Week 3 Update

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FollowerStopper/ACC

Week 2 Accomplishments

Literature reviewed:

- “Dissipation of stop-and-go waves via control”
- “The CAT vehicle testbed: a simulator with hardware in the loop for autonomous vehicle applications”
- “Dissipation of emergent traffic waves in stop-and-go traffic using a supervisory controller”
- “Tracking vehicle trajectories and fuel rates in phantom traffic jams: methodology and data”
- “Real-time distance estimation and filtering of vehicle headways for smoothing of traffic waves”
- “Chapter 4: Longitudinal Vehicle Dynamics”, “Chapter 5: Introduction to Longitudinal Control”, “Chapter 6: Adaptive Cruise Control”, “Chapter 7: Control for Vehicle Platoons” from *Vehicle Dynamics and Control*

Completed actions:

- Configured the laptop given to me so that it has all of the software downloaded from previous weeks (except WebGME)
- Worked through half of the tutorials for C++ on Udacity
- Introduced to TensorFlow
- Worked through all of the introduction to ROS tutorials on their wiki
- Introduced to Simulink but my computer kept freezing
- Uploaded a daily journal to GitHub

What I have learned

- Circular ring experiment to explore phantom traffic jams
- FollowerStopper
- Longitudinal control

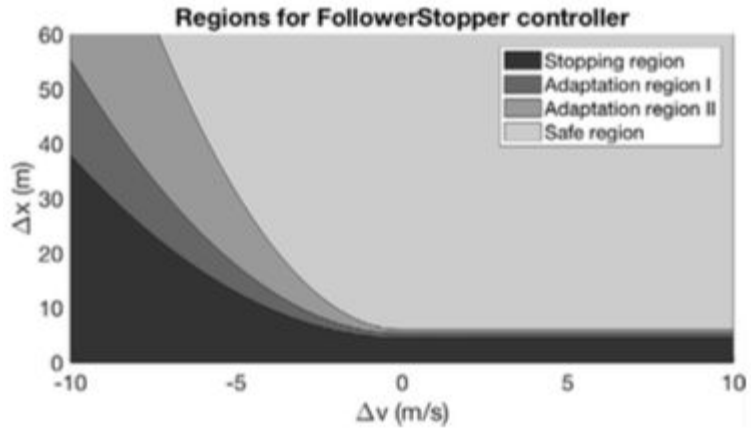
Phantom traffic jams

- 3 experiments with around 20 cars driving in a circle. Each experiment lasts 7-10 minutes, and all include the formation of a phantom traffic jam
- Most desirable to use the FollowerStopper controller that received external input rather than a PI controller with no external input
- Velocity standard deviation, fuel consumption, and excessive braking all decrease if only 5% of vehicles are controlled. Vehicle position measured with 360 camera and fuel consumption measured with OBD-II

→ need to design a method of a local controller sending external inputs to each vehicle on the highway

→ future desire to develop closed-form mathematical model establishing relationship between safety metrics and sensor frequency to use more inexpensive sensors

FollowerStopper



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

- Premise is to command U (desired velocity at which waves dissipate and traffic flow stabilized) whenever safe
- Δx-Δv phase space divided into 3 regions:
  - Safe region where v_cmd = U
  - Stopping region where v_cmd = 0
  - Adaptation region where v_cmd is some weighted average of U and v_lead

→ Optimize the distance and deceleration parameters in following eqn

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

→ Provide formal analysis on providing guaranteed safety of AVs using FollowerStopper

Longitudinal control

- Cruise control: upper level controller determines a desired acceleration and the lower level controller determines the throttle input required to track desired acceleration
- ACC: extension of cruise control, equipped with radar to achieve 1) speed control and 2) vehicle following (i.e. spacing control)
- 2 specifications: 1) individual vehicle stability and 2) string stability
- String stability unachievable with constant spacing. Constant time-gap policy fixes this

→ is there a need for a transitional controller in FollowerStopper for when encountering a new vehicle or is this already considered by the Δx-Δv phase space

→ need to test string stability of FollowerStopper

Questions

String stability: property in which spacing errors are guaranteed not to amplify as they propagate towards the tail of the string

“In a string stable platoon of vehicles, small perturbations will be dissipated as they propagate from one vehicle to another, while in a string unstable platoon small perturbations from equilibrium may amplify as they propagate through the platoon.”

- What is string stability? Are vehicles of the same make and model string stable?
- How many papers should I read per week and how in depth?

Weekly goals

- Optimize parameters for FollowerStopper
- Learn more about string stability
- Read ?? papers