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# Robot Simulation

Home assignment - 2 report in the course TME290 Autonomous Robots


Submitted by:

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Gothenburg, Sweden 2021
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Consider a differentially steered robot as shown in Figure 1.

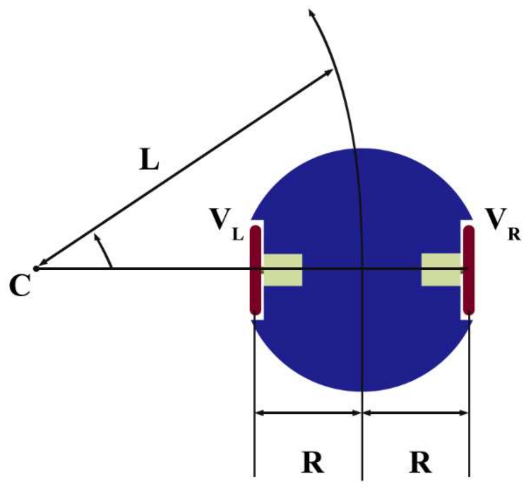


*Figure 1 Differentially steered robot*

The wheel speed varies as follows:

$$V_l(t) = V_0 \times (t/t_1) \tag{1}$$

$$V_r(t) = V_0 \times (t/t_2) \tag{2}$$

Where, $V_0$, $t_1$, $t_2$ are constants whose values are 0.5 m/s, 10s and 5s respectively. The instantaneous center of the robot is denoted by C and is at a distance of L from the center of the robot. The velocity of the wheels based on this is given by,

$$v_L = \dot{\phi}(L - R) \tag{3}$$

$$v_r = \dot{\phi}(L + R) \tag{4}$$

The speed of the robot is given by,

$$V = \dot{\phi} \times L \leftrightarrow L = \frac{V}{\dot{\phi}} \tag{5}$$

Substituting Equation 5 in Equation 3 and 4 will result in the elimination of L and we get,

$$v_L = \dot{\phi}\left(\frac{V}{\dot{\phi}} - R\right) = V - \dot{\phi} \times R \tag{6}$$

$$v_r = \dot{\phi}\left(\frac{V}{\dot{\phi}} + R\right) = V + \dot{\phi} \times R \tag{7}$$

We have two unknown variables (V and $\dot{\phi}$) and two equations (Equation 6 and 7), solving this will result in,

$$V = \frac{v_r + v_l}{2} \tag{8}$$

$$\dot{\phi} = \frac{v_r - v_l}{2 \times R} \tag{9}$$

This velocity V is the with respect to the robot. To convert it to global co-ordinate system we use the yaw angle of the robot and get the following equations,

$$cos(\phi) = \frac{V_x}{V} \leftrightarrow V_x = V \times cos(\phi) \tag{10}$$

$$sin(\phi) = \frac{V_y}{V} \leftrightarrow V_y = V \times sin(\phi) \tag{11}$$

Assuming the initial position and orientation at time $t_0$ of the robot to be ($x_0$, $y_0$, $\phi_0$), to find the position of the robot at time $t_1$, integration is carried out resulting in the following equations,

$$x_1 = x_0 + \int_{t_0}^{t_1} V_x(t)dt = x_0 + \int_{t_0}^{t_1} \frac{v_r(t) + v_l(t)}{2} \times cos\big(\phi(t)\big)dt \tag{12}$$

$$y_1 = y_0 + \int_{t_0}^{t_1} V_y(t)dt = y_0 + \int_{t_0}^{t_1} \frac{v_r(t) + v_l(t)}{2} \times sin\big(\phi(t)\big)dt \tag{13}$$

$$\phi_1 = \phi_0 + \int_{t_0}^{t_1} \dot{\phi}(t)dt = \phi_0 + \int_{t_0}^{t_1} \frac{v_r(t) - v_l(t)}{2 \times R}\, dt \tag{14}$$

For ease we use Euler integration. This is done as follows,

Given that we know the $V_l$ and $V_r$ for the time $t_1$, we calculate $V_1$ and $\phi_1$.

$$V_1 = \frac{v_r + v_l}{2} \tag{8}$$

$$\dot{\phi}_1 = \frac{v_r - v_l}{2 \times R} \tag{9}$$

This $V_1$ and $\dot{\phi}_1$ is then used to update the yaw and position by calculating the $\phi$, x and y co-ordinates as follows

$$\phi_1 = \phi_0 + \dot{\phi}_1 \times \Delta t$$

$$x_1 = x_0 + V_1 \times cos(\phi_1) \times \Delta t \tag{15}$$

$$y_1 = y_0 + V_1 \times sin(\phi_1) \times \Delta t \tag{16}$$

The differentially steered robot must explore the arena without bumping into any of the walls. This is done with the algorithm as shown in Figure 2. This can further be improved to explore the whole arena in the similar way as a lawn mower but given the time constraint for solving the assignment this has not been implemented. But the algorithm used here meets the condition stated in the problem statement and does not bump into any walls of that sort.

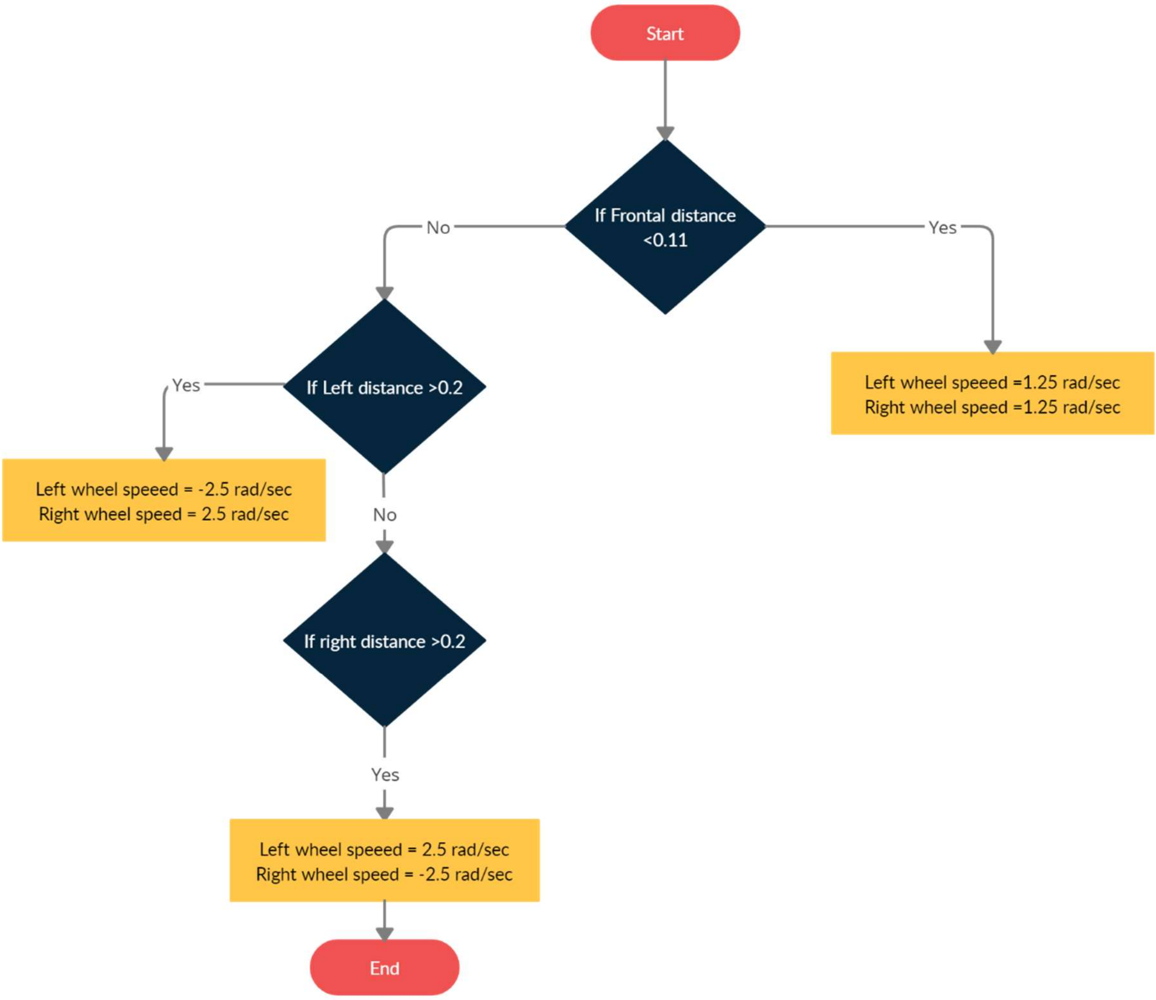


*Figure 2 Flowchart of the algorithm used for automated arena exploring.*

This is implemented in the opendlv-logic-test-kiwi-master microservice. The simulation is run for various maps such that with every trial the number of corners is increased. A total of 3 trials with 4, 5 and 7 corners were carried out and the path followed by the robot is as shown in Figure 3 Figure 4 Figure 5 respectively. Although from the figure here it appears to be colliding with the wall , zooming in closely will indicate that it is deviating and not colliding at any part.

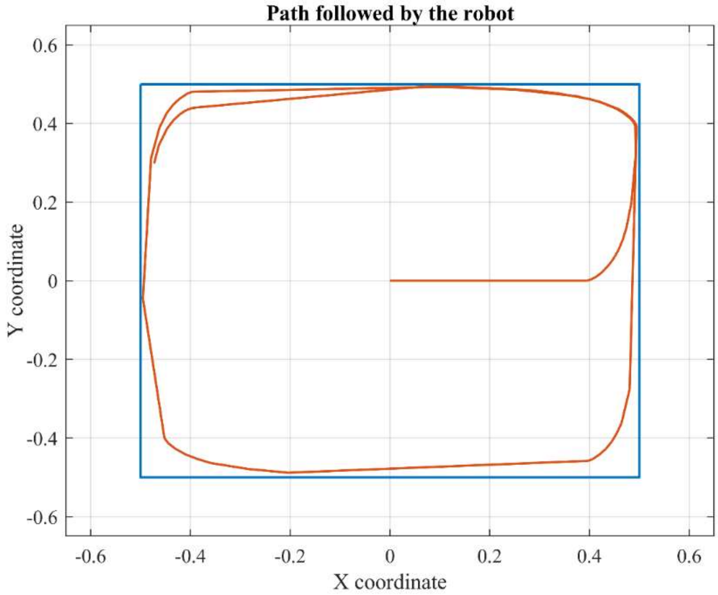


*Figure 3 Path followed by the robot in a maze with 4 corners.*

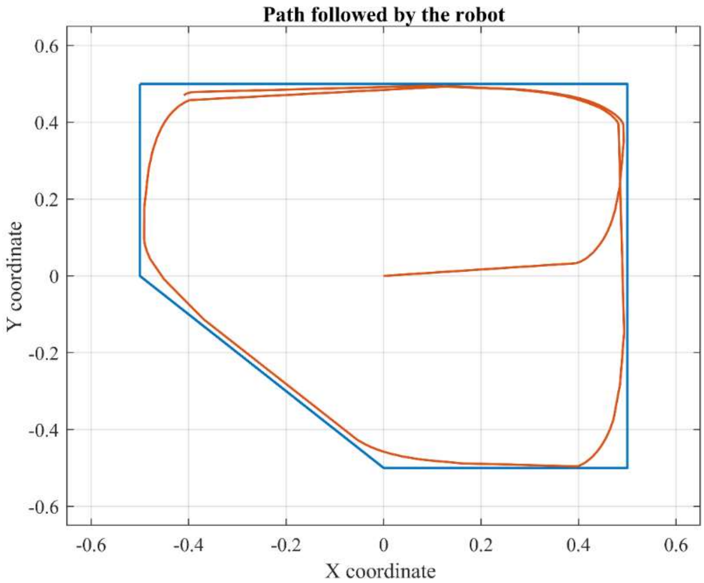


*Figure 4 Path followed by the robot in a maze with 5 corners.*

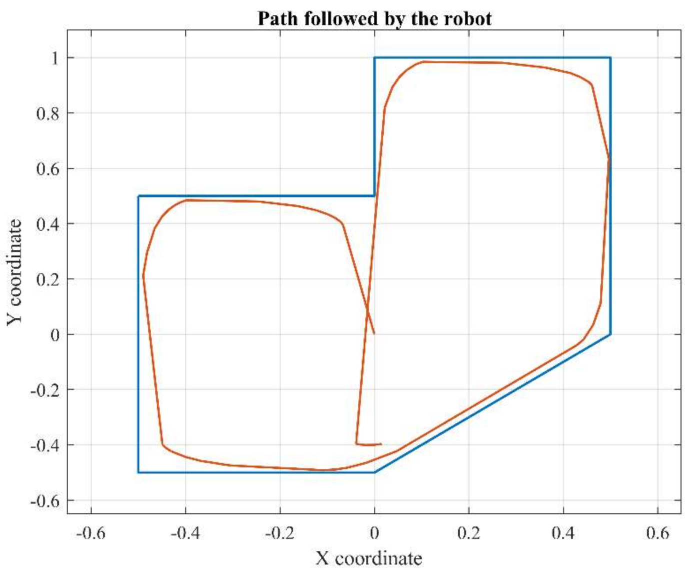


*Figure 5 Path followed by the robot in a maze with 7 corners.*