MTRN4230 Robotics ASSIGNMENT 3

AIMS

1. Kinematics
2. DH parameters
3. Jacobians

DUE DATE

Assessment criteria	*Due date and submission requirements*	*Deadline for absolute fail*	*Marks returned*
Upload completed assignment + code	*Week 8: 11:59pm, Friday via Teams*	*Week9:11:59pm, Wed.*	*1 week after submission*

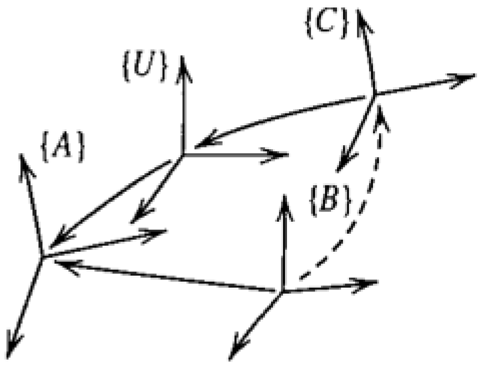
ACTIVITIES

1. Answer to the questions below

a. A vector ${}^{A}p$ is rotated about Z_A axis by θ degrees and then rotated about X_A asis by ϕ degrees. Give the rotation matrix considering the orders given. (0.5)

b. Frame {B} initially coincident with frame {A}. Now rotate {B} about Z_B axis by θ degrees and rotate the resulting frame about $X_B\ axis\ by\ \phi$ degrees. Find rotation matrix for vectors ${}^{B}p\ to\ {}^{A}p$. (0.5)

c. Given below frames



Calculate ${}^{B}_{C}T$ when ${}^{U}_{A}T$, ${}^{B}_{A}T$ and ${}^{C}_{U}T$ are given. (1)

d. Proof that inverse of a rotation matrix must be equal to its transpose and rotation matrix is orthonormal. Show it with the help of two vectors embedded in a rigid body so no matter how the body rotates, the geometric angel between them (two vectors) preserve. (1)

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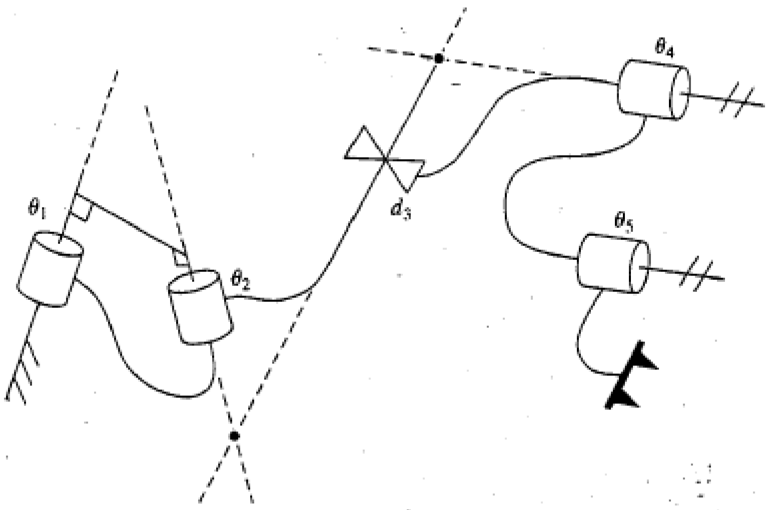
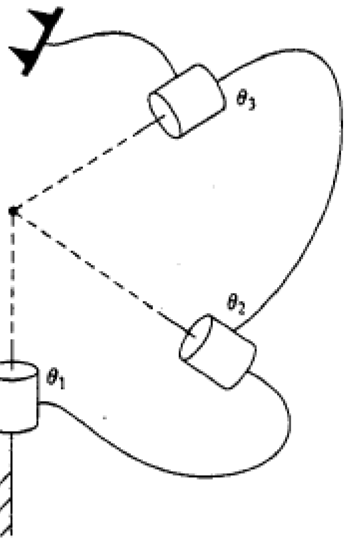
e. Show the link frames for the below manipulators schematically (0.5 + 0.5)





f. A 2DOF positioning table is used to help welding (two rotary joints θ_1, θ_2). The forward kinematics from based (link 1) to the bed of the table (link 2) is

$$
{}^0_2T = \begin{bmatrix} c_1c_2 & -c_1s_2 & s_1 & l_2s_1 + l_1 \\ s_2 & c_2 & 0 & 0 \\ -s_1c_2 & s_1s_2 & c_1 & l_2c_1 + h_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

Unit vector fixed in frame of link 2 is ${}^2V$ $. Find\ inverse - kinematic\ solution\ for$ θ_1, θ_2) when this unit vector is aligned with ${}^0Z\ axis.$ Are there multiple solutions and is there a singular condition? (2)

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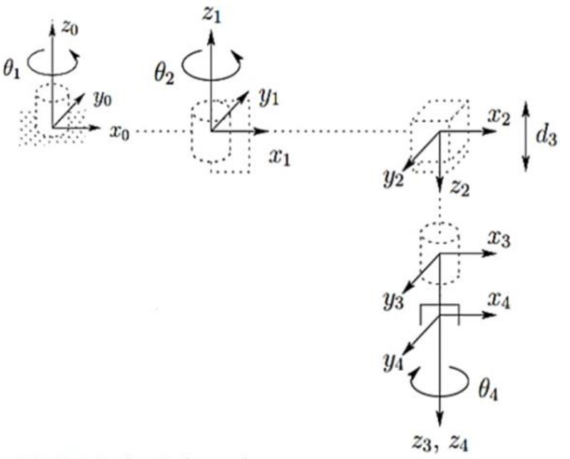
2. A manipulator shown below that is known as SCARA when d4= 0.1, a1 = 0.4 and a2 = 0.3



SCARA Robot Schematic

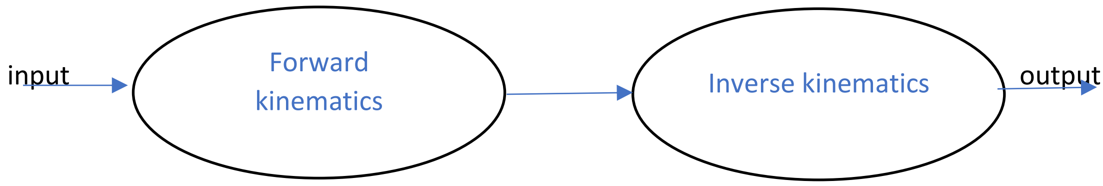
DESCRIPTION:

- **derivations, the steps need to be elaborated with details in your report and please comment the steps. <u>Without a full derivation your MATLAB code won't be evaluated</u>**
- **simulation in MATLAB / SIMULINK**

NOTE: Please DO NOT use any pre-written MATLAB code or toolbox e.g. Peter Corke Robotics Toolbox. Code should be completely written by you.

DELIVERABLES (a, b, c, d, e, f):

a. *Use DH convention find the forward kinematics (MATLAB)*
   - Forward kinematics should be parametric (use syms in MATLAB) *(0.5)[derivation] (1)[MATLAB code]*
   - Small decimal should be considered zero with the below condition |number|<0.0001 is considered zero in calculation of H matrix. (0.5) [MATLAB code]
b. *Find inverse kinematics (1) [derivation] (1) [MATLAB code]*
c. *Create kinematics verification mechanism as below and show the error as defined below in SIMULINK (use the trajectory provided) (2) [Simulink file and error plots]*



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- error = output – input Note: *Use SIMULINK file given that can generate trajectory*

d. *Plot workspace when* $-180^o \le \theta_{1,}\theta_2 \le 180^o$ and $0 \le d_3 \le 0.1$ *in MATLAB(1) [code and plot]*

e. *Calculate Jacobian and provide a function in MATLAB to calculate it (1) [derivation], (1) [code]*

MARKING CRITERIA

Overall mark for this item is 15%. It has been distributed as shown in yellow.

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