Vehicle Dynamics Simulation
Entry Programming Assignment

Answering the Theoretical Questions Part
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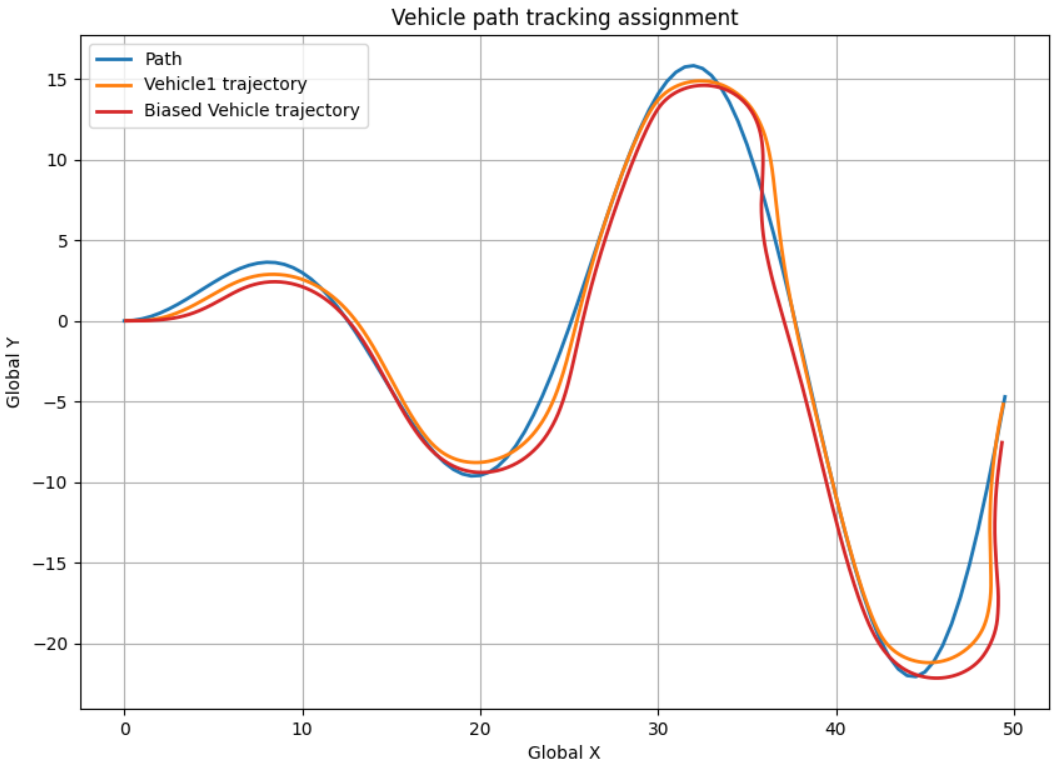
1. Steady State Effect of Bias in Mechanical Road Wheel Servo for Pure–Pursuit Tracking

A bias in the mechanical road wheel servo, when applying the Pure-Pursuit tracking algorithm, would make it more challenging for the vehicle follow the path. The vehicle's steady-state error will grow, and it will take longer for the algorithm to compensate the deviation from the path.

a) This kind of effect can be seen in the simulation below, where the **biased vehicle's steering servo** has an angle based of 5.0 degree:



2. Model for Higher Speeds: Dynamic Bicycle Model

The main reason for using the kinematic bicycle model at lower speeds is the absence (neglectable value) of the lateral and longitudinal forces acting on the vehicle. It comes from small acceleration that results in low forces in compare to the vehicle mass.

The kinematic bicycle model assumes that:

- Tire forces are linearly proportional to slip angles.
- Lateral dynamics are negligible.
- The vehicle's speed is sufficiently low that inertial effects can be ignored.

At higher speeds, these assumptions no longer hold true. Specifically:

- Tire forces become nonlinear functions of slip angles due to tire saturation.
- Lateral forces and weight transfer significantly influence vehicle dynamics.
- Inertial effects and yaw dynamics cannot be neglected.

The dynamic model can be described as the following set of equations (taken form the book "Vehicle Dynamics and Control"):

1) Lateral forces:

$$m\left(\ddot{y} + \dot{\psi}V_x\right) = F_{yf} + F_{yr}$$

Where $\dot{\psi}V_x$ is the addition expression for the centrifugal acceleration.

2) Yaw moment (around Z axis):

$$I_z\ddot{\psi} = l_f F_{yf} - l_r F_{yr}$$

3) Tire force models

$$F_{yf} = 2C_{af}a_f$$
$$F_{yr} = 2C_{ar}a_r$$

where C_{af} and C_{ar} are the cornering stiffness coefficients for the front and rear tires, and a_f and a_r are the slip angles at the front and rear tires.