Q2. Identify one or two examples of robots for each of the seven categories of robots mentioned in class.

Ans:

- Manipulator robot :
    1. https://www.youtube.com/watch?v=F29vrvUwqS4
    2. https://www.youtube.com/watch?v=Q9JOKQaIR1w

Manipulator robots are machines with arms, like a robot's version of a human hand. They're designed to grip, move, and manipulate objects in factories and labs.

- Mobile robots:
    1. https://www.youtube.com/watch?v=k5Er0-HD-qw&list=PLyqSpQzTE6M9CXsZljkH_lCxRSiaXF566&ab_channel=NPTEL-NOCIITM
    2. https://www.youtube.com/watch?v=uhND7Mvp3f4&ab_channel=AwesomeTech

Mobile robots are robots that can move around on their own. They can roll, walk, or even fly! These robots don't need humans to control them all the time. They can follow instructions or figure out things using their sensors. Mobile robots are used in various jobs, like delivering packages, exploring dangerous places, or helping in factories.

- UAV:
    1. https://www.youtube.com/watch?v=SXgocm5YKmk&ab_channel=DefenceSquad

A UAV, or Unmanned Aerial Vehicle, is like a remote-controlled aeroplane without a pilot onboard. People use UAVs for all sorts of tasks, from taking excellent photos up in the sky to helping farmers check on their crops. These flying robots are controlled by computers and sometimes even by people using special controllers. They can go to places hard for humans to reach, like dangerous areas or high above the ground.

- AUV:
    1. https://www.youtube.com/watch?v=Kr68oZ-BFoU&ab_channel=AUVIITB

An Autonomous Underwater Vehicle (AUV) is a particular type of robot that can swim underwater without any person onboard controlling it. AUVs are used to explore the deep parts of the ocean where it's hard for humans to go. They use sensors to see and collect information about the water and the creatures living there.

- Legged robots
    1. https://www.youtube.com/watch?v=xNeZWP5Mx9s
    2. https://www.youtube.com/watch?v=N_QAL2ZCpFM

Legged robots are machines designed to move on legs. These robots can be helpful in places where wheels might struggle, like rocky or uneven surfaces. Engineers study animal movements to create these robots, making them adaptable and stable. From simple insect-like crawlers to complex humanoid designs, legged robots come in various shapes and sizes, with potential uses ranging from search and rescue missions to space exploration.

- Soft robots/exosuits
    1. https://www.youtube.com/watch?v=OoXCO8NB9B8
    2. https://www.youtube.com/watch?v=iwQRYzLZvGE

Soft robots are soft and flexible. They're designed to mimic the movements of living creatures. These robots are made from stretchy materials and use air or fluids to change shape and move around. They're great for tasks that need a gentle touch, like helping people walk better or assisting in physical therapy.

- Nanobots
    1. https://www.youtube.com/watch?v=Na_j0BA55ZE
    2. https://www.youtube.com/watch?v=j_Nws3R4fsA

Nanobots are tiny robots that are so small they can't be seen with our eyes. Think of them as super-miniature machines. They're designed to do really tiny tasks, like delivering medicine inside our bodies or fixing tiny things like computer parts. Scientists and engineers make these nanobots using special materials.

Q3

There are 6 common types of motors:

① Brushed DC Motor:

A brushed DC Motor is an internally commutated electric motor designed to be run from direct current power source and utilizing an electric brush for contact. The speed of these motors can be varied by changing the operating voltage or the strength of the magnetic field.

② AC Induction Motor:

It operates on the principle of electromagnetic induction. It consist of two main parts: a stator and a rotor. The stator generates a rotating magnetic field when connected to an AC power source. This magnetic field induces current in the rotor, which in turn creats a secondary magnetic field that interact with the stator's magnetic field, causing the rotor to turn.

③ AC Synchronous motor:

It is designed to rotate at a fixed and constant speed that synchronizes with the frequency of the applied AC Power. This type of motor is used in application where consistant and accurate speed control is essential.

④ Brushless DC Motor:

This DC motor operates using a commutation system without physical brushes. It relies on electronic controllers to switch the current direction in the motor winding, enabling precise control of its rotation.

⑤ Stepper Motor:

As the name suggest It operates by converting electrical pulses into discrete mechanical movements typically rotating in fixed increment or steps, this is achieved through the activation of electromagnetic

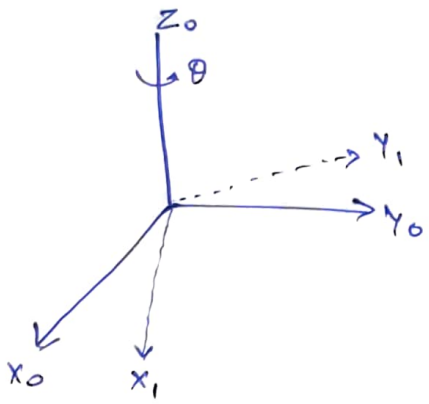
coils in a specific sequence, causing the motor shaft to move step by step.

(6) Servo Motor:

It operates based on feedback control, comprising the 3 main components: a motor (generally stepper), a position sensor (generally a potentiometer) and a control circuit. The control circuit compares the desired position with the actual position from the sensor and generates an error signal. This signal drives the motor to adjust its position until the error becomes minimal.

06. To show that column ~~vectors~~ of rotation matrix R_0^1 are orthogonal.

Let X_0, Y_0 & Z_0 be original axes and let Rotation about Z axis by angle θ.



$$R_0^1 = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Let us first show that R_0^1 is orthagonal.

i.e $[R_0^1][R_0^1]^T = 1$

$$\rightarrow \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \cos & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos^2\theta + \sin^2\theta + 0 & \cos\theta\sin\theta - \cos\theta\sin\theta + 0 & 0 \\ \cos\theta\sin\theta - \sin\theta\cos\theta + 0 & \sin^2\theta + \cos^2\theta + 0 & 0 \\ 0 & 0 & 0+0+1 \end{bmatrix}$$

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

Thus R_0^1 is an orthagonal matrix.

Now to prove that Columns of this matrix are orthagonal we need to show that dot product of its Columns is equal to Zero.

$\Rightarrow$ (Colum 1) $\cdot$ (colum 2) $= 0$

$\Rightarrow \begin{bmatrix} \cos\theta \\ \sin\theta \\ 0 \end{bmatrix} \cdot \begin{bmatrix} -\sin\theta \\ \cos\theta \\ 0 \end{bmatrix}$

$\Rightarrow -\cos\theta \cdot \sin\theta + \sin\theta \cdot \cos\theta + 0$

$= 0$

Similarly (Colum 2) $\cdot$ (colum 3) $= 0$

& (Colum 1) $\cdot$ (colum 3) $= 0$.

Hence Proved.

Q7. To show that $\det(R_0') = 1$.

Suppose rotation about x axis by angle θ.

$$\therefore R_0' = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$\det(R_0') = 1(\cos^2\theta - (-\sin^2\theta)) + 0 + 0$

$= 1(\cos^2\theta + \sin^2\theta) = 1.$

Similarly we can show ~~that~~ the same for rotations about Y or Z axis.