Topics
- Steering discussion
- Digital Filtering
- Software Robustness- Observer
- Steering through Differential Braking
- Skid steering

Notes:
1. Mon. 4/23: (6-7 pm) round 2 (NATCAR rules) (Laval’s at ~7 pm)
   1. 13 makes first turn
   2. 15 half track in < 5 minutes
   3. 18 whole track in less than 120 sec
   4. 20 CW+CCW in < 70 sec
2. CalDay Sat. April 21 @ UCB, 10 am
3. Safety
4. Optional final review Tu 5/1, 5 pm. (Final Fri 5/11 1130 am)
5. Oral reports-scheduling TBA
6. NATCAR, Sat May 5.
7. UCSD Grand PrIEEE 5/20
UCSD NatCAR May 20, 2018
11am-6 pm
https://www.facebook.com/events/552715338419303/
Steering discussion

\[ \delta = k_p y_a + k_d \frac{dy_a}{dt} = (400)(0.04) + k_d 0 = 16 \text{ degrees} \]

\[ k_p = \underline{400} \text{ deg/m}, \quad k_i = \underline{0} \text{ deg/ m-s}, \quad k_d = \underline{60} \text{ deg/m/s} \]
Steering discussion

\[ \delta = k_p y_a + k_d \frac{dy_a}{dt} + k_i \text{integral}(y_a) \]

- \( k_p = 100 \) deg/m
- \( k_i = 300 \) deg/m-s
- \( k_d = 30 \) deg/m/s

Integrator "windup"
Digital Filtering

• Moving average
  – \( y_1[n] = (y[n-2]+y[n-1]+y[n])/3 \)

• Median filter (outlier rejection)

• Notch filter (mechanical vibration)
  – \( y[n] = (x[n-2]+2x[n-1]+x[n])/4 \)

• Model based filtering (or Kalman filter)

(on board)
Software Robustness: Observer

Steering command $\delta$

$y$ position error

State feedback:
Lateral position and velocity

N. Nise, 6th edition, Fig. 12.23
Steering References (on web page)

- Vehicle Dynamics and Control During Abnormal Driving
  
  http://soliton.ae.gatech.edu/people/dcsl/research-abnormal.html
  
  Prof. Panagiotis Tsiotras, Georgia Tech

http://soliton.ae.gatech.edu/people/dcsl/movies/skidding.avi

http://soliton.ae.gatech.edu/people/dcsl/movies/TrailBraking.avi
Steering References (on web page)

- Vehicle Dynamics and Control During Abnormal Driving (Georgia Tech)
- Some nice turning simulation (Georgia Tech): (video 1) (video 2)
Steering: Trail Braking Maneuver

Fig. 3. Trail-Braking maneuver experimental data: (a) Normalized steering command; (b) Normalized throttle and braking commands; (c) Vehicle speed; (d) Vehicle slip angle.

1. Brake hard, drive straight (increased load on front wheels)
2. Increase steering command, reduce braking (oversteering)
3. Decrease steering, counter steers, apply throttle to stabilize

Steering: Trail Braking Maneuver

- Vehicle Dynamics and Control During Abnormal Driving
  http://soliton.ae.gatech.edu/people/dcsI/research-abnormal.html

Prof. Panagiotis Tsiontras, Georgia Tech

http://soliton.ae.gatech.edu/people/dcsI/movies/TrailBraking.avi
1. Turn opposite while applying brakes (increased load on front wheels, oversteering)
2. Throttle blip to damp rotation
3. Steer in direction of turn and apply brakes to rotate fast
4. Decrease steering command, counter-steers, applies throttle to stabilize

http://soliton.ae.gatech.edu/people/dcsl/movies/PendulumTurn.avi
Vehicle Stability through Differential Braking

Fig. 1 Seven DoF vehicle model


Fig. 2 Two DoF model

Tire Slip Angle

http://technicalf1explained.blogspot.com/2012/10/f1-tirespart-2.html
Extra Slides
Steering discussion

\[ k_p = \_400\_ \text{deg/m}, \quad k_i = \_0\_ \text{deg/ m-s}, \quad k_d = \_30\_ \text{deg/m/s} \]

\[ k_p = \_100\_ \text{deg/m}, \quad k_i = \_0\_ \text{deg/ m-s}, \quad k_d = \_10\_ \text{deg/m/s} \]