Autonomous Vehicle: Dynamic Model, Control & Planning

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1 Introduction

This document outlines the dynamic model, control and planning for car like autonomous robot.The this document will focus on motion control and local planning problems.

Figure 1: System architecture for autonomous vehicle

2 Modeling for Planning and Control

2.1 Kinematic model of a car like robot

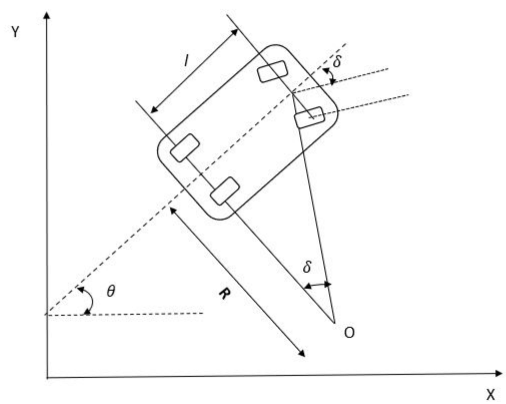

Figure 2: Kinematics of a car like mobile robot

The differential constraint for rear wheel is given by:

$$
\begin{aligned}
R &= \tfrac{l}{\tan\delta} && (1)\\
\dot{x}_r &= v_r \cos(\theta) && (2)\\
\dot{y}_r &= v_r \sin(\theta) && (3)\\
\dot{\theta} &= \tfrac{v_r}{l} \tan\delta && (4)\\
\dot{v}_r &= a && (5)
\end{aligned}
$$

The differential constrain can also be written in terms of motion of forward wheel,

$$
\begin{aligned}
\dot{x}_f &= v_f \cos(\theta + \delta) && (6)\\
\dot{y}_f &= v_f \sin(\theta\delta) && (7)\\
\dot{\theta} &= \tfrac{v_f}{l} \tan\delta && (8)
\end{aligned}
$$

The front wheel speed v_f, is related to rear wheel speed v_f by:

$$\frac{v_r}{v_f} = \cos(\delta) \quad (9)$$

The planning and control problems for this model involve selecting the steering angle δ within the mechanical limits of the vehicle $\delta \in [\delta_{min}, \delta_{max}]$, and forward speed v_r within an acceptable range, $v_r \in [v_{min}, v_{max}]$ [1].

A simplification that is sometimes utilized is to selected the heading rate ω instead of the steering angle δ. These quantities are related by

$$\delta = \arctan\left(\frac{l\omega}{v_r}\right) \tag{10}$$

simplifying the heading dynamics to

$$\dot{\theta} = \omega, \quad \omega \in \left[\tfrac{v_r}{l}\tan(\delta_{min}), \quad \tfrac{v_r}{l}\tan(\delta_{max})\right] \tag{11}$$

3 Vehicle Control

4 Trajectory Planning

References

[1] Brian Paden, Michal Čáp, Sze Zheng Yong, Dmitry Yershov, and Emilio Frazzoli. A survey of motion planning and control techniques for self-driving urban vehicles. *IEEE Transactions on intelligent vehicles*, 1(1):33–55, 2016.