CSE461: INTRODUCTION TO ROBOTICS

MIDTERM

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SECTION: 09

(1) (a) Camera is used for capturing images.
Lidar is used for 3D mapping of the ocean floors.
Sysnoscope is used to measure depth and acceleration.
Infra-red is used for detecting hydrothermal vents on shipwrecks.

(b) DC motor can be used as an electrical actuators. to allow the robot to control speed.
Servo motor can be used to change angle of rotation of the robot and collect data. The robot will be able to have precise speed position. Also, can be high torque.

(c) Microcontroller can be used as the processing device as it can interact with the environment through sensors and actuators. The sensor can send info to the microcontroller; the microcontroller perceive the info and allow actuator to take necessary action.

(c) Sense: Robot has the ability to sense the environment by stimulus such as light, heat, etc. with the help of sensors.

Think: The sensed information is analyzed to produce an optimal plan with the help of controllers.

Act: The optimal plan is executed as a movement by the robot by manipulator, actuator or end-effector.

AI: All the possible outcomes produced by the robot can be learned by the robot with the help of AI.

(d) ~~Hybrid paradigm should be used to develop the robot.~~ Deliberative paradigm allows

(d) Reactive paradigm should be used to develop the robot so that the robot can receive info from the oceanic environment in real time and produce actions according to the sensed information.

(3) (a)

Joint	α_i	a_i	d_i	θ_i
1	-90°	0	0	58.77°
2	0	48	0	25.41°
3	0	23	0	70.5°

D-H parameters

$$T_{i-1}^{i} = \begin{bmatrix} C\theta_i & -C\alpha_i S\theta_i & S\alpha_i S\theta_i & a_i C\theta_i \\ S\theta_i & C\alpha_i C\theta_i & -S\alpha_i C\theta_i & a_i S\theta_i \\ 0 & C\alpha_i & S\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_0^1 = \begin{bmatrix} 0.5186 & 0 & -0.8551 & 0 \\ 0.8551 & 0 & 0.5186 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_1^2 = \begin{bmatrix} 0.9033 & -0.4291 & 0 & 43.36 \\ 0.4291 & 0.9033 & 0 & 20.60 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_{2^2}^3 = \begin{bmatrix} 0.3338 & -0.9426 & 0 & 7.6776 \\ 0.9426 & 0.3338 & 0 & 21.68 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_3^0 = (T_0^1)(T_2^2)(T_2^3)$$

$$= \begin{bmatrix} 0.5185 & 0 & -0.8551 & 0 \\ 0.8551 & 0 & 0.5185 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$\begin{bmatrix} 0.9033 & -0.4291 & 0 & 43.36 \\ 0.4291 & 0.9033 & 0 & 20.60 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$\begin{bmatrix} 0.3338 & -0.9426 & 0 & 7.6776 \\ 0.9426 & 0.3338 & 0 & 21.68 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

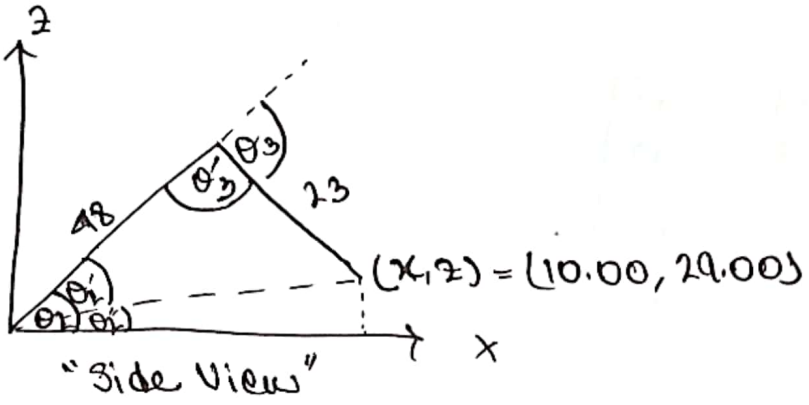
$$T_3^0 = \begin{bmatrix} -0.8594 & -0.801 & 0 & 2.7159 \\ 0.4007 & -0.677 & 0 & 46.293 \\ -0.942 & -0.333 & 0 & -21.68 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Finact
end point $= (T^0_3) \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$

$$= \begin{bmatrix} 2.7159 \\ 46.293 \\ -21.68 \\ 1 \end{bmatrix}$$

$$\boxed{(X, Y, Z) = (2.7159, 46.293, -21.68)}$$

(b)



$$\theta_1'' = \tan^{-1}\left(\frac{29}{10}\right) \Rightarrow \theta_1'' = 70.97^\circ$$

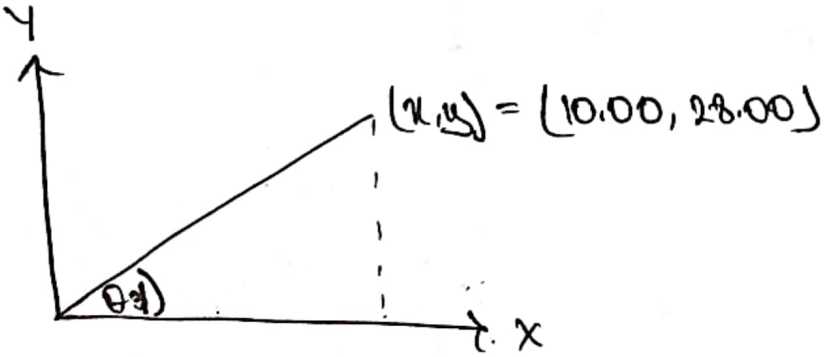
$$\theta_1' = \cos^{-1}\left(\frac{48^2 + \left(\sqrt{(10)^2 + (29)^2}\right)^2 - 23^2}{2(48)\left(\sqrt{(10)^2 + (29)^2}\right)}\right) \Rightarrow \theta_1' = 22.74^\circ$$

$$\theta_1 = \theta_1' + \theta_1'' \Rightarrow \theta_1 = 22.74^\circ + 70.97^\circ \Rightarrow \boxed{\theta_1 = 93.71^\circ}$$

$$\theta_3' = \cos^{-1}\left(\frac{48^2 + 23^2 - \left(\sqrt{(10)^2 + (29)^2}\right)^2}{2(48)(23)}\right) \Rightarrow \boxed{\theta_3' = 31.03^\circ}$$

$$\theta_3 = 180^\circ - 31.03^\circ$$

$$\boxed{\theta_3 = 148.97^\circ}$$



$$\theta_2 = \tan^{-1}\left(\frac{28}{10}\right) \Rightarrow \boxed{\theta_2 = 70.35^\circ}$$