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ME 639: Introduction To Robotics
Assignment 1

TASK 2:
There are a whole lot of types of robots in the world out there today. Here are some seven categories of Robots out of the various other one's:

1. Autonomous mobile robots (AMR's):
   These robots can move around on their own without any oversight, unlike their previous versions of AGV's which moved on pre-defined paths. A few examples are:
   a. Scalable Storage Picking Robots:
      These robots move around the warehouse picking up and storing items at their designated locations. They also have the ability to scale heights to retrieve or place certain items.
      i. https://youtu.be/IRwyOPO6KR4
   b. Vacuum cleaning robots:
      Roomba is a classical example of such robots. These small mostly circular robots move around the place vaccuming autonomously and are also widely used.
      i. https://youtu.be/XIPzSmwClJ8
      ii. https://youtu.be/hoY2YxLGV98
   c.
2. Autonomous underwater vehicles (AUV's):
   These vehicles autonomously navigate the deep seas for explorations, inspection of oil and gas pipelines. They are able to reach and work where humans can't go.
   a. The following video explains 4 such underwater vehicles used for various purposes mentioned.
   b. https://youtu.be/4WOOweslkss
      i.
3. Manipulator Robots:
   These robots have a multi-jointed arm and an end effector. They are majorly used in factories and assembly lines.
   a. SCARA Robot:
      i. Selective Compliance Assembly Robot Arm (SCARA) manipulators have one prismatic joint for Z-axis movement and two parallel revolute joints.
      ii. https://youtu.be/geYyK-zWsmI
   b. Delta Robot:
      i. Used for picking and placing items. Fast manipulators are attached to ceiling of the factory or warehouse and have 3-6 arms each with its own revolute or prismatic joint.
      ii. https://youtu.be/yXNbG4P8fTU

4. Drones or Aerial Robots
   They fly in the air and look very cool. A whole bunch of aerodynamics comes into place in this area.
   a. DJI Mavic 3 Pro:
      i. This first person view drone is used for photography/videography and is equipped with great camera for exploration and good colour resolution. Also has object detection and obstacle avoidance.
      ii. https://youtu.be/r5kukRMmZNI

5. Humaniod Robots:
   They are created to mimic humans, their body movements and the human mind. Scientists have tried to essentially and artificial human.
   a. Ameca:
      It is the world's most advanced robot according to a few news outlets. Built by Engineered Arts, it can perform various human tasks like drawing and moving head and eyes but can not actually walk although it contains a responsive software system present inside.
      https://vimeo.com/651929733

6. Mobile Robots or Quadropeds:
   These are four-legged robots which try to mimic animal or behaviour. They can travel using the "legs" and now also have jumping and dancing capabilities.
   a. Spot:
      Boston Dynamics has created this wonderfully agile and strong mobile robot. With great software, obstacle avoidance and 2 ports it can be used for a plethora of applications.
      https://youtu.be/wlkCQXHEgjA

7. Autonomous Vehicles:
   These are autonomous vehicles which roam our streets.
   a. Self Driving Cars:
      These are cars which move around without any human assistance. They use advanced technology like LiDar and real time image processing. Mainly present as robotaxis in Austin, Phoenix and SF/bay area.
      https://youtu.be/LCNLOJS39V8

TASK 3:

There are two main types of motors that we see around us, one is AC and the other is DC.

AC:

1. Asynchronous:
   The term "asynchronous motor" refers to an electric motor whose structure prevents its rotor from revolving at the same rate as the magnetic field. In real use, the asynchronous motor's rotor rotates at a speed that is substantially slower than the synchronous speed of the revolving magnetic field. The speed of stator and motor are different in this case
2. Synchronous:
   Synchronous motors are the type with rotors that are engineered to rotate at the same speed as the stator's rotating magnetic field (synchronous speed).

DC:

1. Servo Motor:
   Servo motor are essentially used to rotate. The servo motors can rotate very precisely because of the control circuit in the motor, which provides feedback on the motor shaft's current position.

2. Brushed Motor:
   Use brushes and a mechanical commutator to direct current flow through the motor's windings. A stator with two magnets surrounds a turning rotor (or armature). When connected to a current source, opposite polarities create a magnetic field torque. Because of this, the rotor starts turning around its axis.

3. Brushless Motor:
   a. BLDC:
      The windings are stationary, and there are no brushes. There are no windings on the rotor, which rotates. The permanent magnets are installed here. An electronic control circuit must switch current to the proper windings in the proper order to generate rotation in the shaft. Better than brushed since no wear or tear occurs and has longer life.
   b. Stepper motor:
      Similar to BLDC just that in this case the rotations occur in equal steps. Controlled by a driver which turns the motor after one pass of electricity.

TASK 6:

Let our rotational matrix be $R_0 = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} = R_0'$

(This is taken from T-B) ↗

Now, for any matrix to be orthogonal, $AA^T = I$ condition must be satisfied. or $A^T = A^{-1}$

$$\therefore \quad R_0'(R_0')^T = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

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

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

$\therefore$ R_0' is an orthogonal matrix.

TASK 7:

From the previous task we know that R_0' is orthogonal i.e

$$(R_0')(R_0')^T = I$$

Taking det on both sides

$$\det\left((R_0')(R_0')^T\right) = \det(I)$$

$$\det(R_0')\det\left((R_0')^T\right) = 1$$

Now since $(R_0')^T = (R_0')^{-1} \Rightarrow \det(R_0') = \det(R_0')^T$

$$\therefore \quad \det(R_0')^2 = 1$$

$$\therefore \quad \boxed{|R_0'| = \pm 1}$$