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Assignment 1

(ME639)

Q.No = 2) Identify one or two examples of robots for each of the seven categories of robots mentioned in class. Submit your selected examples as a list of youtube links with 2-3 line explanations for each.

Ans = **1) Manipulators:-** All types of robotic arms falls in this category. They have two types of joints, i.e., revolute and prismatic joints.
Based on their configuration, manipulators are divided into three main categories.

1. **Puma robot**:- Playing with my Puma Robot.

This type of robot has the RRR configuration. It is a serial manipulator which has all three joints as Revolute joints.

2. **SCARA robot**:- Project || SCARA Robot

This robot has the RRP configuration where the 1st and 2nd axes are parallel. The acronym stands for Selective Compliance Assembly Robot Arm or Selective Compliance Assembly Articulated Robot Arm.

3. **Standford-type robot:-** Puma and Stanford manipulators

This robot has the RRP configuration where the 1st and 2nd axis is perpendicular to each other. It is a serial manipulator with a prismatic joint at the end and two revolute joints at the base.

2) Mobile robots:- Amazon Reveals First Fully Autonomous Mobile Robot

A mobile robot is an automatic machine that is capable of locomotion. They function using a combination of artificial intelligence and physical robotic elements, such as tracks, wheels, and legs.

3) Aerial robots:- Aerial Robotics Demo at VT and ARL

Aerial robots, as the name suggests, are machines that fly through the air. Aerial robots have dependable position and actuation hardware so they can fly in a controlled manner. Air data probes and altimeters, radar and passive vision sensors, magnetic compasses, distance measuring equipment (DME), global navigation satellite systems, instrument landing systems (ILS), and inertial navigation systems are just a few of the sensing options available to airborne robots (altitude radars, ultrasonic sensors, and laser range finders)

4)Underwater robots:- Underwater Robot

An autonomous underwater vehicle (AUV) which travels underwater without operator input is known as an underwater robot. Frame, pressure vessel, and fairing are the three functional subsystems that make up an underwater robot's mechanical structure. These days, underwater robots are really useful. They can be programmed to travel to far, perilous, and frequently uncharted areas of the ocean to measure its essential elements, such as salinity and temperature as well as the current's speed and direction. They provide incredibly accurate maps of the benthic and seabed ecosystems.

5)Soft robots:- Life at the Lab: Soft Robots

These robots are made from very soft materials. Soft robots are flexible and can be employed to carry out more delicate tasks like reaching into tight spaces or holding onto fragile objects.

6)Microrobots:- Magnetic Micro-Robots

These are mobile robots that have dimensions of less than 1mm. These are very small robots that are built to do very specific tasks. The above video shows a magnetic microrobot, which can be controlled using magnetic moments. These robots are also used for surgery purposes.

Q.No = 3) Review the most common types of motors and summarize them with a 2-3 sentence description of each of them. The description offered in this video may be a good starting point.

Ans = The most common types of motors are:-

1. **AC Synchronous Motors:-** They are AC motors in which the rotation of the rotor (or shaft) is synchronized with the frequency of the supply current. They have electro-magnets that are likewise made of a coil that is looped around a

disc. They operate at the unity power factor (i.e., the current component of current in phase with the applied stator voltage). This condition minimizes the losses and heating in the stator windings and avoids overheating.

2. **AC Asynchronous Motors:-** Asynchronous or induction motors have a rotor with a shorted conductor winding in which the revolving magnetic field induces a current and a stator with a winding that may produce a spinning magnetic field. The fact that the rotor's rotation is always slower than the magnetic field's rotational speed is referred to as being "asynchronous."
3. **Brushed DC Motors:-** Wire coils are used in DC motors to generate a magnetic field. These coils, which make up the "rotor" of a brushed motor, are free to rotate in order to drive a shaft. The coils are typically wound around an iron core; however, there are brushed motors that are "coreless," meaning the winding is sustained by itself. To provide a stationary magnetic field, permanent magnets are typically positioned on the inside surface of the stator. The rotor's magnetic field must constantly rotate in order to provide the torque that causes the rotor to spin.
4. **BLDC (Brushless DC Motors):-** Brushless DC motors work on the same magnetic attraction and repulsion principle as brush motors but are built differently. Instead of a mechanical commutator and brushes, electronic commutation rotates the stator's magnetic field. Active control electronics are required for this.
5. **Servo Motors:-** A servomotor is an electromechanical device that generates torque and speed in response to current and voltage. A servo motor is part of a closed-loop controller, supplying torque and speed as directed by a servo controller that closes the loop with a feedback device. The servo controller modifies the motor action based on the requested parameters using data from the feedback device, such as current, speed, or position.
6. **Stepper motors:** Stepper motors have a rotor containing permanent magnets and a stationary stator that houses the windings. When current flows through the

stator windings, it produces a magnetic flux distribution that interacts with the rotor's magnetic field distribution to produce a turning force. The stepper motor driver energizes each pole in turn, causing the rotor to revolve in increments or steps.

Q.No = 6) Show that columns of the rotation matrix are orthogonal.

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Assignment-1

(6) Rotation matrix R_0^1 is $\begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$

For orthogonal matrix we know that that

$$\boxed{AA^T = A^T \cdot A = I}$$ if A is orthogonal matrix.

Now, to show the columns of Rotation matrix as orthogonal, we need to show.

$$\begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{i}_1 \cdot \hat{j}_0 & \hat{i}_1 \cdot \hat{k}_0 \end{bmatrix} \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 \end{bmatrix} = \underset{\text{Identity matrix}}{I}$$

Hence, we get $(\hat{i}_1 \cdot \hat{i}_0)^2 + (\hat{i}_1 \cdot \hat{j}_0)^2 + (\hat{i}_1 \cdot \hat{k}_0)^2 = I$

Let the angle made by $\hat{i}_1$ axis with the plane of $\hat{i}_0$ & $\hat{j}_0$ is α and the angle made by the projection of $\hat{i}_1$ in the plane of $\hat{i}_0$ & $\hat{j}_0$ with $\hat{i}_0$ is ϕ.

Hence, $(\hat{i}_1 \cdot \hat{i}_0)^2 = \cos^2\alpha \cos^2\phi$

$(\hat{i}_1 \cdot \hat{j}_0)^2 = \cos^2\alpha \sin^2\phi$

$(\hat{i}_1 \cdot \hat{k}_0)^2 = \sin^2\alpha$

Hence, $\boxed{\cos^2\alpha \cos^2\phi + \cos^2\alpha \sin^2\phi + \sin^2\alpha = 1 = I}$

Hence proved

Q.No = 7) Show that det(R1_0) = 1.

Now, similarly for two other columns same approach will work. Hence, column of ~~orthogonal~~ Rotation matrix are orthogonal.

(7) we have to show that $\det(R'_0) = 1$

we know that Rotation matrix is orthogonal

Hence $\boxed{(R'_0)(R'_0)^T = I}$ — (1)

Also, we know that $\boxed{\det(A^T) = \det(A)}$

Now, take determinant to both side in eq^n (1)

$$\Rightarrow \quad \det(R'_0) \cdot \det(R'_0)^T = 1$$

$$\Rightarrow \quad \det(R'_0)^2 = 1$$

$$\Rightarrow \quad \boxed{\det(R'_0) = \pm 1}$$

But for our convince we generally take determinant to be +ve here.

Hence, $\boxed{\det(R'_0) = +1}$ - Hence, proved