AA 274A: Principles of Robot Autonomy I
Problem Set X

Name: Li Quan Khoo (SCPD)
SUID: lqkhoo

Problem 1: Trajectory Generation via Differential Flatness

(i) We are given initial and final conditions in terms of variables $\{x, y, V, \theta\}$. The equations are:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & t_f & t_f^2 & t_f^3 \\ 0 & 1 & 2t_f & 3t_f^2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} x(0) \\ \dot{x}(0) \\ x(t_f) \\ \dot{x}(t_f) \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & t_f & t_f^2 & t_f^3 \\ 0 & 1 & 2t_f & 3t_f^2 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} y(0) \\ \dot{y}(0) \\ y(t_f) \\ \dot{y}(t_f) \end{bmatrix}$$

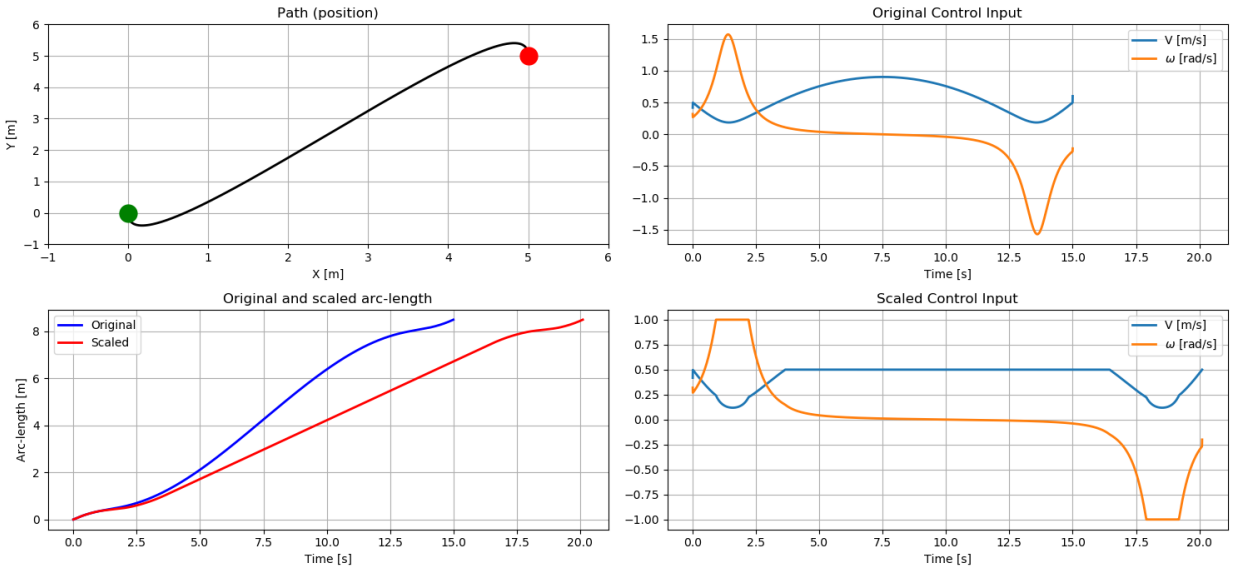
where $\dot{x}(t) = V\cos\theta$ and $\dot{y}(t) = V\sin\theta$ as given by the robot's kinematic model.

(ii) Since $\det(J) = V$, $V > 0\ \forall t$ is a sufficient and necessary condition for the matrix J to be invertible.

(iii) (code)

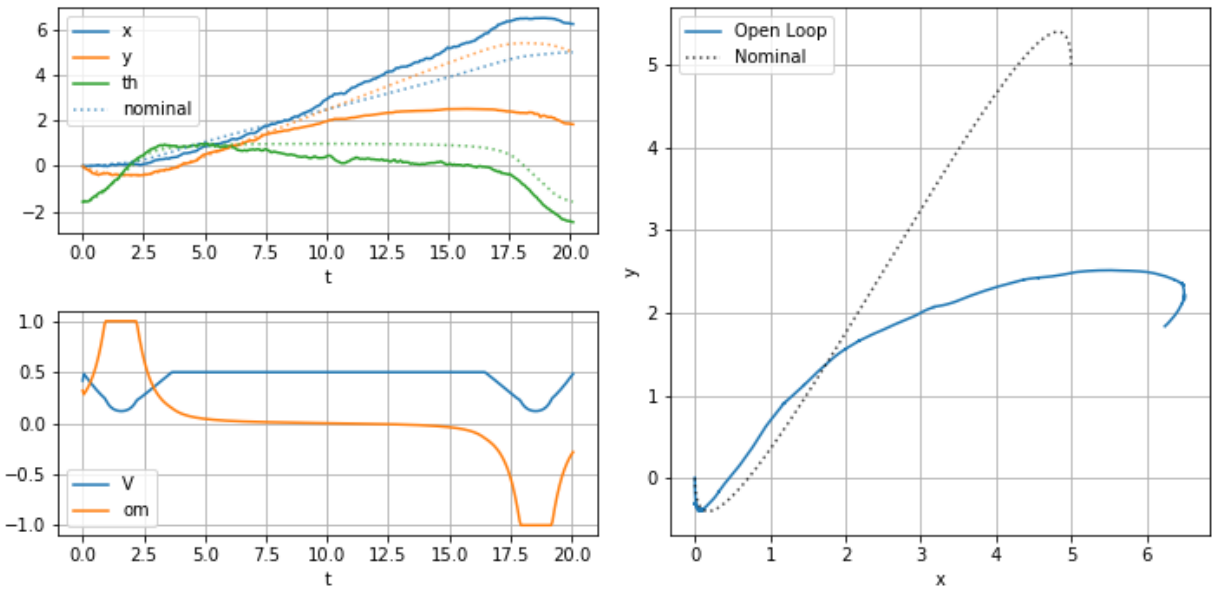
(iv) (code)

(v)



Trajectory of unicycle model in absence of noise. Initial and final conditions as given.

(vi)



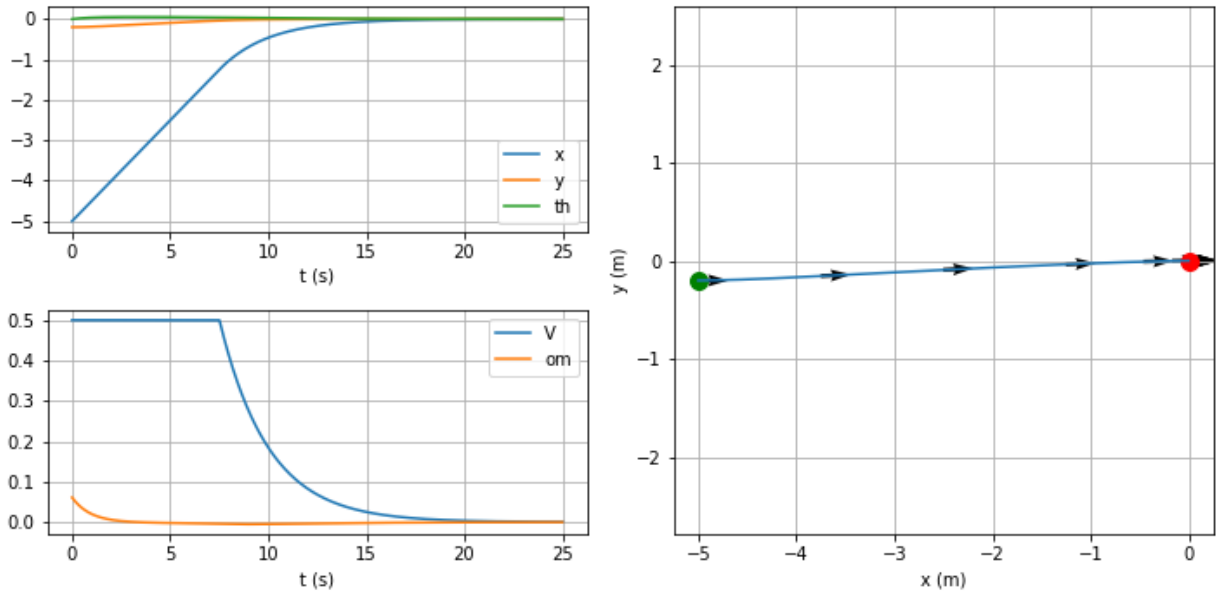
Trajectory of unicycle model where control vector $u_{\text{noisy}} = u + \epsilon$ where ϵ is simulated isotropic Gaussian noise.

Problem 2: Pose Stabilization

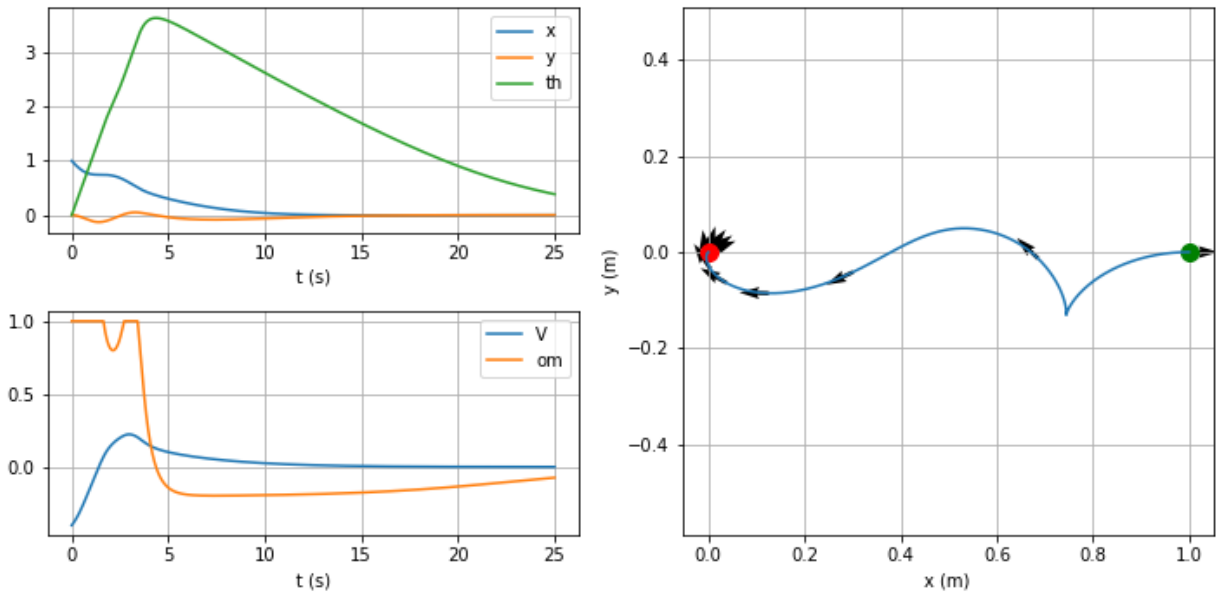
(i) (code)

(ii) (code)

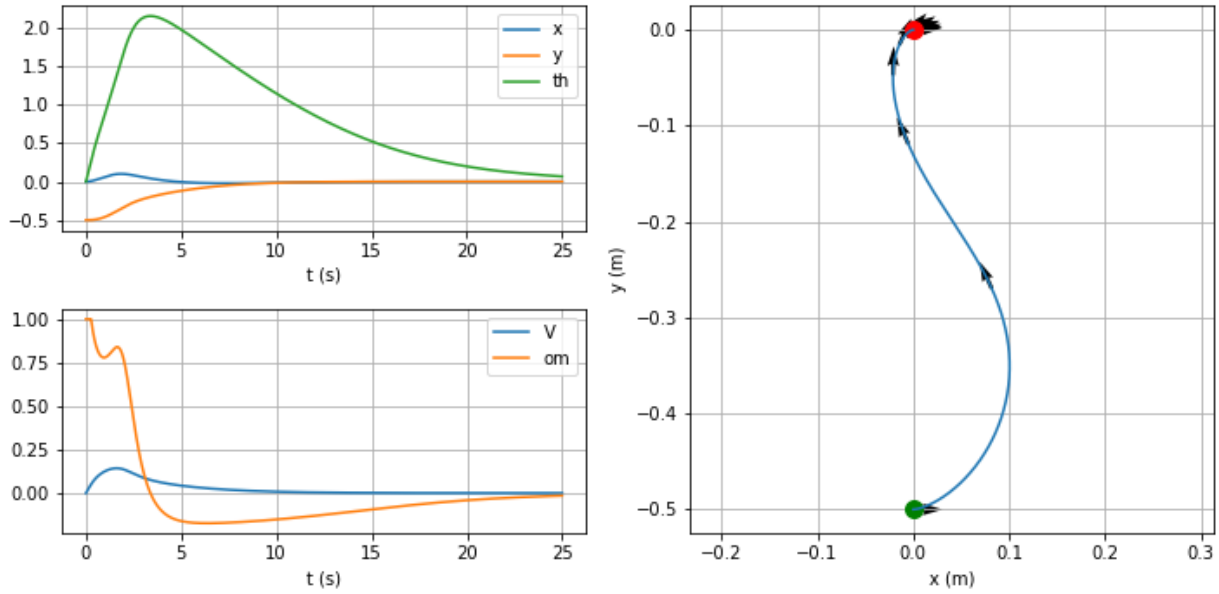
(iii)



Forward parking



Reverse parking



Parallel parking

Problem 3: Trajectory Tracking

Extra Problem: Optimal Control and Trajectory Optimization