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ME - 639 Assignment 1

Task - 2

1. Manipulator - https://www.youtube.com/watch?v=sAOfJgvAiD0

This is an example of a Fanuc robot used in moving heavy structures.

2. Aerial - https://www.youtube.com/watch?v=zDq4kjY19UU

This is an aerial robot made in the shape of a bat allowing aerial maneuvers of nature to be performed easily.

3. Mobile - https://www.youtube.com/watch?v=M0fL5Q6rGws

SEIT robot is a mobile robot that transports material safely and efficiently.

4. Underwater - https://www.youtube.com/watch?v=4WOOwesIkss

This video contains four types of underwater robots Aquanaut, Eelume, Festo, and Subsea 7 AIV. All four of the robots help perform underwater exploration or repair work.

5. Soft - https://www.youtube.com/watch?v=A7AFsk40NGE

This video contains different types of soft robots that can perform tasks that are hard to perform with rigid mechanical arms.

6. Micro - https://www.youtube.com/watch?v=k8IsYb31He8

7. Exoskeleton - https://www.youtube.com/watch?v=Z_pdZ1LW5iw

This video shows an exoskeleton robot that helps in lifting heavy objects with ease for a more extended period.

Task - 3

Motors are mainly categorized by the voltage supply source which are AC and DC motors. The AC motors include asynchronous and synchronous motors whereas DC motors include brushed and brushless motors. Servo motors are also a type of motor.

AC motors convert AC electrical energy into mechanical energy. These motors are usually powered by single-phase or three-phase alternating current.

1. Synchronous motors are AC motors with a constant speed known as synchronous speed, which is determined only by the frequency of the supply current. The speed of such electric motors changes solely with the supply frequency and remains constant with variable loads.
2. Asynchronous motors refer to an AC motor that never works at synchronous speed. Its rotor speed is never greater than its synchronous speed. It does not require any additional rotor excitation.

DC motors are run through the direct current. Direct current doesn't have any phase so the DC motor only has 2 wires.

1. Brushed DC motor uses brushes and commutators. They are used to connect a stationary circuit with a revolving circuit.
2. A Brushless DC motor, as the name suggests does not have any conductive brushes or commutators. There are no electrical or electromagnetic sounds or sparks created in mechanical commutation since there are no brushes. It contributes to an increase in the motor's life span and efficiency.

Servo motors are specialized motors used to push/pull, lift, or rotate an item at a specified angle. Servo motors can be built to operate on both AC and DC power supplies. It's a basic motor with a controller and several gears to boost torque. Three wires are connected to servo motors. Two provide electricity, while the third control the servo's position. PWM (pulse width modulation) regulates it by sending a pulsing signal through a microcontroller.

Task -6) To show that the columns of R_0' matrix are orthogonal to each other.

We know that,

$$R_0' = \begin{bmatrix} \hat{i}_1 \hat{i}_0 & \hat{j}_1 \hat{i}_0 & \hat{k}_1 \hat{i}_0 \\ \hat{i}_1 \hat{j}_0 & \hat{j}_1 \hat{j}_0 & \hat{k}_1 \hat{j}_0 \\ \hat{i}_1 \hat{k}_0 & \hat{j}_1 \hat{k}_0 & \hat{k}_1 \hat{k}_0 \end{bmatrix}$$

$\therefore$ The ~~columns of~~ columns of R_0' can be represented as

$$c_1 = \begin{bmatrix} \hat{i}_1 \hat{i}_0 \\ \hat{i}_1 \hat{j}_0 \\ \hat{i}_1 \hat{k}_0 \end{bmatrix}, \quad c_2 = \begin{bmatrix} \hat{j}_1 \hat{i}_0 \\ \hat{j}_1 \hat{j}_0 \\ \hat{j}_1 \hat{k}_0 \end{bmatrix}, \quad c_3 = \begin{bmatrix} \hat{k}_1 \hat{i}_0 \\ \hat{k}_1 \hat{j}_0 \\ \hat{k}_1 \hat{k}_0 \end{bmatrix}$$

Now, let the three columns c_1, c_2 and c_3 be individual vector components represented in three perpendicular directions.

$\therefore$ Taking dot product of c_1, c_2, we get

$$c_1 \cdot c_2 = (\hat{i}_1 \hat{i}_0)(\hat{j}_1 \hat{i}_0) + (\hat{i}_1 \hat{j}_0)(\hat{j}_1 \hat{j}_0) + (\hat{i}_1 \hat{k}_0)(\hat{j}_1 \hat{k}_0)$$

Here $\hat{i}_1 \cdot \hat{j}_1 = 0 \Rightarrow \boxed{c_1 \cdot c_2 = 0}$

$\therefore$ c_1 and c_2 are orthogonal to each other.

Now, for c_2, and c_3 we have

$$c_2 \cdot c_3 = (\hat{j}_1 \hat{i}_0)(\hat{k}_1 \hat{i}_0) + (\hat{j}_1 \hat{j}_0)(\hat{k}_1 \hat{j}_0) + (\hat{j}_1 \hat{k}_0)(\hat{k}_1 \hat{k}_0)$$

Here, $\hat{j}_1 \cdot \hat{k} = 0 \Rightarrow \boxed{c_2 \cdot c_3 = 0}$

$\therefore$ c_2 and c_3 are orthogonal to each other.

Also for c_1 and c_3 we have,

$$c_1 \cdot c_3 = (\hat{i}, \hat{i}_0)(\hat{k}, \hat{i}_0) + (\hat{i}, \hat{j}_0)(\hat{k}, \hat{j}_0) + (\hat{i}, \hat{k}_0)(\hat{k}, \hat{k}_0)$$

Here, $\hat{i}, \hat{k}, = 0 \Rightarrow \boxed{c_1 \cdot c_3 = 0}$

$\therefore$ c_1 and c_3 are also orthogonal to each other.

$\therefore$ The columns of the R_0' matrix are orthogonal to each other.

Hence proved.

Task - 7) From the Task-6, we know that R_0' is an orthogonal matrix.

$$\Rightarrow R_0' \cdot (R_0')^T = I \quad \text{— (1)}$$

Also, we know that,

$$R_0' \cdot (R_0')^{-1} = I \quad \text{— (2)}$$

From (1) and (2), we get

$$(R_0')^T = (R_0')^{-1} \quad \text{— (3)}$$

Now, $(R_0')^{-1} = \dfrac{1}{\det(R_0')} \cdot (R_0')^T$

So from (3), we get

$$(R_0')^T = \frac{(R_0')^T}{\det(R_0')}$$

$$\Rightarrow \boxed{\det(R_0') = 1}$$