SC626-Systems and Control Laboratory

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Overview

Week 1: Robotics System Toolbox and Kinematics Model

1. The Robotics System Toolbox of MATLAB provides tools and algorithms for designing and simulations of Mobile Robots.
2. Following algorithms are available,
   - Mapping
   - Path planning
   - Path following and Motion Control
3. They are available as MATLAB Objects and Simulink Blocks.

Kinematics Model

Dynamics is the study of motion in which force acting on a system are modelled.

Kinematics is the study of mathematics of the motion of the robot and is based on the geometric relationship of the system.

1. Unicycle Kinematics Model
2. Differential Drive Kinematics Model
3. Bicycle Kinematics Model
4. Ackerman Kinematics Model

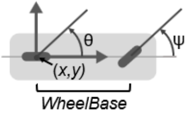


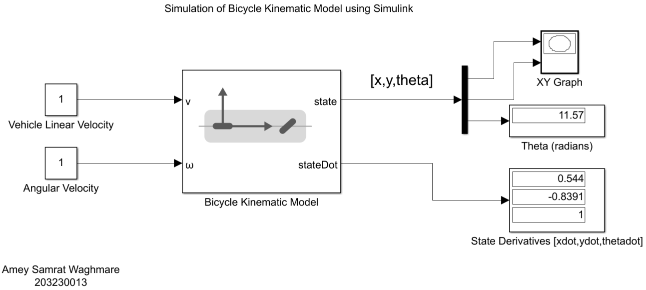
Figure: Bicycle Kinematics Model

1. Equations of Bicycle Kinematics Model

$$\dot{x} = v\ cos(\theta)$$
$$\dot{y} = v\ sin(\theta)$$
$$\dot{\theta} = \omega = \frac{v}{L} tan(\psi)$$

2. Inputs to this Model are,
   - Linear Speed v
   - Angular Speed ω
3. Outputs of the model,
   - States of the system x, y, θ
   - Derivatives of the state

Week 2: Simulation of Bicycle Kinematics Model



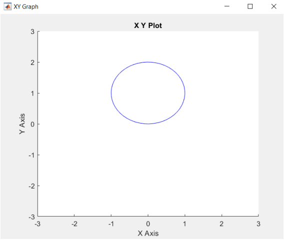


Figure: Circular Path Traversed by robot

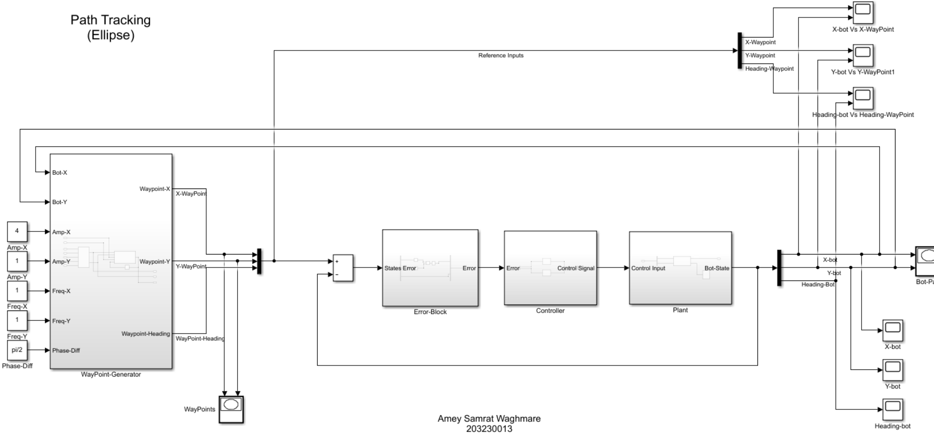


Figure: Path Tracking

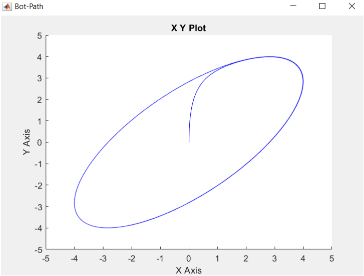


Figure: Skewed Elliptical Path

Comparison for Skewed Elliptical Path		
-	$P(P_1,P_2) = (10,1.5)$	$PI\ (P_1,I_1) = (10,1),\ (P_2,I_2) = (5,4)$
MSE_X	0.1918	0.1959
MSE_Y	0.7887	0.6471
MSE_θ	0.2342	0.1494

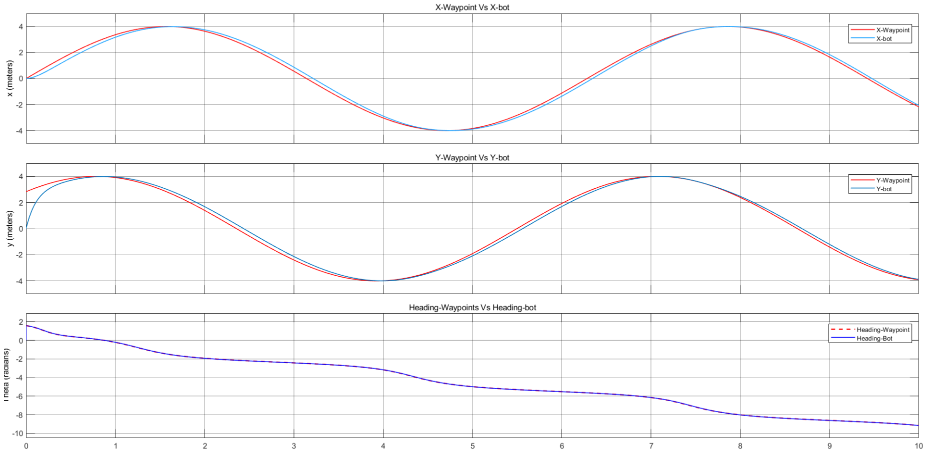


Figure: Skewed Elliptical Path Trajectory

Week 5: Reference Vehicle Tracking

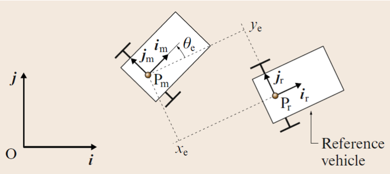


Figure: Reference Robot and Controlled Robot

Kinematics of Controlled Vehicle,

$$\dot{x} = u_1 cos(\theta)$$
$$\dot{y} = u_1 sin(\theta)$$
$$\dot{\theta} = \frac{u_1}{L} tan(\phi)$$
$$\dot{\phi} = u_2$$

Kinematics of Reference Vehicle,

$$\dot{x}_r = u_{1r} cos(\theta_r)$$
$$\dot{y}_r = u_{1r} sin(\theta_r)$$
$$\dot{\theta}_r = \frac{u_{1r}}{L} tan(\phi_r)$$
$$\dot{\phi}_r = u_{2r}$$

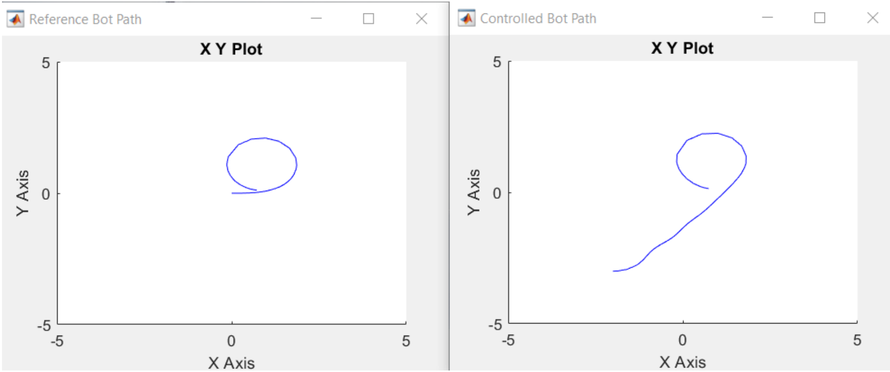


Figure: Vehicle Tracking for circular path

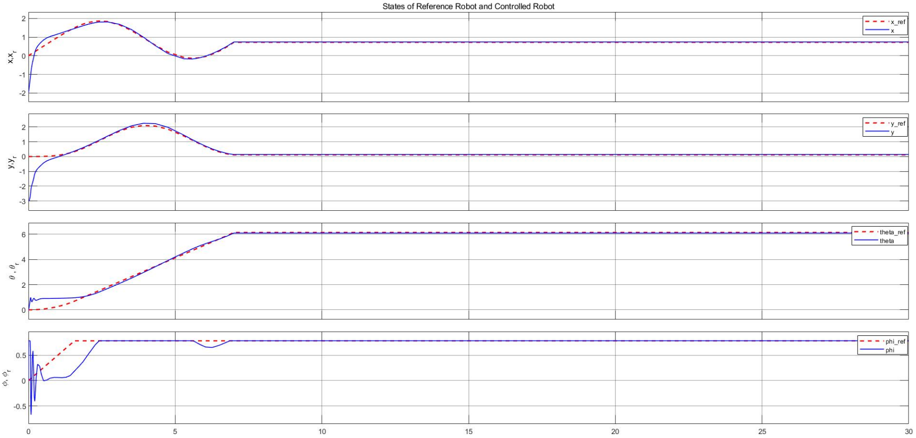


Figure: States of Reference vehicle and Controlled Vehicle for Circular path

Error

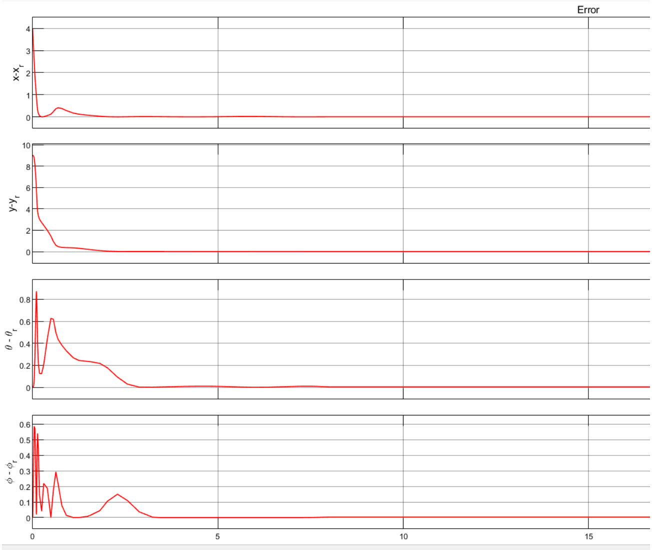


Figure: Error

-	$k_1 = 5, k_2 = 5, k_3 = 15, k_4 = 9$	$k_1 = 5, k_2 = 2, k_3 = 10, k_4 = 5$
MSE_X	0.7100	0.6929
MSE_Y	1.2503	1.2627
MSE_θ	0.3936	0.3276
MSE_ϕ	0.3044	0.2643

Performance Index for Nonlinear Controller

-	PI $(P_1, I_1) = (4, 0.5), (P_2, I_2) = (2, 1)$	K = (5,2,10,5)
MSE_X	0.7338	0.6929
MSE_Y	1.6879	1.2627
MSE_θ	0.2075	0.3276

Comparison of PI Controller with Nonlinear Controller

References

1. Robotics System Toolbox, MATLAB User manual.
2. Mobile Robot Kinematics
3. Advanced Robotics 2: Forward Kinematics of Car-Like Mechanisms
4. Springer Handbook of Robotics
5. SC626-Lab Report 203230013

Thank You