Algorithms for Intelligent Robots

Tutorial 3: Motion control

Question 1

A car-like robot is at the location (1,3). Calculate its steering angle to reach the goal location (10,8) using the pure pursuit method.

Answer:

We have:

$$|y| = 8 - 3 = 5$$

$$L^2 = (10-1)^2 + (8-3)^2 = 81 + 25 = 106$$

$$\gamma = \frac{2|y|}{L^2} = \frac{2 \times 5}{106} = 0.094\, rad$$

Question 2

Find the feedback control laws for *v* and *w* of a differential drive mobile robot to drive it from the current pose (-5, -3, 45^0) to the goal (1, 1, 0^0) given the control parameters (γ, λ, h)=(3, 6, 1).

Answer:

First, we need to calculate new variables according to the formula:

$$\rho = \sqrt{(x_2 - x)^2 + (y_2 - y)^2}$$
$$\phi = \operatorname{atan} 2(y_2 - y, x_2 - x) - \theta_2$$
$$\alpha = \operatorname{atan} 2(y_2 - y, x_2 - x) - \theta$$

We have:

$$\rho = \sqrt{(1-(-5))^2 + (1-(-3))^2} = 7.2$$
$$\phi = atan2(1+3, 1+5) - 0 = 0.588$$
$$\alpha = atan2(1+3, 1+5) - \frac{\pi}{4} = -0.1974$$

Now, by applying the formula:

$$v = (\gamma \cos \alpha)\rho; \quad \gamma > 0$$

$$\omega = \lambda \alpha + \gamma \frac{\cos \alpha \sin \alpha}{\alpha}(\alpha + h\phi)$$

we have:

$$v = 3\cos(0.2)\,7.2 = 21.17\ m/s$$

$$w = 6 \times (-0.1974) + 3\frac{cos(-0.1974)sin(-0.1974)}{(-0.1974)}(-0.1974 + 1 \times 0.588)$$

$$= -0.0428\ rad/s$$

Question 3

Using the Simulink model of the differential robot developed in Tutorial 1 (t1q2.m and diffcar.mdl) and the feedback control laws in Lecture 3, develop the following simulation programs:

a) The robot goes from an initial pose to a final pose of your choice
b) The robot follows a curve defined by function arctan(x^2)
c) Plot the planned path and the actual trajectory of the robot

Answer: See the attached MATLAB files

Question 4

Using the kinematic equations of a tricycle robot provided in lecture 2:

$$\begin{cases} \dot{x} = v_c \cos\theta \\ \dot{y} = v_c \sin\theta \\ \dot{\theta} = v_c(\tan\alpha)/d \end{cases}$$

Develop the following simulation programs:

a) A Simulink model of the robot
b) The robot follows a set of waypoints of your choice using the pure pursuit algorithm
c) Plot the waypoints and the actual trajectory of the robot

Answer: See the attached MATLAB files