Experiment No: 5

Experiment Name: Mobile robot moving to point, following a line.

Objective:

1. To program a mobile robot to move to a point.
2. To program a mobile robot following a straight line.

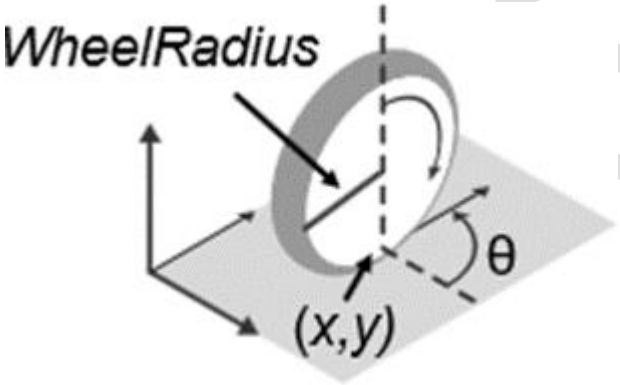
Theory:

Mobile Robots

A mobile robot is a machine controlled by software that use sensors and other technology to identify its surroundings and move around its environment. Mobile robots function using a combination of artificial intelligence (AI) and physical robotic elements, such as wheels, tracks and legs. Mobile robots are becoming increasingly popular across different business sectors. They are used to assist with work processes and even accomplish tasks that are impossible or dangerous for human workers.

Unicycle Model

A unicycle model of control a mobile robot is a simplified modelling approach modified from the differential drive mobile robots.



$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} cos\phi & 0 \\ sin\phi & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix}$$

Where v and ω are the linear and angular velocities of the robot.

Moving to a point

Consider the problem of moving toward a goal point (x∗, y∗) in the plane. The linear velocity is given by

$$v^* = K_v \sqrt{\left(x^* - x\right)^2 + \left(y^* - y\right)^2}$$

and to steer toward the goal which is at the vehicle-relative angle in the world frame with angular velocity

$$\theta^* = \tan^{-1}\frac{y^* - y}{x^* - x}$$

Following a line

A mobile robot is to follow a line on the plane defined by ax + by +c = 0. This requires two controllers to adjust the angular velocity with the linear velocity kept constant. One controller steers the robot to minimize the robot's normal distance from the line which according to the equation

$$d = \frac{(a,b,c).(x,y,1)}{\sqrt{a^2+b^2}}$$

The proportional controller

$$\alpha_d = -K_d d, \qquad K_d > 0$$

turns the robot toward the line. The second controller adjusts the heading angle, or orientation, of the vehicle to be parallel to the line

$$\theta^* = \frac{-a}{b}$$

using the proportional controller

$$\alpha_h = K_h(\theta^* - \theta), \qquad K_h > 0$$

The combined control law

$$\gamma = -K_d d + K_h(\theta^* - \theta)$$

turns the steering wheel so as to drive the robot toward the line and move along it.

Procedure:

Create model

1. Open MATLAB and Simulink.
2. Create a unicycle model as per the diagram.
3. The initial position of the robot is given in integrator as a workspace variable `x0`; which is a 1x3 vector given by [0 0 0];
4. Save the unicycle model(* Refer calculation) as a subsystem. (select all >> right click>> create subsystem.)

Moving to a point

5. Define the change in initial position if any by changing the variable `x0`
6. Define the final position xg in workspace.
7. Complete the block diagram "Moving to a point" and run the same.

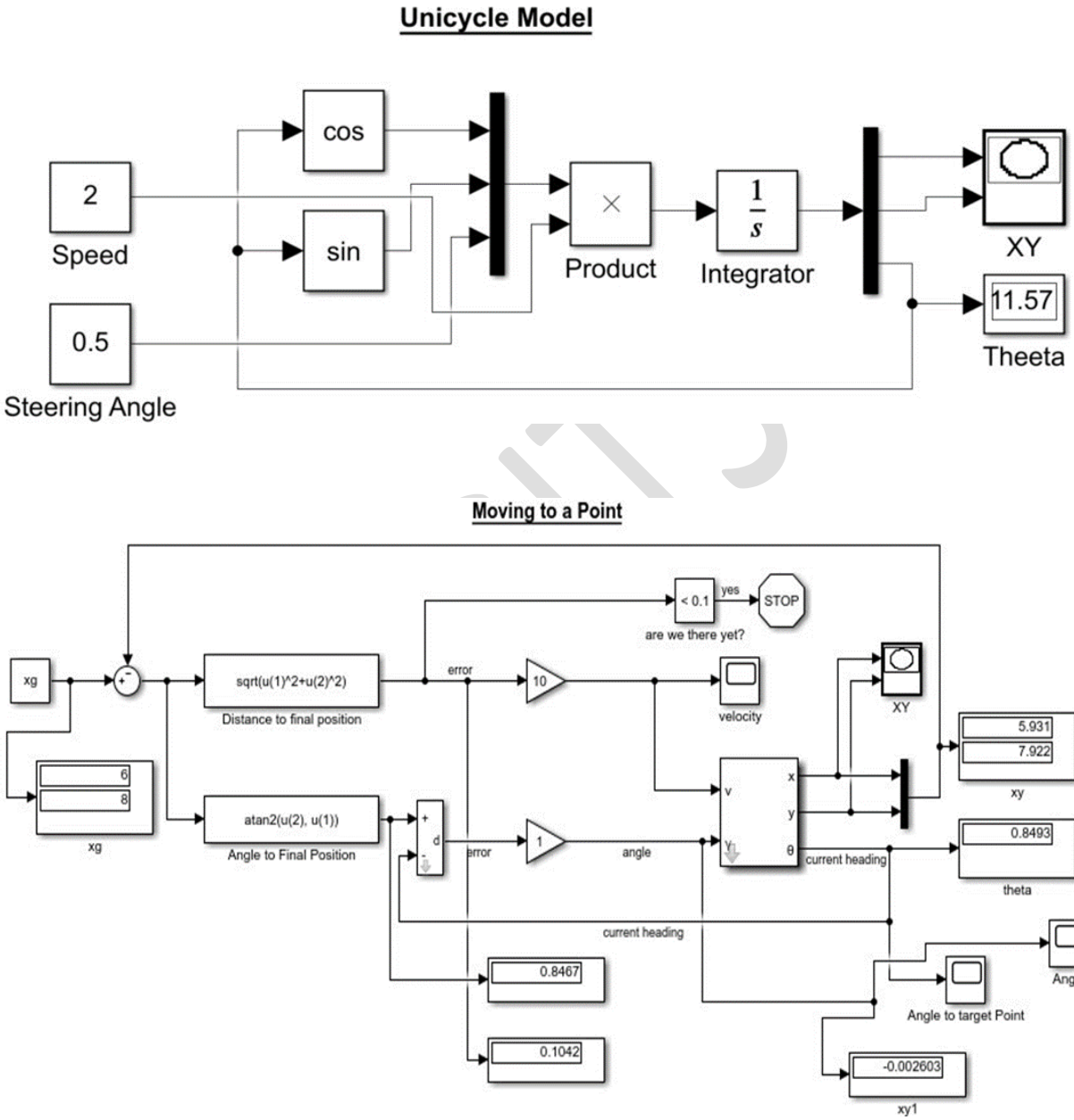
Following a line

8. Specify the target line as a 3-vector (a, b, c) as a variable `L`. For eg; if (a,b,c) are (1,-2,4) then `L = [1 -2 4]`

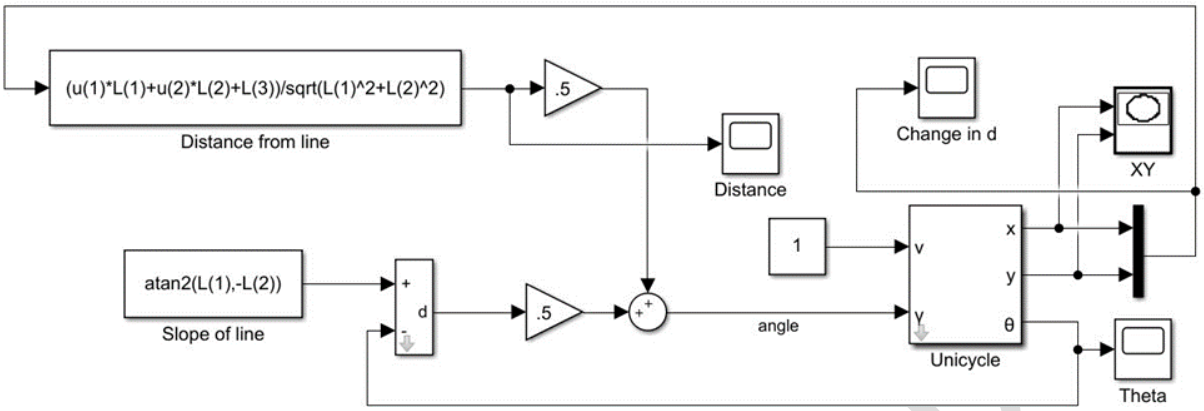
9. Define the initial pose in the integrator by equating the workspace variable, for eg: `x0 = [8 5 pi/2]`
10. Complete the block diagram for following a line in simulink and run the code.

Calculation:

Block diagram



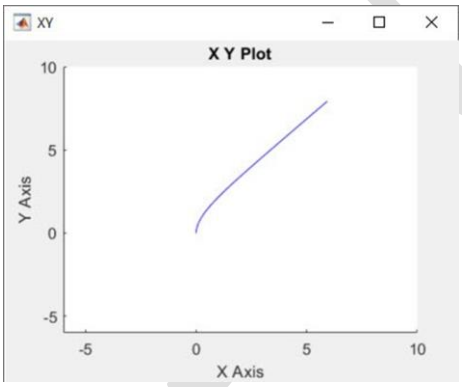
Following a Line



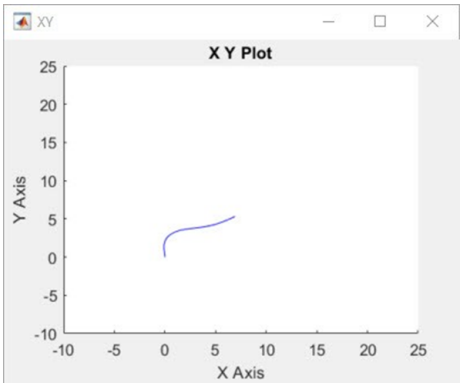
Observation:

Graph:

Sample graph



a) Moving to a point



b) Following a line

Result: