SOLUTIONS: QUIZ 6

CONTROL OF MOBILE ROBOTS

1

Which of the following statements is true?

SOLUTION

Let's go through the statements one by one:

In a world populated solely by convex obstacles, simple go-to-goal and purely reactive (point straight away from the obstacle) avoidance behaviors will suffice. As seen in class, it is possible to get stuck even though the obstacle is convex. This happens when the obstacle-avoidance and go-to-goal behaviors "point" in the opposite directions of each other. As such, this statement is false.

It is always better to switch among behaviors than to blend them. Not true! Switching is nice because you can trust that the behavior gets the job done since it has sole control over what the robot is doing. But, at the same time, you get an overall robot performance that is jerky and all-around unpleasant.

The induced modes can help avoid having the robot get stuck in complex environments. This statement is true. The whole point with the induced mode (the"follow-wall" behavior) is to avoid getting stuck. As such, this is the correct answer to the question.

Without the induced modes, the navigation system can potentially exhibit Type 2 Zeno Behavior. The induced mode is there to remove Type 1 Zeno (a.k.a. chattering Zeno) and not Type 2 Zeno (a.k.a. genuine Zeno). As such, this statement is false.

2

In Week 6, we used a point-robot model,

$$\dot{x} = u, \quad x \in \mathbb{R}^2,$$

to describe the robot dynamics. But, the actual robot is nonlinear. So, when implementing the behaviors, we have to map the point-robot input

$$u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix},$$

onto the real control signals, i.e., onto (v, ω) in the unicycle case. Which of the following control designs would make a unicycle model mimic the point-robot model reasonably well?

SOLUTION

We notice that in the unicycle model, v is the speed and ω is the angular velocity, while in the point-model, the speed of the robot is $\|u\|$. As such, it makes sense to set

$$v = \|u\|.$$

Moreover, we can think of u as giving us a desired heading, which is given by $atan(u_2/u_1)$. If we follow this desired heading using a P-regulator, we get

$$\omega = K(atan(u_2/u_1) - \phi),$$

where the P-gain K has to be positive (otherwise we go away from the desired heading). As such, the correct answer is

$$v = \|u\|, \;\; \omega = K(\text{atan}(u_2/u_1) - \phi), \;\; K > 0$$

3

Assume that we have constructed two different behaviors that give the desired direction of travel as u_1 and u_2, where $u_1, u_2 \in \mathbb{R}^2$. Moreover, assume that the induced mode on the switching surface between these two behaviors is given by

$$u_{ind} = M u_2,$$

where M is given by

$$M = \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix}.$$

SOLUTION

From the answer choices, it seems like rotations may play a role. And, we recall from the lectures on the follow-wall behaviors that the rotation matrix $R(\theta)$ that rotates a vector θ radians is given by

$$R(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}.$$

Some basic trigonometry tells us that

$$\cos(\pi/4) = \cos(-\pi/4) = 1/\sqrt{2}$$

while

$$\cos(3\pi/4) = \cos(-3\pi/4) = -1/\sqrt{2}$$

i.e., the rotation angle is either $\pi/4$ or $-\pi/4$. But,

$$\sin(\pi/4) = 1/\sqrt{2}$$

while

$$\sin(-\pi/4) = -1/\sqrt{2}.$$

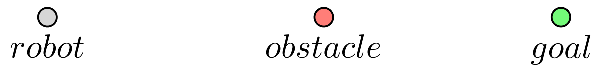
Checking these values against the M matrix gives that only one rotation angle is possible, i.e.,

$$M = \begin{bmatrix} \cos(-\pi/4) & -\sin(-\pi/4) \\ \sin(-\pi/4) & \cos(-\pi/4) \end{bmatrix} = R(-\pi/4),$$

i.e., the correct answer is u_{ind} *is* u_2 *rotated* $-\pi/4$ *radians.*

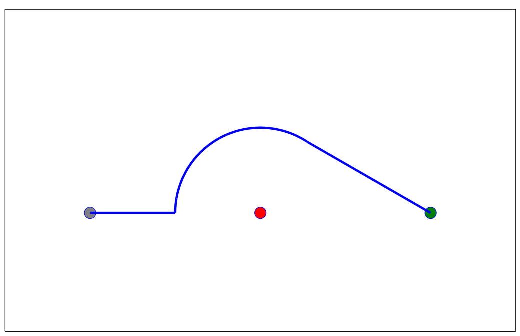
4

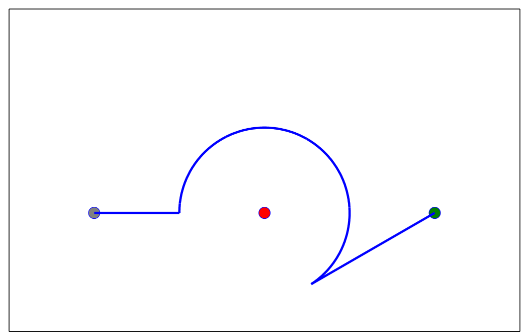
Given a point-robot in the environment shown below. Let the robot execute the navigation scheme in slide 6.6.3. Which of the following trajectories is correct? (Note that the robot goes clockwise around the obstacle – this is arbitrary as both clockwise and counter-clockwise follow-wall behaviors are consistent with the geometry).



SOLUTION

We know two things about when the "follow-wall" behavior should release and "go-to-goal" should take over again, namely (1) that the angle between go-to-goal and avoid-obstacle should be less than or equal to $\pi/2$. Based on the options given, only two plots satisfy this, as shown below:





But we also know (2) that the release happens as soon as the behaviors point in the appropriate directions and the robot is closer to the goal than it was when the follow-wall behavior took over. This is only true in the left plot above, which is the correct answer.

5

In the videos in Lecture 6.8, the light was dimmed when driving the robots around. What is the reason for this?

SOLUTION

Ultrasonic sensors and wheel encoders do not care about a bit of extra light, while IR-sensors are *light* sensors, i.e., the studio spot-lights are certainly going to affect them. Ignoring the somewhat silly options, the correct answer is thus *The obstacle-avoidance behaviors use infra-red sensors, and they are light sensitive.*