Assignment 3

SC42090 Robot Motion Planning and Control

Xander Guy Gerrmann
4139186

February 2018

Exercise 2

The model represents a simple vehicle. Compared to the model in [1, Chapter 13] only the change in heading term is different ($\dot{\theta} = v/L \tan(\phi_s)$), where for this exercise we have $\dot{\theta} = (vs/L)$. Here v is the velocity, ϕ_S is the steering angle, s is the steering torque, L is the wheel base width and $\dot{\theta}$ is the rate of change of the heading θ. Thus the main difference is that in the s

Exercise 3.5

Table 1 shows the effect of changing the cost function parameters on a set of chosen performance indicators. It can be seen that reducing the cost on y, the total number steps of increases due to a reduced max velocity v_{max}. Also the relative cost of the acceleration force F increases, this can be seen by the reduction of absolute values of F_{max} and F_{min}. Increasing the cost of the steering torque s increases the minimum torque s_{min}, as expected. In conclusion, increasing the (relative) cost of a certain parameter directly reduces the maximum absolute value of its corresponding parameter.

a [-]	b1 [-]	b2 [-]	F_{min} [N]	F_{max} [N]	s_{min}	s_{max} [Nm]	v_{max} [m/s]	θ_{max} [rad]	n_{steps} [-]
100.00	0.10	0.01	-3.28	5.00	-1.00	0.15	2.00	2.36	29
50.00	0.10	0.01	-2.74	5.00	-1.00	0.15	2.00	2.36	30
10.00	0.20	0.01	-1.64	5.00	-1.00	0.16	2.00	2.36	34
2.00	0.20	0.01	-1.18	5.00	-1.00	0.13	2.00	2.36	40
0.50	0.20	0.01	-0.74	2.61	-1.00	0.12	1.77	2.36	50
0.20	0.20	0.01	-0.47	1.67	-1.00	0.13	1.41	2.36	63
0.20	0.20	0.02	-0.47	1.68	-1.00	0.12	1.41	2.36	62
0.20	0.20	0.05	-0.48	1.68	-0.94	0.13	1.41	2.36	62
0.20	0.20	0.10	-0.48	1.69	-0.74	0.13	1.41	2.36	61
0.20	0.20	0.50	-0.50	1.69	-0.40	0.13	1.43	2.36	59

Table 1: Resulting performance indicators (last 7 columns) for different sets of cost-function parameters (left 3 columns). The max number of iterations is set to 2000, the horizon N to 100.

The control horizon N indicates how many steps forward the optimization should run. The optimization algorithm tries to optimize the total cost over the control horizon. If it is needed for the car to reach it's destination, then the control horizon should be long enough. From table 1, a time line of around 70 should be sufficient for testing the different sets of parameters.

Exercise 3.6

Figure 1 shows the custom world including two obstacles, namely a square and a circular area.

The inequality constraint for the circular area is as follows:

$$lb_1 \leq (x - a_1)^{p_1} + (y - b_1)^{p_1} \leq ub_1 \tag{1}$$

$$lb_1 = 0.05 \quad ub_1 = \infty \quad a_1 = -0.8 \quad b_1 = 2.5. \quad p_1 = 2 \tag{2}$$

For the square, the following constraint is applied:

$$lb_2 \leq (x - a_2)^{p_2} + (y - b_2).^{p_2} \leq ub_2 \tag{3}$$

$$lb_2 = 1 \quad ub_2 = \infty \quad a_2 = -1.5 \quad b_2 = 1 \quad p_2 = 20 \tag{4}$$

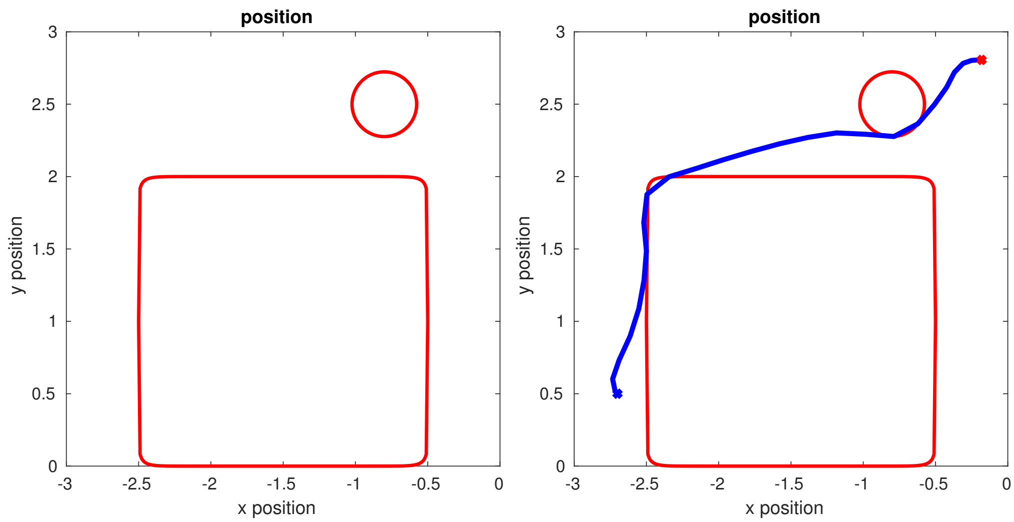

Figure 1: Left: World with two obstacles. Right: path through the same world

The cost function knows three terms, (1) the total distance to the goal, (2) the cost on the acceleration force, and, (3) the cost on the steering torque. The resulting cost function looks as follows:

$$cost(t) = 100((x(t) - x_f)^2 + (y(t) - y_f)^2) + F(t)^2 + s(t)^2; \tag{5}$$

Here $x_f = -0.2$ and $y_f = 2.8$. It can be observed hat the obstacles are correctly avoided taking into account the step size of the dynamical simulation.

Exercise 3.7

When the real size of the robot needs to be considered, a dilation operation can be performed on the obstacles. The dilation causes the obstacles to grow virtually in size. The size of the dilation depends on the size of the robot, e.g. if the robot is circular, then the obstacles need to be dilated at least with the size of the radius of the robot.

References

[1] Steven M LaValle. *Planning algorithms*. Cambridge university press, 2006.