Exercises 1-2

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Exercises 1-2

Vehicle Motion Control

Assignment for Block 1:

1. Investigate the friction limited particle and the friction limited particle with rate limited direction control and compare them.
   - Half the group min t_f, and the other half max v_0
   - Some may try the simpler(?) version of the rate limited particle by setting the force always to constant maximum, $u_1 = m\mu g$.
2. Select at least one PEP in consultation with course leaders.
   - Would like to see at least one looking at racing (How to make the vehicle make a lap.)

Vehicle Motion Control—Problem 1

The friction limited particle avoiding an obstacle centered at $X = X_a$

$$
\begin{aligned}
\text{minimize} \quad & -v_0 \\
\text{subject to} \quad & u_1^2 + u_2^2 \leq (m\mu g)^2, \\
& x(0) = 0, \quad y(0) = 1, \quad x_f = 2X_a, \quad y_f = 1, \\
& -\left(\frac{(X_P - X_a)}{R_1}\right)^6 - \left(\frac{Y_P}{R_2}\right)^6 + 1 \leq 0 \\
& m\dot{v}_x = u_1, \\
& m\dot{v}_y = u_2, \\
& \dot{x} = v_x, \\
& \dot{y} = v_y
\end{aligned}
$$

The friction limited particle with rate limited direction control:

$$
\begin{aligned}
\text{minimize} \quad & -v_0 \\
\text{subject to} \quad & u_1^2 \le (m\mu g)^2, \\
& x(0) = 0, \quad y(0) = 1, \quad x_f = 2X_a, \quad y_f = 1, \\
& -\left(\frac{(X_P - X_a)}{R_1}\right)^6 - \left(\frac{Y_P}{R_2}\right)^6 + 1 \le 0 \\
& m\dot{v}_x = u_1 \cos(\delta), \\
& m\dot{v}_y = u_1 \sin(\delta), \\
& \dot{\delta} = u_2 \\
& |\delta| \le \delta_{max}, \quad |\dot{\delta}| \le \dot{\delta}_{max} \\
& \dot{x} = v_x, \\
& \dot{y} = v_y
\end{aligned}
$$

PEP Assignments from Lectures

PEP: Kinematic model vs Point mass model

Which one is simplest? Which is best?

PEP: Time difference between these three criteria

Compute and compareare time used for these criteria. You can use avoidance for kinematic model or point mass model, or some other scenario.

PEPs

PEP: vehicle/obstacle representation

Represent vehicle by corners (two). Truck-trailer with more corners. Are the computation times much worse? (Single track but even particle.)

PEP: Pendulum turn?

Experiment with vehicle parameters (especially inertia) to see if it occurs. (Are many rally drivers wrong?)

PEP: max v_f property

Prove that the torque contribution from outer wheels is zero.

PEPs

PEP: steering in direction of the road

Check that equation above is correct and solve optimization.
(Automatically a paper (cheaply?).)

PEP: Determine departure velocity

Solve for v_D by including min R_o in the optimization (instead of iteration as in paper)

Racing - Possible studies

PEP: Constant friction

Compute the raceline for Soval. Choose k, n for racetrack shape. Compare different values of constant friction μ. (May extend and vary model including steering constraints.)

PEP: Friction after rain

Compute the raceline for circular racetrack. Analytically when not time varying.

PEP: Extension

Try any extension of above.

PEP: Paper or thesis

Formulate a synopsis of an investigation or a definition of a Master thesis. Same amount of text as usual for a Master thesis proposal.

Preview

Exercises 3-4 are not yet finalized, but it will be mandatory to solve an optimal control problem with

- some maneuver like Curve, Hairpin, Avoidance, or Double lane change
- some model with wheel dynamics and a tire model (ST or DT)

Also mandatory to do one exercise with obstacle-centric and force-centric perspective.

As before for Block 1, there will be some individual assignment.