

CSCI 545 – Summer 2009

Homework 3

Due Date: 07/21/09 4:00 PM

Please submit the hard copy of your answers at the class or at the professor's office hours. Note that questions are chosen from the book.

3-13 Solve the inverse position kinematic for the cylindrical manipulator of figure 3.34.

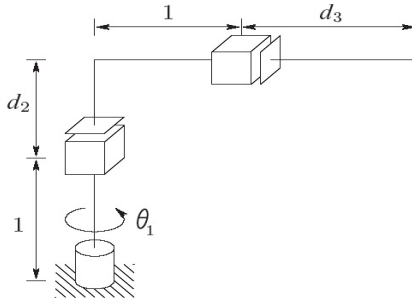


Figure 3.34: Cylindrical configuration.

3-15 Add a spherical wrist to the three-link cylindrical arm of problem 3-13 and write the complete inverse kinematic solution.

3-21 Modify the solution Θ_1 and Θ_2 for the spherical manipulator given by Equation (3.47) and (3.49) for the case of shoulder offset.

4-6 Suppose that $a = [1, -1, 2]^T$ and that $R = R_{x,90}$. Show by direct calculation that $RS(a)R^T = S(Ra)$

4-10 Given any square matrix A , the exponential of A is matrix defined as

$$e^A = I + A + (1/2)A^2 + (1/3)A^3 + \dots$$

Given $S \in so(3)$ show that $e^S \in SO(3)$.

Use the facts that $e^A e^B = e^{A+B}$ provided that A and B commute, that is, $AB=BA$, and the fact that $\det(e^A) = e^{Tr(A)}$.

4-13 Given Euler angle transformation

$$R = R_{z,\psi} R_{y,\theta} R_{x,\phi}$$

Show that $\frac{d}{dt}R = S(w)R$ where

$$w = \{c_\psi s_\theta \dot{\phi} - s_\psi \dot{\theta}\}i + \{s_\psi s_\theta \dot{\phi} + c_\psi \dot{\theta}\}j + \{\dot{\psi} + c_\theta \dot{\theta}\}k$$

The components of i, j, k , respectively, are called the **nutaton**, **spin**, and **precession**.

4-15 Two frames $o_0x_0y_0z_0$ and $o_1x_1y_1z_1$ are related by the homogeneous transformation

$$H = \begin{bmatrix} 0 & -1 & 0 & 1 \\ 1 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

A particle has velocity $v_1=[3,1,0]^T$ relative to frame $o_1x_1y_1z_1$. What is the velocity of the particle in frame $o_0x_0y_0z_0$?

4-17 compute jacobian J_{11} for the 3-link elbow manipulator of example 4.9 and show that it agrees with Equation (4.98). show that the determinant of this matrix agrees with equation(4.99).