Car-like Steering

Car-like steering is a configuration in which two wheels are used to change the direction that a robot is moving. Typically the two front wheels) are used, but rear wheel steering has also been employed.

Basically the wheels that are used for steering are each mounted on separate angled armatures called (appropriately enough) "steering arms". These armatures are attached to the frame of the robot is such a way that the angled part of of each arm points towards the non-steering end of the robot's frame. Also, the arms are attached to the frame using a short axle called a "king pin", which allows the steering arms to move. Moving the arms shifts the angle of the wheels with reference to the robot's frame.

The ends of the angled part of the steering arms are connected together with what is called a "tie rod". The point at which each of the steering arms is connected to the tie rod are joined in such a way that they can pivot and thus acts like hinge. The tie rod, steering arms and the frame form a four bar linkage .

The tie rod is connected to some type of actuator, which is used to shift the tie rod left or right, thereby changing the angle of the wheels with respect to the robot's frame. As a result, the robot turns as it moves forward or backward.

Parallel Steering

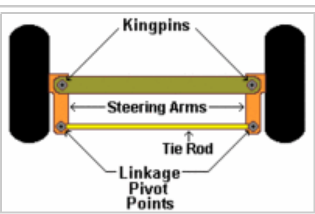

Figure 7 Basic configuration used for parallel steering

If the steering arm angle is 90 degrees, the wheels being used for steering will always be parallel to each other regardless of their steering angle. Due to the relative simplicity, of this design, it is often used on robots that have a car-like wheel pattern. However, there is a problem.

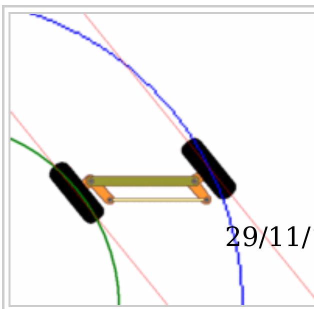

Figure 8
Green = Inner radius

As long as the robot is traveling in a straight line there are no drawbacks to this configuration. However, as can be seen in figure 8, when turning the wheels

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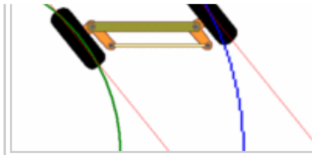


Figure 8
Green = Inner radius
Blue = Outer radius
Red = Steering angle

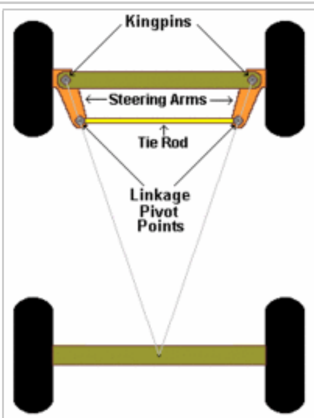
As long as the robot is traveling in a straight line there are no drawbacks to this configuration. However, as can be seen in figure 8, when turning the wheels are each traversing a different circumference. The wheel on the inside of the turn follows a path with a tighter radius than does the wheel on the outside of the turn.

This results in**:**

- Both wheels experiencing an increase in friction due to having to follow a path to which they are not properly aligned.
- An increase in energy required to make the turn.
- Additional stress being placed upon the wheels and motors.
- Excessive wear on the surface of the wheels.

Fortunately there is a fairly simple way to deal with this problem, which is described in the next section.

Ackerman Steering



Ackermann steering configuration

Ackermann steering (`named for its inventor Rudolph Ackermann`) solves the problem inherent with parallel steering, as described above.

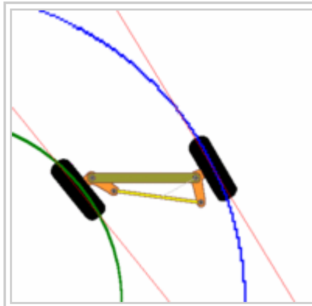


Figure 10
Green = Inner radius
Blue = Outer radius
Red = Steering angle

Figure 9, shows how a simple approximation of the perfect Ackermann steering geometry can be achieved by angling the steering arms inward so that the pivot points where the tie rod and steering arms are joined, lie along a line drawn between the steering arm kingpins and the center of the non-steering (`typically the rear`) axle.

As shown in figure 10, using this type of configuration results in the wheel on the inside of the turn being angled more acutely than the wheel on the outside of the turn. Using the perfect Ackermann angle will insure that at any steering angle both wheels will be properly aligned to trace out the necessary radius on each side of the turn. This of course results in a minimum of friction and stress on the wheels.

This has only been a cursory description of the **Ackermann steering geometry**. It should be mentioned that there are sometimes reasons why a perfect Ackermann angle may not be wanted. Instead what is called a positive Ackermann, or a negative Ackermann angle may be more desirable. It is recommended that the reader check out some of the external references listed below to learn more about these alternative configurations.

Calculating the Turning radius of a Car-like Robot

The turning radius of a robot that utilizes car-like steering (parallel or Ackermann geometries) will depend on the wheelbase of that robot and its maximum steering angle. A longer robot will require more space to turn

Calculating the Turning radius of a Car-like Robot

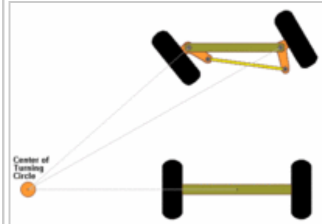


Figure 11 Turning radius

The turning radius of a robot that utilizes car-like steering (parallel or Ackermann geometries) will depend on the wheelbase of that robot and its maximum steering angle. A longer robot will require more space to turn around than would a shorter robot possessing the same steering angle.

The following formula is crude but works well enough when used to calculate the turning radius of car-like robot. Be sure to use consistent units when entering everything.

Turning radius = track / 2 + wheelbase / sin (steering angle in degrees)

Where**:**

- track = the distance (center to center) between the left and right wheels
- Wheelbase = the distance (center to center) between the front and rear wheels
- Steering angle = the maximum angle that the steerable wheels may be turned

Note with **Ackerman steering** the actual steering angle is an average of the angles of both the left and right wheels)

This does not define the wall to wall turning circle, for which you would need to consider any body overhangs.

Related External References

- Wikipedia Article: – Ackerman steering geometry
- RcTek Article: Model Car Handling - Ackerman Steering Principle
- RcTek Article: Model Car Handling - The Circle
- RcTek Article: Model Car Handling - How Toe Angle Affects Ackerman Angles
- RcTek Article: Toe Angle Basics