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Programme – Start Early PhD (EE)

Assignment 1

ME 639 – Introduction to Robotics

IIT Gandhinagar

2.

(a) RRR

Cincinnati Milacron T3 manipulator

Link: https://youtu.be/P04etfWzDkY

KUKA

Link- https://youtu.be/tIIJME8-au8

(b) RRP

Lego NXT ROB-FIB

Link- https://youtu.be/UCuL-Keg65A

Fanuc

Link: https://youtu.be/wsahWzDgXCs

Adept

Link: https://youtu.be/nHv4OIjAckk

(c) RPP

Cylindrical manipulator

Link- https://youtu.be/sx3ZNbjDkys

3.

(a) Brushed DC motors

Many motion control applications use permanent magnet DC motors. Speed, torque and position control of these motors are comparatively simple. DC motors use wound coils of wire to create a magnetic field. In a brushed motor, these coils are free to rotate to drive a shaft – they are the part of the motor that's called the rotor. Usually the coils are wound around an iron core. The fixed part of the motor is called the stator. Permanent magnets are used to provide a stationary magnetic field.

(b) Brushless DC motors

In BLDC motors, instead of a mechanical commutator and brushes, the magnetic field of the stator is rotated by using electronic commutation. This requires the use of active control electronics. The rotor has permanent magnets affixed to it, and the stator has windings. Brushless motors can be constructed with the rotor on the inside, as shown above, or with the rotor on the outside of the windings (sometimes called an "outrunner" motor).

(c) Stepper motors

A stepper motor is an electric motor whose main feature is that its shaft rotates by performing steps, that is, by moving by a fixed degrees. This feature allows to know the exact angular position of the shaft by simply counting how may steps have been performed, with no need for a sensor. Commercially, stepper motors are used in floppy disk drives, flatbed scanners, computer printers, plotters, slot machines, image scanners, compact disc drives, intelligent lighting, camera lenses, CNC machines, and 3D printers.

(d) Servo motors

The servo motor is usually a simple DC motor controlled for specific angular rotation with the help of additional servomechanism (a typical closed-loop feedback control system). It consists of a motor coupled to a sensor for position feedback. Servo motor applications are also commonly seen in remote-controlled toy cars for controlling the direction of motion, and it is also very widely used as the motor which moves the tray of a CD or DVD player.

(e) Induction motors

An induction motor (also known as an asynchronous motor) is a commonly used AC electric motor. In an induction motor, the electric current in the rotor needed to produce torque is obtained via electromagnetic induction from the rotating magnetic field of the stator winding. The rotor of an induction motor can be a squirrel cage rotor or wound type rotor. Induction motors are referred to as 'asynchronous motors' because they operate at a speed less than their synchronous speed.

(f) Synchronous motors

A synchronous motor is one in which the rotor normally rotates at the same speed as the revolving field in the machine. The principle of operation of a synchronous motor can be understood by considering the stator windings to be connected to a three-phase alternating-current supply. The effect of the stator current is to establish a magnetic field rotating at $120 f/p$ revolutions per minute for a frequency of f *H*ertz and for p poles.

6.

Rigid transformations (rotation and translation) do not change the relative distance between two points.

Let $\boldsymbol{R}$ be the rotation matrix that is applied to the system and the relative distance between the points is compared.

$$\|\boldsymbol{R}x - \boldsymbol{R}y\|^2 = \|x - y\|^2 \; \forall \; x, y$$

$$\Rightarrow (x - y)^T \boldsymbol{R}^T \boldsymbol{R}(x - y) = (x - y)^T (x - y) \; \forall \; x, y$$

$$\Rightarrow \boldsymbol{R}^T \boldsymbol{R} = \boldsymbol{I}$$

Thus, any matrix $\boldsymbol{R}$ for which $\boldsymbol{R}^T \boldsymbol{R} = \boldsymbol{I}$ will maintain distance between points. This is a property of orthogonal matrix. Such matrices are called orthogonal matrices where the rows are orthogonal.

7.

$$\boldsymbol{R}^T \boldsymbol{R} = \boldsymbol{I}$$

Taking determinant on both the sides,

$$|\boldsymbol{R}^T||\boldsymbol{R}| = |\boldsymbol{I}|$$

$$\Rightarrow \text{Det}(R^2) = 1$$

$$\Rightarrow \text{Det}(R_0^1) = \pm 1$$