ME 639: Assignment 1

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Q2:

1. Robotic Manipulators: https://www.youtube.com/watch?v=SisrRUX_Zfk
   This robot has 6 degrees of freedom provided by three prismatic and three rotary joints. It can be used to produce precise and complex motions in various applications across industries.
2. Mobile Robots: https://www.youtube.com/watch?v=NnXYX3Y2KIk
   Dingo is a lightweight, compact indoor mobile robot designed for robotics research and education. Dingo is ideal for a wide range of robotic applications, including autonomous navigation, mobile manipulation and mapping.
3. Aerial Robots: https://www.youtube.com/watch?v=zMi5v2KznU4
   This robot can change its shape in the air by using the multi-motor system attached to each of its blocks on it. These blocks are interconnected through rotary joints, which allow the change in shape.
4. Underwater Robots: https://www.youtube.com/watch?v=shimvNXyVtw
   This robot can submerge and emerge out of the water by compressing and decompressing the air inside it. It also has manipulators attached, which may be used to pick objects underwater.
5. Soft Robots: https://www.youtube.com/watch?v=qevIIQHrJZg
   The Soft robot described in this video can change its size and go into small holes. This robot may be used for resume operations since it has the ability to access places that are non-accessible by humans.
6. Micro Robots: https://www.youtube.com/watch?v=-QxioOUyFLg
   These robots can morph into a specific shape, and it helps them to travel easily in the bloodstream. They are used in targeted drug delivery.
7. Hybrid Robots: https://www.youtube.com/watch?v=xLuQifpJv_8
   The quadcopter described in this video is a hybrid of aerial and mobile robots. It can not only fly according to the command, but it can also crawl on the ground using the crawler mechanism attached beneath it.

Q3:

1. Brushed DC motor:
   Brushes are used to change the polarity of the magnetic field. The advantages of brushed motors are their simple configuration and ability to operate without an electronic drive circuit in applications where speed control is not needed.
2. Brushless DC motor:
   They do not have brushes but instead have a current carrying conductor placed in a magnetic field where it experiences a force that drives the motor. It has better speed vs torque characteristics.
3. Stepper Motor:
   A Stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps, and the position can be commanded to move and hold at one of these steps without any position sensor for feedback.
4. Servo Motor:
   This is a brushed motor with an in-built feedback loop which correctly adjusts its position. They can be directly used without the need for a motor driver since the voltage required for them is small.
5. Induction motor:
   This is a motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding.
6. Asynchronous motor:
   A synchronous electric motor is an AC electric motor in which, at steady state, the rotation of the shaft is synchronized with the frequency of the supply current; the rotation period is exactly equal to an integral number of AC cycles.

Q6 we know

$$R_0^1 = \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

We take three ~~vectors~~ unit vectors :

$a_1 = \hat{i}_0$, $b_1 = \hat{j}_1$, $c_1 = \hat{k}_1$

Here we know a_1, b_1, c_1 are orthogonal (since they are along x_1, y_1, z_1 axes)

$$\therefore a_0 = R_0^1 \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 \end{bmatrix}$$

$$b_0 = R_0^1 \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} \hat{j}_1 \cdot \hat{i}_0 \\ \hat{j}_1 \cdot \hat{j}_0 \\ \hat{j}_1 \cdot \hat{k}_0 \end{bmatrix}$$

$$c_0 = R_0^1 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} \hat{k}_1 \cdot \hat{i}_0 \\ \hat{k}_1 \cdot \hat{j}_0 \\ \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

Hence we know a_0, b_0, c_0 are columns of R_0^1

Since a_1, b_1 and c_1 are orthogonal, a_0, b_0 and c_0 must also be orthogonal since they are only represented in rotated axes.

Hence proved that columns of R_0^1 are orthogonal

Q7

We know $R_{x,\theta} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$, $R_{y,\phi} = \begin{bmatrix} \cos\phi & 0 & \sin\phi \\ 0 & 1 & 0 \\ -\sin\phi & 0 & \cos\phi \end{bmatrix}$

$R_{z,\psi} = \begin{bmatrix} \cos\psi & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$\det(R_{x,\theta}) = 1(\cos^2\theta + \sin^2\theta) = 1$, similarly:

$\det(R_{y,\phi}) = \det(R_{z,\psi}) = 1$

Any rotation matrix R_0^1 will be a combination of $R_{x,\theta}, R_{y,\phi}$ and $R_{z,\psi}$ where θ, ϕ and ψ may change.

We know property $\det(AB) = \det(A)\det(B)$

Hence any R_0^1 made of above three rotations cannot have any ~~other~~ value other than 1

Hence proved $\det(R_0^1) = 1$