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DEPT. : MECHANICAL ENGINEERING

ASSIGNMENT 1 → ME 639

Q2) 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.

MANIPULATORS (ROBOTIC ARM)

https://youtu.be/Iv6op2HHIuM?feature=shared

- RRR configuration with the end effector mimicking a human wrist.
- Flexing Accuracy comparing a human.

https://youtu.be/BRpUcKsvr4I?feature=shared

- Cable driven robotic art
- remote controlled, low latency, quite comparable to a human arm.

LEGGED ROBOTS - BIPEDS, QUADRAPEDS

https://youtu.be/Is4JZqhAy-M?feature=shared

- Biped robot mimicking the Cassowary, a flightless bird
- Complex design replicates two legged locomotion with perfect balance for crouching. etc.

https://youtu.be/_rPvKlvyw2w?feature=shared

- Hybrid between legged and wheeled robot
- enables various dynamic movements. Focuses on energy efficiency.

AUTONOMOUS UNDER WATER VEHICLES

UNMANNED AERIAL VEHICLES

https://youtu.be/4aaPZ80Yo4s?feature=shared

- Maritime inspection ; great potential for joining optical fibres
- Rescue missions and mapping the ocean floor for for various earth science studies

https://youtu.be/bzv8pPGfSI8?feature=shared

- Used after 9/11 attacks. Important for military purposes
- Used mostly in surveillance and other war related areas.

EXOSKELETON

https://youtu.be/b4I2iBhK6no?si=q1Xt-JXbRQtgy2-G

- Helping disabled people for locomotion, walking help etc.
- Great potential in future development to the disabled

NANOBOTS

https://youtu.be/2TjdGuBK9mI?feature=shared

- Used in medical technology ; boosted by the revolution in micro - and nano electronics

HUMANOIDS

https://youtu.be/LzBUm31Vn3k?feature=shared

- Simulates human expressions. Achieves facial expressions through mechanics.
- Incorporated further with many AI features

https://youtu.be/-e1_QhJ1EhQ?feature=shared

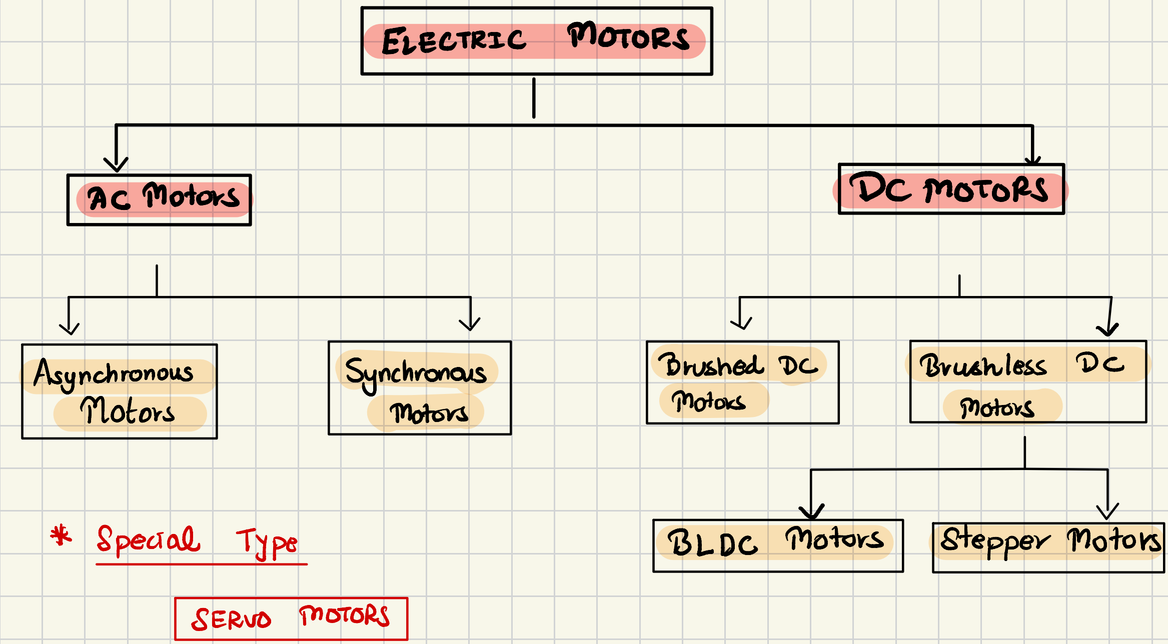
- Humanoid robot cable of various difficult task of legged locomotion, interacting with physical objects around etc.

SWARM ROBOTS

https://youtu.be/18vMbCm-mHI?feature=shared

- Group of robots coordinating with each other to achieve a common goal

Q3) Review the most common types of motors and summarize them with a 2-3 sentence description of each of them. The description off may be a good starting point. (https://youtu.be/I2_-etus0KQ)



AC MOTORS :

- electrical energy → alternating power current → mechanical motion.
- operate using a changing polarity of the current, inducing a rotating magnetic field in the motor shaft
- magnetic field interacts with the rotor causing it to turn and generate mechanical output.

DC MOTORS :

- DC current → mechanical rotational motion
- Works due to the interaction between a stationary magnetic field created by the stator and a movable coil
- Direction can be controlled by reversing the polarity.

- **Brushed DC Motor :**

  - Copper brushes / copper pads on the stator side help change the polarity thus causing the rotor to move.

  - Two permanent magnets are also present on the stator side.

  - Metal laminated core is present to hold the magnetic fieldings.

  - To change the speed we need to change the applied DC value. (we can use a PWM speed control)

- **AC Induction motor :** (Asynchronous Motor)

  - Magnetic field created by a winding ; the magnetic field oscillates due to the AC current.

  - Further the magnetic field induces a magnetic flux in the metal core.

  - The copper coil in the centre is affected by the Flux and by Lorentz law current flows through it . Now the electromagnetic force causes the coil to rotate.

- **Ac Synchronous motor**

  - The rotor speed and the speed of the stator magnetic field is equal.

  - Here the rotor compared to the induction motor is not made up of coils but permanent magnet.

- There is a coil around the permanent magnet where we provide the AC /current, this causes the permanent magnet to rotate.

- BLDC Motors

  - The signal applied to the coils resemble the shape of AC Current. The supplied current is not AC but pulse DC

  - There are two types of BLDC - outrunner / Inrunner

  - Three inputs (A, B, C). There is a predefined switching sequence to make the motor rotate. To control this motor a ESC is needed.

- Stepper Motors

  - Brushless motors without a 3 phase input. Motor has 8 windings with 8 windings and 2 coils.

  - Moreover there are ferromagnetic conductor on the tip of the coil and rotor this allows us to create steps.

  - To control stepper motors drivers are required.

- Servo Motors

  - Generally have a DC motor inside; can also be used with AC motors

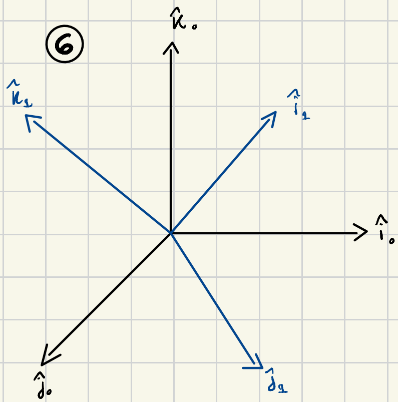
  - Have an encoder / potentiometer for feedback

  - consists of a gear box for more torque

6. Show that columns of the rotation matrix R^{1}_{0} are orthogonal.

7. Show that $\det(R^{1}_{0}) = 1$.

⑥



Let us represent the basis vectors by

$$\{\hat{e}_i\}$$

Now from the basis vector property we know that basis vectors set is

(i) orthogonal

(ii) Normalised.

Now applying rotation to our basis vectors we get.

$$\begin{pmatrix} \hat{e}_1' \\ \hat{e}_2' \\ \hat{e}_3' \end{pmatrix} = R \begin{pmatrix} \hat{e}_1 \\ \hat{e}_2 \\ \hat{e}_3 \end{pmatrix} \quad \rightleftharpoons \quad \hat{e}_i' = R_{ij}\hat{e}_j$$

We know that from the Rotation matrix property that rotations preserve length and angles

$$\therefore \hat{e}_i' \cdot \hat{e}_j' = \delta_{ij}$$

Now
$$\begin{aligned} \hat{e}_i' \cdot \hat{e}_j' &= (R_{ik}\hat{e}_k)(R_{jl}\hat{e}_l) \\ &= (R_{ik}R_{jl})\,\hat{e}_k \cdot \hat{e}_l \\ &= R_{ik}R_{jl}\,\delta_{kl} \\ &= R_{ik}R_{jk} \\ &= R_{ik}(R^T)_{kj} \end{aligned}$$

$$RR^T = 1$$

$\boxed{\therefore \text{Hence proved that } R_0^1 \text{ is an orthogonal matrix}}$

(7) Let us assume a vector $\vec{v}$

From the properties of rotation matrix we know that vector $\vec{v}$ after applying rotation matrix (A) the length $A\vec{v}$ is same as $\vec{v}$

$$\therefore \quad \|A\vec{v}\|^2 = \|\vec{v}\|^2 \qquad \text{— (i)}$$

Now let us consider the eigenvector and eigenvalue of the rotation matrix A. Let $\vec{x}$ be the eigenvector and λ be the eigen-value

$$\therefore \quad \|A\vec{x}\| = |\lambda| \cdot \|\vec{x}\| \qquad \text{— (ii)}$$

Since $\|A\vec{x}\| = \|\vec{x}\|$

$|\lambda|$ must be 1.

We know that the determinant of a matrix is the product of its eigenvalues.

Now for A all eigenvalues have absolute value 1

$$\therefore |\det(A)| = |\lambda_1| \cdot |\lambda_2| \cdot \ldots \ldots |\lambda_n| = 1$$

Hence the determinant of rotation matrix is 1