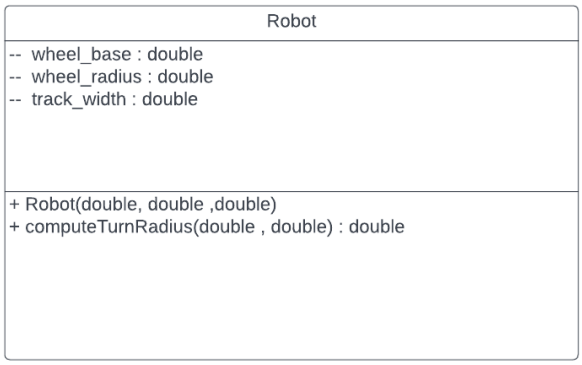
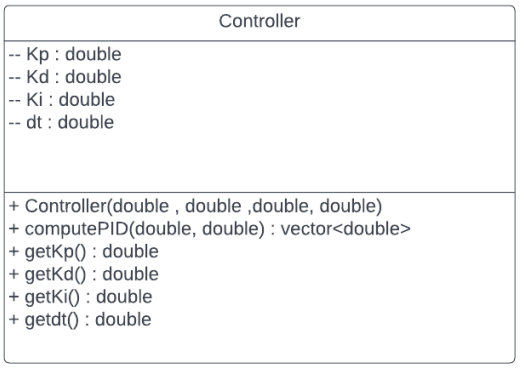
1. Introduction:

The objective of this project is to design and implement a controller for an Ackermann kinematic model for the Acme Robotics company. This controller can possibly be a component of a self driving car software stack. It can take inputs such as a goal location and goal heading from a path planning module and apply the appropriate control input to the motors of the vehicle. The input for our Ackermann controller is a target heading angle and velocity. The output will be the steering angles and angular velocities for each of the front wheel. We assume that the ideal steering angle for a given set of inputs is unique.
Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheel slippage while executing a turn. The model has independent steerable wheels, to execute a turn, the inner and outer wheels have to trace out concentric circles of different radii. This ensures that the wheels do not slip.
The kinematic equations for this controller can be derived with basic trigonometry. These equations will be implemeted in C++ , because of its performance in real time systems. OOP practices will be used to make the code scalable.
The controller will use a PID control algorithm for calculating the ideal inputs to the system at every time step. The PID control has many advantages, the major advantage being its simplicity. But, the biggest disadvantage of PID is that we cannot add any constraints to the output signals and sometimes it can reach very high values, which may not be possible to attain in physical systems. Here one of our constraints is that maximum steering angle constraint < 45 degrees.

2. Development:

This development of this project will be in the form a pair programming process.
For Phase 0 -
Driver - Badrinarayanan Raghunathan Srikumar
Navigator - Smit Dumore





This project will be developed in a Linux environment and will make use of C++ 11/14/17 features. Tools like Travis, Coveralls , cppcheck, cpplint and GoogleTest will be used to created a industry standard software.

3. Ackermann Model Geometry:

For a vehicle turning around a point with angle θ in time t, the radius of curvature is given by

$$R=\frac{v_t}{\omega} \qquad R=\frac{v_t * t}{\theta}$$

The indivisual steering angles can be calculated uisng the following formulaes,

$$\delta_i=\arctan\left(\frac{L}{R-(T/2)}\right)$$

$$\delta_0=\arctan\left(\frac{L}{R+(T/2)}\right)$$

distance travelled by the car along the arc is given by

$$S_i=\left(R-\frac{T}{2}\right)*\theta$$

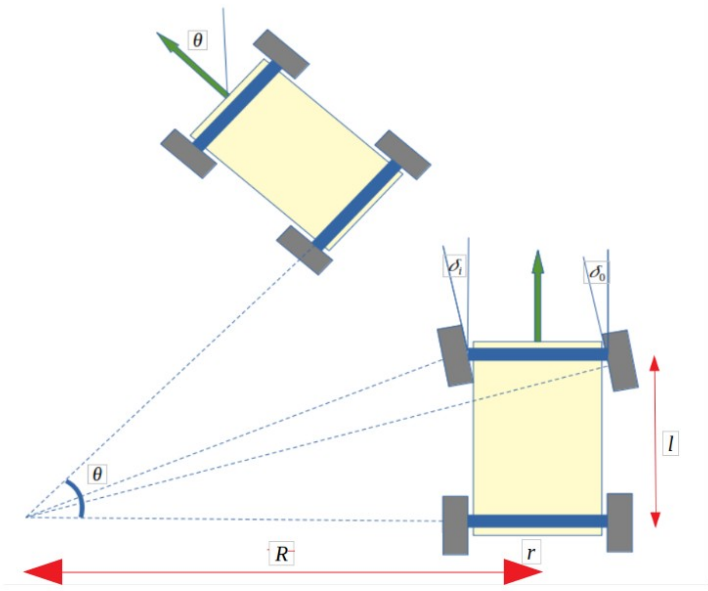
$$S_i=\left(R+\frac{T}{2}\right)*\theta$$

using the above results , the angluar velocity of indivisual wheels can be obtained as the following,

$$\omega_i=\frac{S_i}{r_w * t}$$

$$\omega_0=\frac{S_0}{r_w * t}$$

Notations:



1. ***R*** – Turning radius of the vehicle
2. ***l*** – Wheel base
3. **r** – track width
4. **θ** – heading of the vehicle
5. δ**i** = inner wheel steering angle
6. δ**o** = Outer wheel steering angle