ITR Assignment 1

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Ans 2

Categories of robots are:

1. **Manipulators :**
   These robots look like arms. They are mostly used in industries and are popular for their pick and place use. There are many different types of robot manipulators having different degrees of freedom. Two of them are:

   1. **RRR PUMA Robot**: It is a 3 D.O.F robot with 3 revolute joints.
      Link : Playing with my Puma Robot.

   2. **RRP SCARA Robot**: It is a 3 D.O.F robot with 2 revolute and 1 Prismatic joint.
      Link : Fast Scara Robot

2. **Mobile Robots (ground based) :**
   Ground based mobile robots are typically automatic machines that are capable of doing locomotion on ground. These robots are mainly used for surveillance, rescue, inspection, transportation, etc. There are many types of ground based mobile robots of which two are:

   1. **SEIT Robot:** It is mainly used for material transport from one place to another in industries.
      Link: Autonomous Mobile Robots (AMRs) in Action

   2. **ARTI Robot:** This robot is capable of moving on dull and dirty places, climb stairs and perform dangerous jobs that are difficult for humans.
      Link: ARTI Mobile Robot Platform - Stair-Climbing Robot and UGV

3. **Aerial Robots (UAVs):**
   These robots can fly and perform several tasks in air. They range from standard drones to autonomous robots. One such type of aerial robot is:

   1. **CW 10D Drone:** These robots come under the category of drones. They are used for surveillance purposes.
      Link: CW 10D& CW 30D live video surveillance drone system

4. **Underwater robots (AUVs):**
   These robots are designed for underwater operations. They can perform various tasks that are very difficult for humans to do. Example of an AUV is:

   1. **COTSbot:** It is an underwater patrolling robot that is capable of killing starfishes in the ocean. It follows a preprogrammed path and can inject salts in to water.
      Link: COTSbot injects a COTS

5. **Soft robots:**
   These robots are made up of compliant materials rather than metals and ceramics as in case of rigid bodied robots. These robots are safer to use in close contact with humans, animals and delicate objects compared to other robots. One such type of soft robot is:

   1. **Soft Robotic Gripper:** It is a soft gripper that is attached to a normal robotic arm. It is used to pick and place delicate objects and organisms such as egg, fruits, living organisms (like crab) etc.
      Link: Universal Soft Robotic Gripper

6. **Micro robots:**
   These robots are getting very popular these days. They are used to perform micro level tasks such as drug delivery, cell manipulation, microassembly, etc. One such robot is:

   1. **HAMR Micro robot:** This robot mimics the motion small living organisms like cockroaches and can also carry a load upto twice its weight. Its movements are very rapid.
      Link: Meet HAMR, the Cockroach-Inspired Robot

7. **Exoskeletons:**
   These are wearable electromechanical devices/robots that enhance that the physical performance of the wearer. One such robot is:

   1. **Honda Walking Assist:** This exoskeleton helps the wearer to enhance his/her walking abilities and assist them in walking.
      Link: Meet HAMR, the Cockroach-Inspired Robot

Ans 3

Types of motors are:

- **Brushed DC motor:** These are one of the basic type of DC motors. The current is delivered to the motor windings through brushes using mechanical commutation.

- **BLDC (Brushless DC) motor:** These motors do not need brushes to flip the electromagnetic field. The flipped inside out configuration serves the purpose of flipping the electromagnetic field.

- **Stepper motor:** These motors are a type of BLDC motors that take discrete steps rather than continuous motion. They are multiple coils organised in phases that serve the purpose of discrete steps.

- **Servo motor:** These motors are rotary or linear actuators. They allow control of angular or linear position, velocity and acceleration. Its main task is to convert the control signal into the desired angular displacement or angular velocity.

- **AC motor:** In simple words, these motors convert the AC current into mechanical power.

Ans 6

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

also,

$$R_0^1 (R_0^1)^T = I$$

$$\begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix} \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{i}_1 \cdot \hat{j}_0 & \hat{i}_1 \cdot \hat{k}_0 \\ \hat{j}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{k}_0 \\ \hat{k}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\Rightarrow (\hat{i}_1 \cdot \hat{i}_0)^2 + (\hat{i}_1 \cdot \hat{j}_0)^2 + (\hat{i}_1 \cdot \hat{k}_0)^2 = 1 \quad -(1)$$

$$(\hat{j}_1 \cdot \hat{i}_0)^2 + (\hat{j}_1 \cdot \hat{j}_0)^2 + (\hat{j}_1 \cdot \hat{k}_0)^2 = 1 \quad -(2)$$

$$(\hat{k}_1 \cdot \hat{i}_0)^2 + (\hat{k}_1 \cdot \hat{j}_0)^2 + (\hat{k}_1 \cdot \hat{k}_0)^2 = 1 \quad -(3)$$

$$(\hat{i}_1 \cdot \hat{i}_0)(\hat{j}_1 \cdot \hat{i}_0) + (\hat{i}_1 \cdot \hat{j}_0)(\hat{j}_1 \cdot \hat{j}_0) + (\hat{i}_1 \cdot \hat{k}_0)(\hat{j}_1 \cdot \hat{k}_0) = 0 \quad \text{— (4)}$$

$$(\hat{j}_1 \cdot \hat{i}_0)(\hat{k}_1 \cdot \hat{i}_0) + (\hat{j}_1 \cdot \hat{j}_0)(\hat{k}_1 \cdot \hat{j}_0) + (\hat{j}_1 \cdot \hat{k}_0)(\hat{k}_1 \cdot \hat{k}_0) = 0 \quad \text{— (5)}$$

$$(\hat{i}_1 \cdot \hat{k}_0)(\hat{k}_1 \cdot \hat{i}_0) + (\hat{i}_1 \cdot \hat{j}_0)(\hat{k}_1 \cdot \hat{j}_0) + (\hat{i}_1 \cdot \hat{k}_0)(\hat{k}_1 \cdot \hat{k}_0) = 0 \quad \text{— (6)}$$

In eqn (4), (5), (6), it is used that due to orthogonality of matrix R'_0,

$$\hat{i}_1 \cdot \hat{j}_0 = -\hat{j}_1 \cdot \hat{i}_0, \quad \hat{i}_1 \cdot \hat{k}_0 = -\hat{k}_1 \cdot \hat{i}_0,$$

$$\hat{j}_1 \cdot \hat{k}_0 = -\hat{j}_0 \cdot \hat{k}_1$$

$$\text{columns} = \underbrace{\begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 \end{bmatrix}}_{V_1}, \underbrace{\begin{bmatrix} \hat{j}_1 \cdot \hat{i}_0 \\ \hat{j}_1 \cdot \hat{j}_0 \\ \hat{j}_1 \cdot \hat{k}_0 \end{bmatrix}}_{V_2}, \underbrace{\begin{bmatrix} \hat{k}_1 \cdot \hat{i}_0 \\ \hat{k}_1 \cdot \hat{j}_0 \\ \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}}_{V_3}$$

For orthogonality,

$$\vec{v_1} \cdot \vec{v_2} = 0$$

$$\vec{v_2} \cdot \vec{v_3} = 0$$

$$\vec{v_1} \cdot \vec{v_3} = 0$$

$$\vec{v_1} \cdot \vec{v_2} = (\hat{i}_1 \cdot \hat{i}_0) \cdot (\hat{j}_1 \cdot \hat{i}_0) + (\hat{i}_1 \cdot \hat{j}_0) \cdot (\hat{j}_1 \cdot \hat{j}_0) + (\hat{i}_1 \cdot \hat{k}_0) \cdot (\hat{j}_1 \cdot \hat{k}_0)$$

from eqⁿ (4),

$$\boxed{\vec{v_1} \cdot \vec{v_2} = 0}$$

Similarly,

from eqⁿ (5),

$$\boxed{\vec{v_2} \cdot \vec{v_3} = 0}$$

from eqⁿ (6),

$$\boxed{\vec{v_1} \cdot \vec{v_3} = 0}$$

Hence orthogonality is proved.

Ans 7

R_0^1 is an orthogonal matrix.

$$\therefore \quad R_0^1 (R_0^1)^T = I$$

$$\therefore \quad |R_0^1|\,|(R_0^1)^T| = |I|$$

$$|R_0^1|^2 = 1$$

$$\therefore \quad \boxed{|R_0^1| = \det(R_0^1) = \pm 1}$$

Hence Proved.