Professor Fearing  
EECS192/Assignment #1  
Spring 2007  

Due by 5 pm Friday, March 23 in 265M Cory Hall

For all plots, time axes should be in seconds, and lateral errors in m or cm. Do not use the white-on-black screen dump (which wastes toner). Show plots of lateral error and speed as appropriate with constants used. ($k_p$ should have units of radians/meter, etc.)

(20 pts) 1. Steering Simulation

For each part below, plot tracking performance (lateral error as a function of time), and state the gain constants used. Use initial offset of 20 cm, parallel to a straight track.

a. Using the nonlinear Matlab simulation, with speed 3 m/s, how well can the car steer using pure position control, $\delta = k_p y_a$?

b. Using the nonlinear Matlab simulation, with speed 3 m/s, how well can the car steer using position + derivative control, $\delta = k_p y_a + k_d \dot{y}_a$?

(20 pts) 3. Steering Servo Speed

Estimate the slew rate limit or time constant for your servo. You can estimate delay using a Hamamatsu optical sensor or wire contact sensor on your steering linkage.

(60 pts) 4. Answer one of a), b), or c).

- Use a nonlinear bicycle model with the steering slew rate limited. (That is, add a state equation for the steering angle $\delta$.)
- Include sensor noise in your model, for example add uniformly or normally distributed $\pm 5 mm$ noise to estimated sensor readings.
- Simulate behavior starting off the track with an initial 20 cm position and 30° orientation error.
- Include plot of $x - y$ position.
- Attach listing of Matlab code or Simulink block diagram.

a. Simulate tracking around minimum radius “S” curves. Consider 45° and 180° curves. How good a job can you do with proportional + derivative? State constants used.

b. Extend the simulation to include car speeding up/slowing down, for example, decelerate when the lateral error is large, and speed up when tracking well. Use example path below. Use realistic car accelerations.

c. For a track with a straight line followed by minimum radius 180° curve, consider a control law which has a partial (say 60/40) feedforward steering signal superimposed with proportional + derivative control.

Figure 1: Example distance-from-track calculation. In Region III, $d = \sqrt{(x_a - x_2)^2 + (y_a - y_2)^2} - r$. For simplicity, ignore sensor orientation effects.