Week 4 Update

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FollowerStopper/ACC

Abstract

Humans naturally cause traffic jams.

A steady velocity is an inexpensive solution to traffic.

FollowerStopper is a controller that gives an **optimal** velocity to a self-driving vehicle based on traffic conditions.

We want to prove that FollowerStopper will lessen traffic jams and optimize it to account for different traffic conditions such as amount of cars on the road. We also want to prove that FollowerStopper is safe.

Week 4 Accomplishments

Literature reviewed:

- “Are Commercially implemented adaptive cruise control systems string stable?”
- “Model Based string stability of adaptive cruise control systems using field data”
- “String stability for vehicular platoon control: Definitions and analysis methods”
- “Experimental verification platform for connected vehicle networks”
- “Experimental validation of connected automated vehicle design among human-driven vehicles”

Completed actions:

- Introductory knowledge of ROS, Gazebo, and Simulink
- Published commands to a ROS topic to control turtles and to control the car in Gazebo
- Viewed camera and velodyne sensor data through RViz
- Developed a Simulink model to control the car in Gazebo
- Learned about different kinds of human car-following models
- Clarified definitions of string stability

Topics of Interest

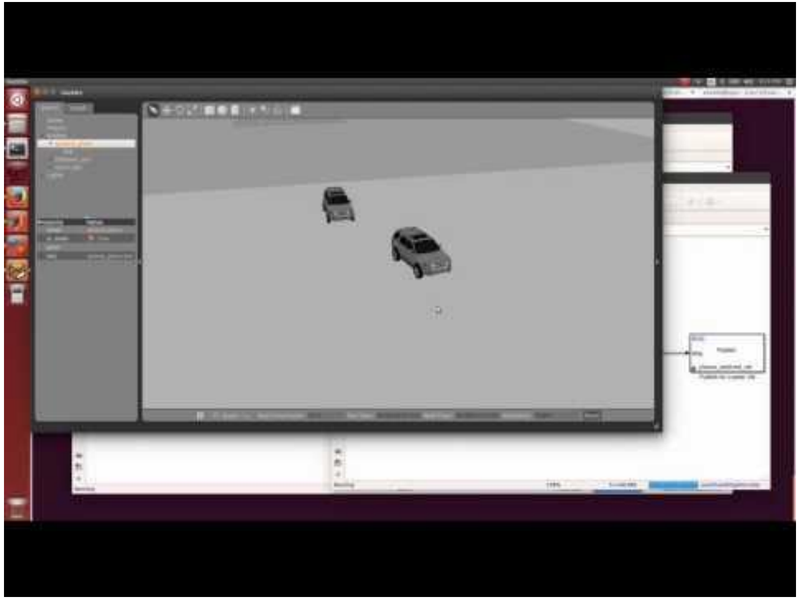
1. Simulations in Gazebo
2. Human Car-Following Models
3. String Stability

Simulations in Gazebo

- Published to the cmd_vel topic for car to travel at a constant velocity, sine wave velocity, and random velocity using Simulink

- Desire to model FollowerStopper and human car-following models with Simulink

- Desire to recreate the ring-road experiment and model a straight path



Vehicle follower in straight line with a random velocity to the leader vehicle (0:39)
Created by Rahul Bhadani

Human Car-Following Models

"Our view is that there are probably too many microsimulation models in circulation. (It has become fashionable for every researcher to derive his own model, perhaps because this leads to more publications!)" (Wilson 16)

Optimal Velocity with Relative Velocity (OVRV) model

$$f(s_n, \Delta v_n, v_n) = \alpha(V(s_n) - v_n) + \beta \Delta v_n$$

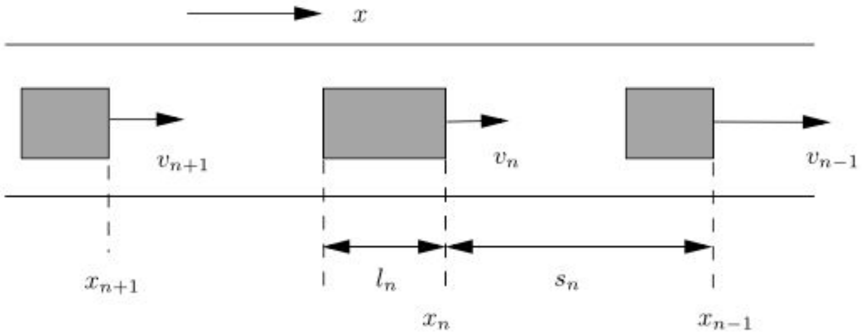
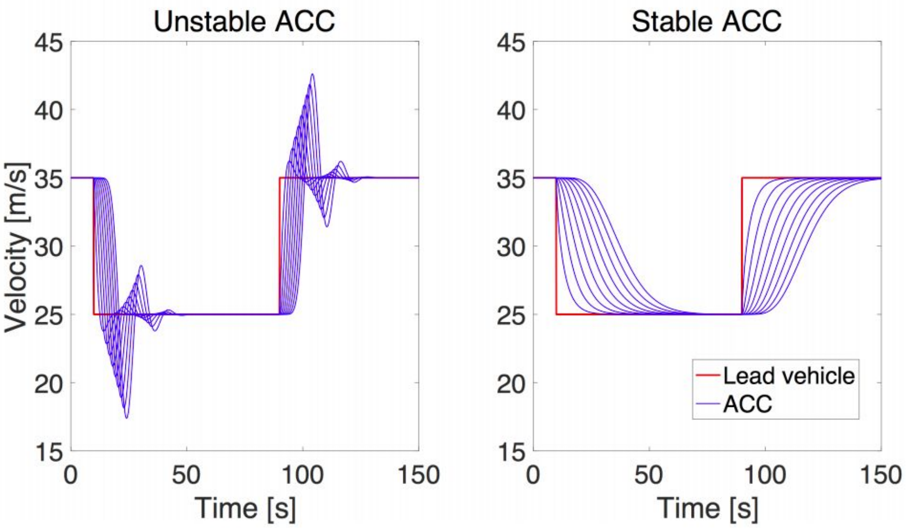


Figure 2. General car-following model set-up.

String Stability

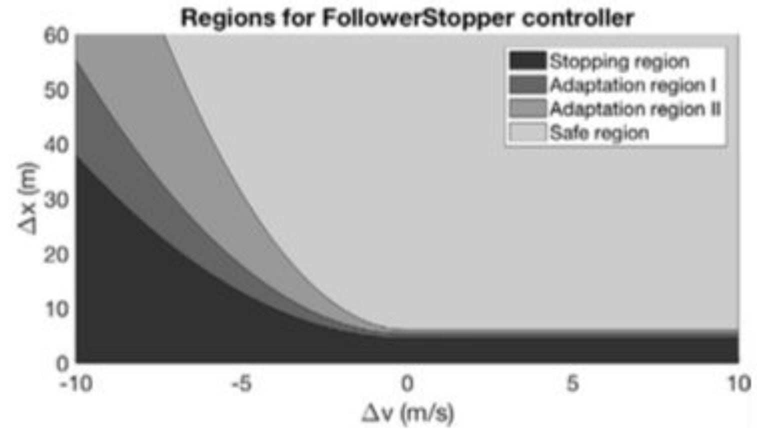
- There are a lot of definitions of string stability and many ways of assessing if a model is string stable

- String Stability: “When disturbances are imposed on the head vehicle, the system is said do be string stable if the disturbances are attenuated when reaching the tail vehicle” (Gunter, 5)



Weekly goals

- Simulink code to model a human driver and FollowerStopper in Gazebo
- Recreate the ring-road experiment and a long string of vehicles with a FollowerStopper
- Write a report on if FollowerStopper is string stable
- Begin to optimize the parameters in the FollowerStopper controller



$$v^{\mathrm{cmd}} = \begin{cases} 0 & \text{if } \Delta x \leqslant \Delta x_1 \\ v\dfrac{\Delta x - \Delta x_1}{\Delta x_2 - \Delta x_1} & \text{if } \Delta x_1 < \Delta x \leqslant \Delta x_2 \\ v + (U - v)\dfrac{\Delta x - \Delta x_2}{\Delta x_3 - \Delta x_2} & \text{if } \Delta x_2 < \Delta x \leqslant \Delta x_3 \\ U & \text{if } \Delta x_3 < \Delta x. \end{cases}$$

$$\Delta x_k = \Delta x_k^0 + \frac{1}{2d_k}(\Delta v_-)^2, \quad \text{for } k = 1,2,3.$$