University of British Columbia
Department of Electrical & Computer Engineering
EECE 487 (Winter 2012-2013): Introduction to Robotics
Assignment #2, due Thursday Feb 7th

Exercise # 1:
A rigid motion $\underset{\sim}{y} = \underset{\sim}{o} + \underline{d} + \underline{\underline{Q}}(\underset{\sim}{x} - \underset{\sim}{o})$ mapping a point $\underset{\sim}{x}$ to another point $\underset{\sim}{y}$ changes the point coordinates(with respect to $\{\underset{\sim}{o}, \underline{C}\}$) from x to y according to

$$\begin{bmatrix} y \\ 1 \end{bmatrix} = \begin{bmatrix} Q & d \\ 0^T & 1 \end{bmatrix} \begin{bmatrix} x \\ 1 \end{bmatrix}$$

What is the inverse of this transformation? Does this inverse always exist? Explain.

Exercise # 2:
What is the acceleration of a point with coordinates $y(t) = d(t) + Q(t)x(t)$, where $Q(t)$ is a rotation matrix?

Exercise # 3:

The Puma 560 shown in Figure 1 has a reach of approximately 0.92m, and a payload capacity of 2.3kg. This makes it ideal for medium-to-lightweight assembly, welding, materials handling, packaging and inspection applications.

Figure 1: Photo of a 500 series Puma robot.

Using the schematic of Figure 2, do the following:

DH Parameter	θ_i (deg)	d_i (mm)	a_i (mm)	α_i (deg)
Link 1				
Link 2				
Link 3				
Link 4				
Link 5				
Link 6				

Table 1: DH Parameters for the Puma 560

(a) Directly on the schematic, assign coordinate frames by means of the Denavit-Hartenberg convention. Assume $\underline{C}_0$ and $\underline{C}_6$ are as illustrated in the "home" position. Fill in Table 1 the values of the DH-parameters. For each joint, consider the positive rotation to be in the *right-handed sense* (NB: These are different from what is in the notes).

(b) Compose a chain of transformations that will give you the relationship between the base frame, $\{\underset{\sim}{o}_0, \underline{C}_0\}$, and the end-effector frame $\{\underset{\sim}{o}_6, \underline{C}_6\}$ (use notation from Salcudean notes as was done for example 2.5 on p 31).

(c) Write a Matlab m-file which prompts the user for the sequence of 6 joint angles in degrees (for example, the user might type "45,-45,45,0,-30,90"), then *outputs the resulting homogeneous transformation matrix* relating the base and end effector frames. As well, graphically plot the location of each link origin (e.g., using Matlab's "plot3" function, indicate each origin with an "*") for the given joint angles.

(d) Use your code to compute base-to-gripper transformations and display your results and the locations of the link origins for the following sets of joint configurations: $\underline{q} = [0° \ 0° \ 0° \ 0° \ 0° \ 0°]^T$, $\underline{q} = [0° \ 0° \ -90° \ 0° \ 0° \ 180°]^T$, $\underline{q} = [45° \ -45° \ 45° \ 0° \ -30° \ 90°]^T$, $\underline{q} = [15° \ 30° \ -30° \ -30° \ 15° \ -15°]^T$

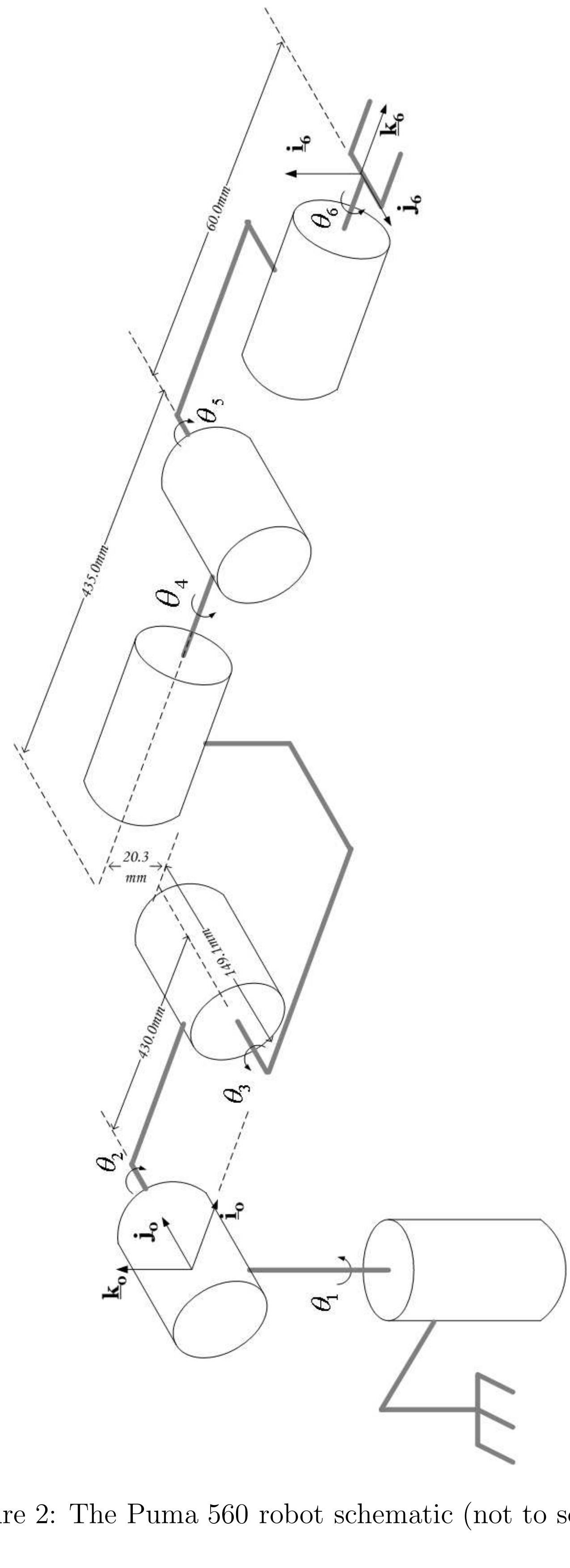

Figure 2: The Puma 560 robot schematic (not to scale).