7th sem.

Robotics

Final 17-18

1 (a)

A robot is a programmable machine capable of carrying out complex tasks autonomously or semi-autonomously. They can:

→ sense their environment through sensors like cameras, lasers, and microphones.

→ process information using computer algorithms and software.

→ Make decisions based on their programming and sensor data.

→ Perform actions in the real world using motors, actuators, and other mechanisms.

~~present application~~

* Robotics in the present and Future:-

Robotics has become an integral part of modern civilization and industrialization for several reasons:

(1) Increased efficiency and productivity:- Robot can work tirelessly and accurately, performing task faster and more consistently than humans.

(2) Improved Safety:- Robotics can handle dangerous tasks, protecting human workers

from accidents and injuries.

(3) Enhanced capabilities:- Robot can perform tasks beyond human limitations.

(4) New Applications:- Robotics is constantly evolving, opening up new possibilities in various fields like:

* Healthcare
* manufacturing
* Agriculture etc.

(5) Future impact:- As Robots become more sophisticated and integrated into society, they have the potential to:

* Transform industries further
* Create new jobs in robotics desing, development, and maintenance.

1 (b)

~~Evaluation of~~

Evolution of robotics ~~rea~~ research:

~~First generation~~

The three main categories of robot:

1) Robot manipulators (industrial robots)
2) Biologically Inspired Robots
3) Mobile Robots.

1960s - 1970s: Beginnings.

i) Industrial robots were the first widely researched and implemented robots, focused on tasks like manufacturing and assembly.

1980s: Mobile and Biologically inspired Robots

i) Introduction of mobile Robots, which could move in their environments.

ii) Biologically Inspired Robots began to appear such as—
   * walking robots
   * Humanoid Robots

1990s: Expansion and Specialization

i) Flexible automation evolved from industrial robots.

ii) New types of robots emerged
   * Underwater Robots
   * personal Robots

Mid-1990's to Early 2000s: Service Robots Era

i) Robots became more specialized in function:

- Medical Robots
- Field Robots
- Construction Robots
- security Robots
- power assist Robots
- office / tour guide Robots

1 (c)

The laws of Robotics

(1) A robot may not injure a human being or through inaction, allow a human being to come to harm.

(2) A robot must obey the orders given to it by human being's except where such orders would conflict with the First law.

(3) A robot must protect its own existence as long as such protection does not conflict with the First ~~and~~ or second law.

2[illegible]

⧉ Classifying Robots based on Implementation Areas:

① Industrial Robots:

* Areas: Manufacturing, assembly lines, welding, painting

* Features: High precision, powerful manipulators, ~~tag~~ large workspace

* Objectives: Increase efficiency and productivity, Improve product quality, ensure worker safety.

* Striking Features: Six-axis articulated arms, collaborative robots for safe human-robot interaction.

② Service Robots:

* Areas: Healthcare, household cleaning, logistics, education, entertainment.

* Features: Sensors for perception, navigation capabilities, user interface

* Objectives: provide assistance and support in various settings, improve quality of life perform dangerous tasks.

* Striking Features: Robotic vacuum cleaners,

delivery drones, humanoid robots for customer service.

③ Mobile Robots:

* Areas: Exploration, search and rescue, environmental monitoring, agriculture transportation.

* Features: Autonomous navigation, obstacle avoidance, sensor fusion.

* Objectives: operate in dynamic environments collect data, support various exploration and service missions.

* Striking Features: mars rovers, underwater robots for ocean exploration, agriculture robots for autonomous farming, self-driving cars.

④ Aerial Robots:

* Areas: Aerial photography, surveillance, inspection, delivery, disaster response.

* Features: Flight capabilities, equipped with cameras and sensors for data collection

* objectives: provide aerial views and access, perform tasks in difficult-to-reach areas, offer efficient delivery solutions.

* Striking features: Drones for various applications, flying taxis for future transportation.

③ i

coordinate frames

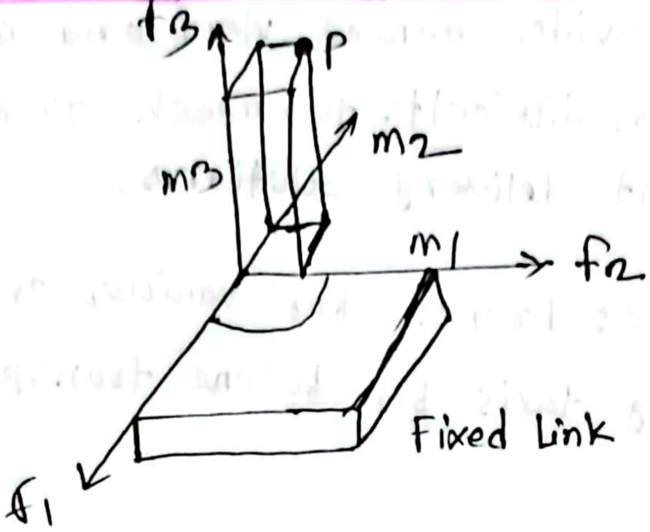
If 'p' is a vector in R, and $X = \{x^1, x^2, x^3 \dots x^n\}$ be a complete orthonormal set of R, then the coordinates of p with respect to x are denoted as $[P]^X$ and are defined as

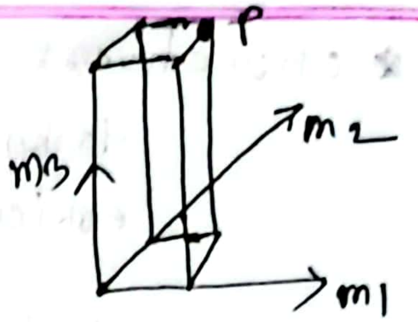
$$P = \sum_{k=1}^{n} [P]^X_k \, x^k$$

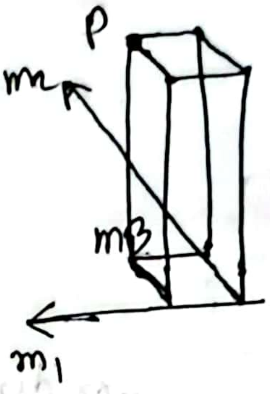
The complete orthonormal set X is sometimes called an orthonormal coordinate frame.

Coordinates Transformations

Represent position of p wrt fixed frame $f=\{f_1, f_2, f_3\}$







The two sets of coordinates of P are given by

$[P]^M = [P \cdot m1, P \cdot m2, P \cdot m3]$

$[P]^f = [P \cdot f1, P \cdot f2, P \cdot f3]$

The coordinate transformation problem is to find the coordinates of P wrt F, given the coordinates of P wrt M.

The matrix A is known as coordinate transformation matrix.

$$A = \begin{bmatrix} f^1 \cdot m^1 & f^1 \cdot m^2 & f^1 \cdot m^3 \\ f^2 \cdot m^1 & f^2 \cdot m^2 & f^2 \cdot m^3 \\ f^3 \cdot m^1 & f^3 \cdot m^2 & f^3 \cdot m^3 \end{bmatrix}$$

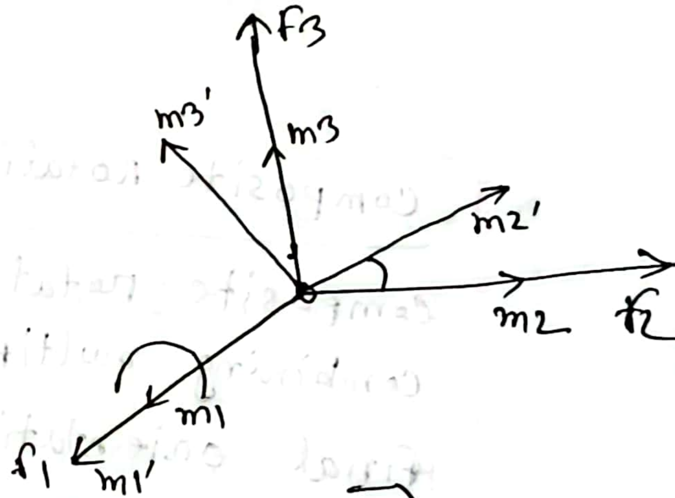
ii

Rotations

In order to specify the position and orientation of the mobile tool in terms of a coordinate frame attached to the fixed base, coordinate transformations involving both rotations and translations are required.

Fundamental Rotations

If the mobile coordinate frame is obtained from the fixed coordinate frame F by rotating M about one of the unit vectors of F, then the resulting coordinate transformation matrix is called a fundamental rotation matrix.



In the space R3, there are 3 possibilities.

$$R_1(\phi) = \begin{bmatrix} f^1 \cdot m^{1'} & f^1 \cdot m_2' & f^1 \cdot m^{3'} \\ f^2 \cdot m^{1'} & f^2 \cdot m_2' & f^2 \cdot m_3' \\ f^3 \cdot m^{1'} & f^3 \cdot m_2' & f^3 \cdot m_3' \end{bmatrix} \Rightarrow \begin{bmatrix} 1 & 0 & 0 \\ 0 & f^2 \cdot m^{2'} & f^2 \cdot m^{3'} \\ 0 & f^3 \cdot m^{2'} & f^3 \cdot m^{3'} \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \sin(\phi) & \cos(\phi) \end{bmatrix}$$

$$R_2 = \begin{bmatrix} \cos(\phi) & 0 & \sin(\phi) \\ 0 & 1 & 0 \\ -\sin(\phi) & 0 & \cos(\phi) \end{bmatrix}$$

$$R_3 = \begin{bmatrix} \cos(\phi) & -\sin(\phi) & 0 \\ \sin(\phi) & \cos(\phi) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

4 (a)

Composite rotation:

Composite rotation in robotics refers to combining multiple rotations to achieve a final orientation for a robot or object. It involves sequentially applying individual rotations arround different axes to attain the desired overall rotation.

Yaw-pitch-Roll transformation matrix is a mathematical representation used to describe the orientation or rotation of an object in three-dimensional space.

Yaw : Rotation around the vertical axis

pitch : Rotation around the horizontal axis

Roll : Rotation around the adjacent axis

The matrix combines these rotations to represent the overall orientation of an object.

$$Y_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_1 & -s_1 \\ 0 & s_1 & c_1 \end{bmatrix}, \quad P_y = \begin{bmatrix} c_2 & 0 & s_2 \\ 0 & 1 & 0 \\ -s_2 & 0 & c_2 \end{bmatrix}, \quad R_z = \begin{bmatrix} c_3 & -s_3 & 0 \\ s_3 & c_3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$YPR = \begin{bmatrix} c_3 & -s_3 & 0 \\ s_3 & c_3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} c_2 & 0 & s_2 \\ 0 & 1 & 0 \\ -s_2 & 0 & c_2 \end{bmatrix} \cdot \begin{bmatrix} 1 & & 0 \\ 0 & c_1 & -s_1 \\ 0 & s_1 & c_1 \end{bmatrix}$$

$$= \begin{bmatrix} c_2c_3 & -s_3 & c_3c_2 \\ c_2s_3 & c_3 & s_2s_3 \\ -s_2 & 0 & c_2 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_1 & -s_1 \\ 0 & s_1 & c_1 \end{bmatrix}$$

$$=$$

$$= \begin{bmatrix} c_2 c_3 & -c_1 s_3 + s_1 s_2 c_3 & s_1 s_3 + c_1 c_3 s_2 \\ c_2 s_3 & c_1 c_3 + s_1 s_2 s_3 & -s_1 c_3 + c_1 s_2 s_3 \\ -s_2 & s_1 c_2 & c_1 c_2 \end{bmatrix}$$

4(b)

Given that

Roll, $\theta_1 = \pi/2$

pitch, $\theta_2 = -\pi/2$

yaw, $\theta_3 = \pi/2$

$$\therefore R_1(\theta_1) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_1 & -\sin\theta_1 \\ 0 & \sin\theta_1 & \cos\theta_1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\pi/2 & -\sin\pi/2 \\ 0 & \sin\pi/2 & \cos\pi/2 \end{bmatrix}$$

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

$$R_2(\theta_2) = \begin{bmatrix} \cos\theta_2 & 0 & \sin\theta_2 \\ 0 & 1 & 0 \\ -\sin\theta_2 & 0 & \cos\theta_2 \end{bmatrix}$$

$$= \begin{bmatrix} \cos(-\frac{\pi}{2}) & 0 & \sin(-\pi/2) \\ 0 & 1 & 0 \\ -\sin(-\pi/2) & 0 & \cos(-\pi/2) \end{bmatrix}$$

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

$$R_3(\theta_3) = \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 \\ \sin\theta_3 & \cos\theta_3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\pi/2 & -\sin\pi/2 & 0 \\ \sin\pi/2 & \cos\pi/2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

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

We know —

$$R = R_3(\theta_3) \cdot R_2(\theta_2) \cdot R_1(\theta_1) \cdot I$$

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

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

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

4(c)

Here, $\theta_1 = 45^\circ$

$\theta_2 = 60^\circ$

$\theta_3 = 90^\circ$

$$R = \begin{bmatrix} \cos 90^\circ & -\sin 90^\circ & 0 \\ \sin 90^\circ & \cos 90^\circ & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \cos 60^\circ & 0 & \sin 60^\circ \\ 0 & 1 & 0 \\ -\sin 60^\circ & 0 & \cos 60^\circ \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos 45^\circ & -\sin 45^\circ \\ 0 & \sin 45^\circ & \cos 45^\circ \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \frac{1}{2} & 0 & \frac{\sqrt{3}}{2} \\ 0 & 1 & 0 \\ -\sqrt{3}/2 & 0 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2\sqrt{2}} & \sqrt{3}/2\sqrt{2} \\ 0 & \frac{1}{\sqrt{2}} & -1/\sqrt{2} \\ -\frac{\sqrt{3}}{2} & \frac{1}{2\sqrt{2}} & \frac{1}{2\sqrt{2}} \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -0.707 & 0.707 \\ 0.5 & 0.612 & 0.612 \\ -0.866 & 0.353 & 0.353 \end{bmatrix}$$

$$P^F = \begin{bmatrix} 0 & -0.707 & 0.707 \\ 0.5 & 0.612 & 0.612 \\ -0.866 & 0.353 & 0.353 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0.6 \end{bmatrix}$$

$$= \begin{bmatrix} 0.4242 \\ 0.3672 \\ 0.2118 \end{bmatrix}$$

5(a)

Degree of ~~Fee~~ Freedom (DOF)

In general, degrees of freedom (DOF) are the set of independent displacements that specify completely the displaced or deformed position of the body or system.

In robotics, degrees of freedom is often used to describe the number of directions that a robot can move a joint.

5(b)

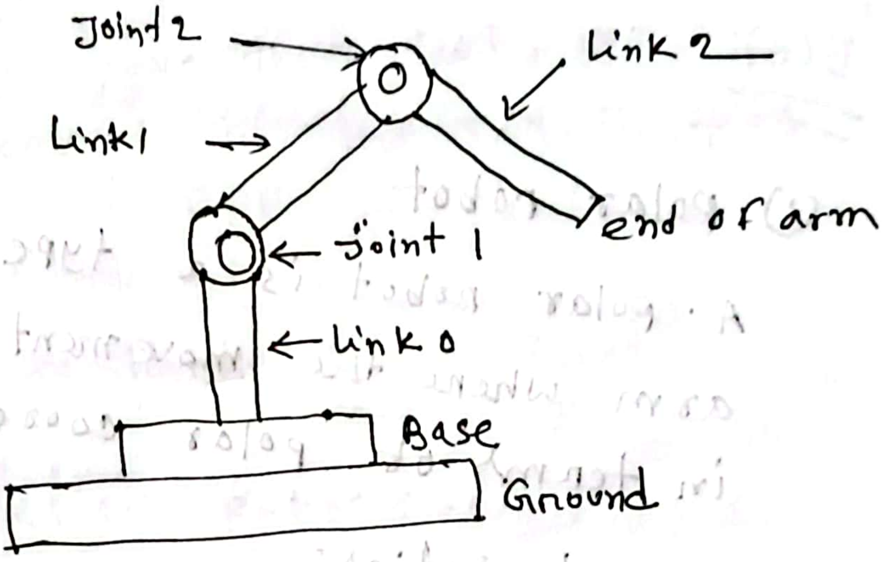
Robot Anatomy

* Manipulator consists of joints and links
  - → joints provide relative motion
  - → Links are rigid members between joints
  - → various join types: linear and rotary
  - → Each joint provides a "DOF"
  - → most robots processes 5 or 6 DOF

~~N~~ Robot manipulator consists of two sections:

→ Body-and-arm - for positioning of objects in the robot's work volume.

→ Wrist assembly - for orientation of objects.



Common Architectures

① polar Coordinate Robot (RR:P)

1) Two rotary joints, one prismatic joint

2) Allows positioning in a polar coordinate system

(ii) Jointed-Arm. Body and Arm Assembly (RRR)

1) Three rotary joints

2) Offers flexibility with all three rotations, commonly used in industrial robots.

(iii) Cylindrical Body and Arm Assembly (RPP)

1) One rotary joint, two prismatic joints

2) provides positioning and movement in cylindrical coordinates.

5(c)

(1) polar robot

A. polar robot is a type of robotic arm where the movement is defined in terms of polar coordinates.

Characteristics:

→ The robot's motion is specified by radial distance, angular position, and vertical position.

→ can move horizontally and vertically

→ Called RRP Robot.

(ii) cylindrical robot:

cylindrical robots operates in cylindrical coordinates, combining linear and rotational movements.

Characteristics:

- → They have three DOF, typically allowing movement in the x, y, z axes.
- → Notation RPP
- → Easy to display
- → Can handle large force

(iii) cartesian Robot:

They operates using cartesian coordinates (x, y, z).

characteristics

- → Movement is along the three mutually perpendicular axes.
- → Notation PPP
- → Easy to display
- → simple kinematic model.

(IV) Angular robot.

They move in angular coordinates, emphasizing rotational movements.

Characteristics

- → suited for tasks that involve manipulation in terms of angles and rotations.
- → Notation RRR
- → 3D Rotation
- → Configuration of human arm.

(V) SCARA Robot

They have two parallel joints that provided compliance in ~~once~~ one selected plane.

Characteristics:

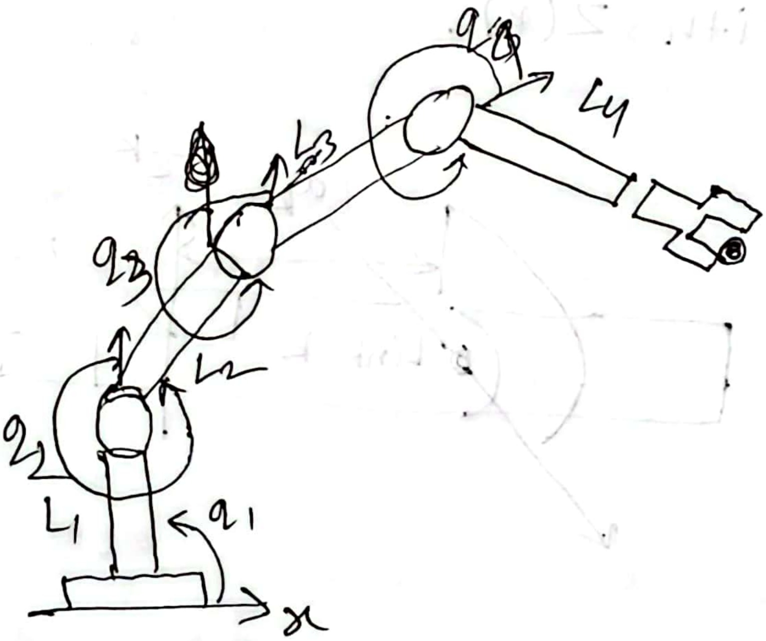
- → movement is similar to a human arm with shoulder, elbow, and wrist joints.
- → can handle high-speed works
- → Notation RRP.

Qn 6(a)

Joint parameter:

1) joint Angel
2) joint distance

joint Angles: represents the angular displacement of a joint from its reference position. In the following pictures, q_1, q_2, q_3, q_4 are joint angel.



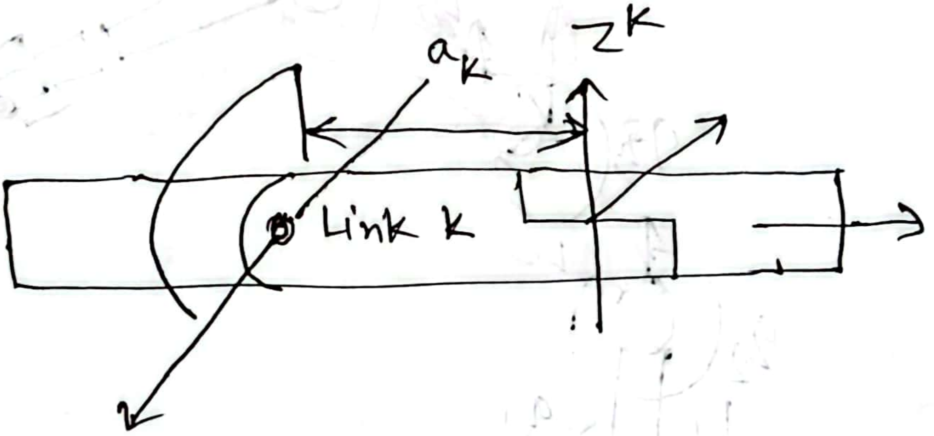
Joint distance: is the distance between the centers of adjacent joints. In the pictures, L1, L2, L3, L4 are joint distance.

Link parameter

1. Link length
2. link twist ϕ angle

Link length: is the translation along xk needed to make axis Z(k-1) intersect Z(k).

Link twist angle: is the rotation of xk needed to make axis Z(k-1) parallel with Z(k).



6(b)

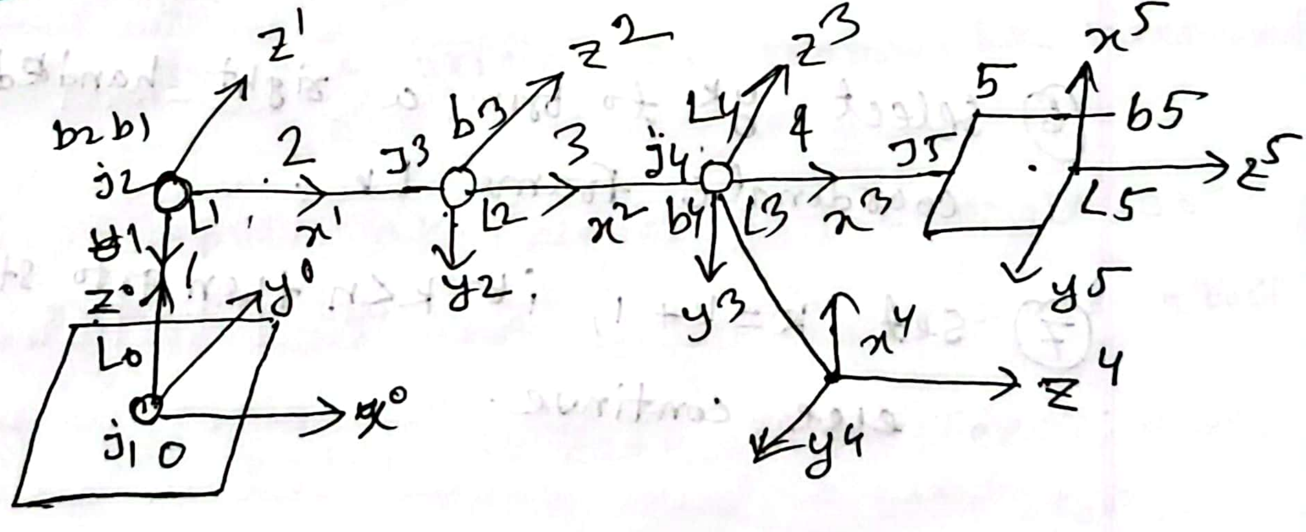
Direct kinematics : refers to the use of the kinematic equations of a robot to compute the position of the end-effector from specified values for the joint parameters.

problems :

Given the vector of joint variables of a robotic manipulator determine the position and orientation of the tool with respect to a coordinate frame attached to the ~~rob~~ robot base.

We have to find a concise formulation of a general solution.

6(c)



DH Algorithm

① Number the joints from 1 to n startin with the base and ending with the tool yaw, pitch and roll in that order

② Assign a right-handed ~~orthogonal~~ orthonormal coordinate frame L_0 to the robot base, making sure that Z^0 alligns with the axis of joint 1.
set $k=1$.

③ Align z^k with the axis of joint $k+1$

④ Locate origin of L_k at the intersection of the z^k and z^{k-1}.

⑤ select x^k to be orthogonal to both z^k and z^{k-1} ..

⑥ Select y^k to form a right handed coordinate frame L_k.

⑦ Set $k=k+1$, if $k<n$ then goto step 2 else continue.

⑧ set the origin of L_n at the tool tip. Align z^n with the approach vector, y^n with the sliding vector, and x^n with the normal vector of the tool. set $k=1$

⑨ Locate point b_k at the intersection of x^k and z^{k-1} axes. If they do not intersect, use the intersection of x^k with a common normal between x^k and z^{k-1}.

⑩ compute θ_k as the angle of rotation from x^{k-1} to x^k measured about z^{k-1}

⑪ computed d_k as the distance from the origin f frame L_k to point b_k measured along z^{k-1}.

⑫ Compute a_k as the distance from the point b_k to the origin of frame L_k measured along x^k.

⑬ compute α_k (alpha) as the angle of rotation from z^{k-1} to z^k measured about x^k.

⑭ set $k=k+1$, if $k<=n$, go to step 9; else stop.

7(a)

Autonomy : refers to the ability of a system or entity to operate independently, without direct human control or intervention.

Autonomy in Human-Robot Interaction (HRI):

In HRI, autonomy plays a crucial role in determining the level of collaboration and cooperation between humans and robots.

Levels of Autonomy :

① Tele operation :

② Assisted Tele operation :- The robot and human share control, with the robot taking care of certain low-level tasks, while the human retains overall control.

③ Shared Control with Robot Initiative :- In shared control scenarios, the robot takes a more active role in decisionmaking and action execution. The human provides high-level goals and supervision, while the robot autonomously performs certain tasks and makes decisions within defined parameters.

(a) Supervised Autonomy

(b) Full autonomy

7(b)

In HRI, humans can play various roles depending on the context, application, and level of autonomy of the robot. Here are several roles:

(i) Operator / Teleoperator:

The human serves as the operator or teleoperator, directly controlling the robot's movements and actions. The operator is responsible for guiding the robot, making decisions and ensuring that the robot performs tasks according to the human's intentions.

(ii) Supervisor / Controller:

The human acts as a supervisor, overseeing the robot's actions and providing high-level instructions.
The supervisor monitors the robot's performance, ensures alignment with objectives.

(iii) Programmer / Developer:

Humans in this role are responsible for programming and developing the software and algorithms that govern the robot's behavior.

(iv) Trainer / Teacher:

The human serves as a trainer or teacher, guiding the robot in learning new tasks, behaviors, or skills.

(v) Evaluator/user:

In this role, humans use the robot as a tool or resource to accomplish specific tasks.

(vi) Interactor:

The human acts as the recipient or interactor, receiving information or assistance from the robot.

7(c)

A robot locates itself and navigates through an environment using sensors and algorithms.

Localization:

Sensors like cameras, lasers, or odometry help the robot understand its position.

Mapping:

The robot create a map of the

environment based on sensor data.

Path planning:

Algorithms determine the best route from the robot's current position to its destination on the map.

Obstacle Avoidance:

Sensors detect obstacles, and algorithms adjust the robot's path to avoid them.

Feedback loop:

The robot continually updates its position, adjusts its map, and refines its path as it moves.

8(a)

Yes, robots can be designed to understand human speech through the field of Natural Language processing (NLP). Here's some method's of language understanding in HRI:

Speech Recognition: Speech recognition system's convert spoken language into text. Robot's equipped with speech recognition can understand spoken commands and engage in verbal interactions with users.

Natural Language understanding (NLU): NLU goes beyond simple speech recognition by focusing on extracting meaning from language. It enables robots to comprehend complex instructions.

Dialogue management: This systems handle the flow of a conversation, keeping track of content, managing turn-taking, and ensuring coherent interactions.

Semantic parsing: involves converting natural language sentences into structured representations, such as logical forms ~~or~~ or executable commands.

Machine learning and Deep learning:

Machine learning and deep learning techniques, including neural networks, are employed to improve language understanding. These models can be trained on large datasets to recognize patterns and relationships in language.

8(b)

Non-verbal interaction involves communication without the use of spoken or written words. Here are some types of non-verbal interaction:

(1) Body language:

Body language encompasses the use of body movements, postures, and gestures to convey information or emotions. It includes facial expressions, eye contact, hand movements, and overall body posture.

(2) Facial Expressions:

Facial expressions involve the use of facial muscles to convey emotions and feelings. Different facial expressions can communicate happiness, sadness, surprise, anger and more.

③ movements:

Gestures involve hand movements or body ~~movement~~ motions that convey meaning. They can be symbolic.

④ posture:

posture refers to the way individuals position their bodies. It includes how people stand, sit or move, and it can convey confidence, attentiveness, relaxation or tension.

⑤ Touch:

Touch communication involves physical contact between individuals. touch can convey warmth, support, empathy, or discomfort.

⑥ Appearance:

Appearance includes clothing, grooming, and overall presentation.

8(c)

Robot perception of non-verbal cues involves using sensors and algorithms to interpret various non-verbal signals emitted by humans during interaction. Here's how a robot can perceive non-verbal cues:

Computer vision:

→ Facial recognition: Identifies emotions by analyzing facial expressions.

→ Gaze Tracking: Tracks eye movements to understand user focus.

Audio processing:

→ Voice Analysis: Examines speech tone, pitch, and ~~ry~~ rhythm for emotional cues.

→ Speaker Localization: Determines speaker direction, crucial in multi-party interactions.

NLP:

→ Prosody Analysis: NLP techniques

analyze speech rhythm, pitch and intonation.

→ contextual understanding: processes language in context for accurate non-verbal cue interpretation.

machine learning and AI:

→ Emotion Recognition: Trains on datasets to recognize facial expressions and voice patterns.

→ Behavior prediction: predicts user behavior based on historical interactions and non-verbal cues.

user feedback Integration:

→ Adaptive systems: Allows robots to adapt based on user feedback, improving understanding over time.

Final 18-19

1(a)

An actuator is a device that converts energy into mechanical motoin. It is a core component in mechatronics and robotics used to move or control a mechanism or system.

Types of Actuators

① Electrical Actuators

Convert electrical energy into mechanical motoin.

Types of electric motors:

→ DC motors: continuous rotation with speed control

→ Servo motor: controlled position; ideal for robotic arms.

② Pneumatic Actuators

use compressed air to produce linear or rotary motion. It is fast, simple and cost-effective.

③ Hydraulic Actuators:

use pressurized liquid to produce motion. It is very powerful, used in high force applications.

④ Thermal ~~or magnetic~~ Actuators

uses heat expansion for movement.

⑤ Magnetic Actuators

uses magnetic field interaction.

1(b)

Electric Actuators are widely used in robotics because of their:

① Precision and control

→ Provide accurate control of position, speed and torque.

→ Ideal for tasks requiring fine movements like robotic arms.

② Clean and Quiet operation

→ No fluids or emissions.

→ Suitable for indoor, cleanroom, or medical environments.

(3) Efficiency

→ Convert energy directly ~~φ~~ into ~~moto~~ motion with less energy loss.

~~③ A~~

④ Integration with Electronics

→ Easily controlled using microcontrollers, PLCs, or computers.

Electric Actuators are used in :

(i) Industrial Robots : Robotic Arms

~~(ii)~~ (ii) Automation systems : conveyor belts

(iii) Humanoid Robots : joint movements

(iv) Medical Robots : Surgical Robots.

(v) Autonomous vehicles : steering, braking or adjusting mirrors.

(vi) Service Robots : Delivery bots, vacuum cleaners.

D How they are used

(1) Component : Electric actuator

(2) Input : Control signal

(3) process : Controller sends signal → Actuator moves → Feedback sent back

(4) output : Mechanical motion.

2(a)

Electric motors are used in robots to create movement, such as rotating wheels, moving arms, or turning joints.

Main components

(i) Electric motor

· ~~converts elect~~

(ii) Microcontroller

(iii) Motor driver

(iv) power supply

ⓥ sensors (optional)

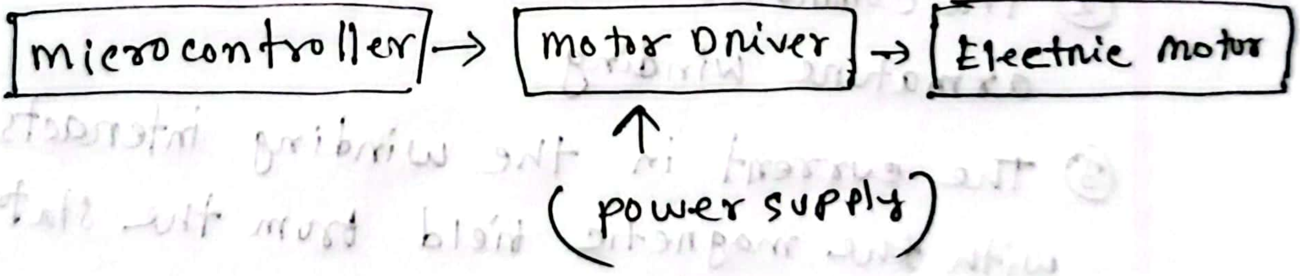
How it works:

① The microcontroller sends a signal to the motor driver

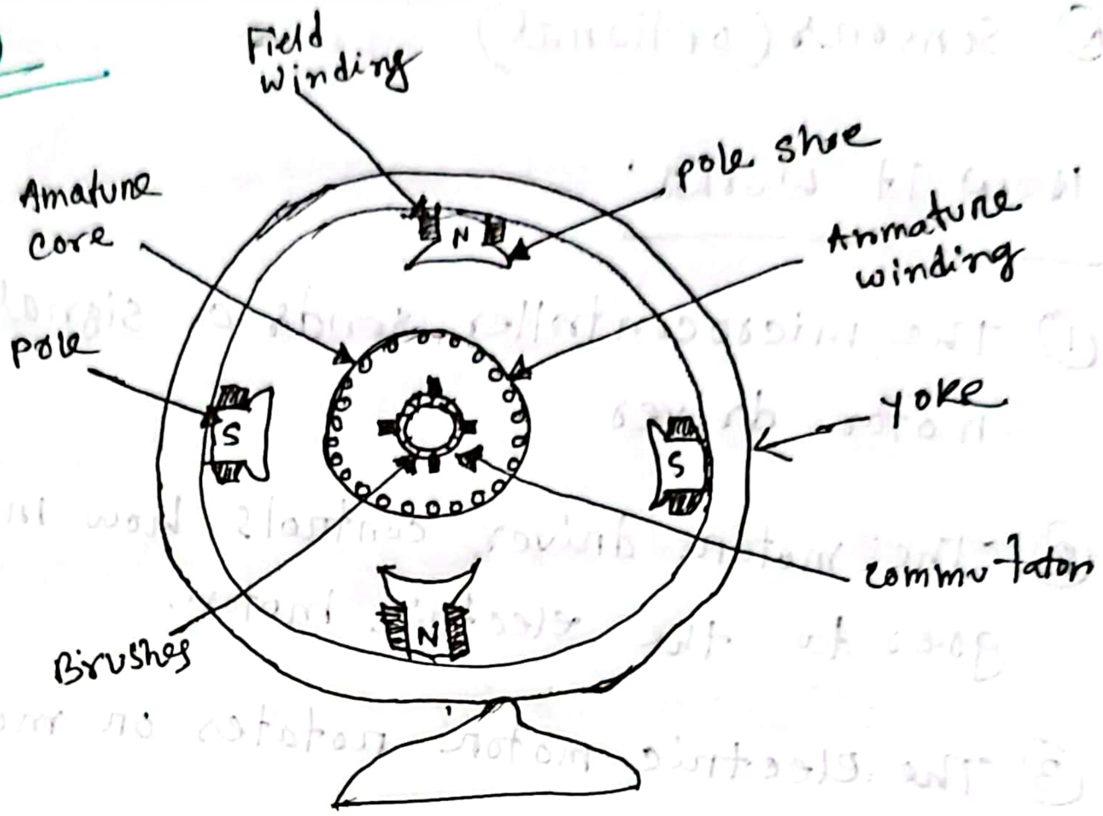
② The motor driver controls how much power goes to the electric motor.

③ The electric motor rotates or moves based on the signal.

④ If using sensors, feedback goes back to the microcontroller to adjust the motor movement for better accuracy.



2(b)



operation

① current flows from the battery into the brushes.

② The commutotor transfers current to the armature winding

③ The current in the winding interacts with the magnetic field from the stator

④ According to Fleming's Left-Hand Rule, the coil experiences a rotating force.

⑤ The commutator keeps switching the current direction, allowing continuous rotation.

Principles of DC motor Control

1. Speed Control
   - * By changing voltage
   - * Higher voltage = faster motor.

2. Direction control
   - * By reversing the current in the motor

3. position Control
   - * Use servo motors or encoders with feedback