driver gear (ω_2)	3.674rad/sec
Angle of rotation of driver gear	45 degrees
Angle of rotation of driven gear	17.1 degrees

According to the fabrication of swerve steer wheel drive we can conclude that the angular speed of the drive gear is more than driven and when the pinion gear rotates with an angle of 45° then the driven gear rotates with 17.1° which is less than the drive gear. All the calculation show that by using the swerve steer wheel drive Omni drive platform is possible which solve the problem in parallel parking skidding during sudden turn and the problem of sliding pair in Davis steering mechanism .The incorporation of surveillance camera in our swerve steer wheel drive makes it more flexible while capturing the scene .

9.0 Conclusion

Steering system is to allow the driver to guide the vehicle. The basic aim of steering is to ensure that the wheels are pointing in the desired directions. The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints. To improve stability of vehicle, where vehicle handling changes with road speed and to increase response of steer in both time and direction we use swerve steer wheel drive. This also help to overcome 2 wheels steering and used for parking purpose. But the normal (Ackerman) steering is not used in rovers and robots because it consumes more power. The rovers also need Omni wheel (each wheel is driven by individual motor) to increase speed stability and maneuvarability.

As per the focus of the project we have created an innovative 4 wheel active steering mechanism using IR circuit which is feasible to manufacture, easy to install and highly efficient in swerve steer and coordinated steering. This system assists in high speed lane changing and better cornering. It combats the problems faced in sharp turning. It reduces the turning circle radius of the car and gives better maneuverability and control while driving at high speeds, thus attaining neutral steering. Moreover components used in this system are easy to manufacture, material used is feasible, reliable and easily available in market. The system assembly is easy to install and light in weight and can be implemented in all sections of rovers efficiently

References

[1] Jungmin Kim, Seungbeom Woo, Jaeyong Kim, Joocheol Do,Sungshin Kim, Inertial navigation system for an automatic guided vehiclewith Mecanum wheels Volume 13, Issue 3, March 2012, Issue 3, pp 379–386.
[2] Douglas Ollerenshaw and Mark Costello, Simplified Projectile Swerve Solution for General Control Inputs, Journal of Guidance, Control, and Dynamics, September, Vol. 31, No. 5 : pp. 1259-1265
[3] GUAN Shengwen1, LI Yongkui2, HU Yanqing2, Design of Automatic Drive Farm Wheel Testing Vehicles, Cnki journal
[4] Vitthal Dharmashale, Dr. S. T. Chavan, Ajit Pawar, STUDY & DESIGN OF FIRE DETECTING& FIRE EXTINGUISHING ROBOT,Vol-1 Issue-2 ,2015, IJARIIE-ISSN(O)-2395-4396
[5] Arun Singh, Abhishek Kumar, Rajiv Chaudhary, R. C. Singh, Study of 4 Wheel Steering Systems to Reduce Turning Radius and Increase Stability International Conference of Advance Research and Innovation (ICARI-2014)
[6] Saket Bhishikar, Vatsal Gudhka, Neel Dalal, Paarth Mehta, Sunil Bhil, A.C. Mehta Design and Simulation of 4 Wheel Steering System International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 12, June 2014
[7] F.G. Pin, S.M. Killough, A new family of omnidirectional and holonomic wheeled platforms for mobile robots IEEE Transactions on Robotics and Automation Volume: 10, Issue: 4, Aug 1994