Robotics

Variable → Object

Physical → real world environment

Characteristics to understand Physical Presence

1. Temperature — feel করা যায়
2. Light / Energy Emission — দেখা যায়
3. Motion - Independent object এর movement দেখলে বুঝা যায়

Classification of Sensors

- Mechanical Quantities / Physical Quantities — Measure করে যেগুলো পাওয়া যায়
- Thermal Quantities - Feel করে পাওয়া যায়
- Electromagnetic / Optical quantities — A, Voltage, Resistance
- Chemical Quantities - moisture, pH value

Accuracy vs Precision

Arduino -

Analog pins - Physical existense sense করে, value read করে

Digital pins - Ata Analog data কে digital এ (0/1) এ convert করে

① Precision Without Accuracy

∴ Reading Target এর থেকে দূরে আছে but value ঠিক আছে. মানে value ঠিক আছে but correct place এ নাই

② Accuray Without Precision

Target এর ভিতরে ও বাইরে value আছে.
Target এর বাইরের গুলোকে outlier বলে, যেগুলো errors increase করে.

③ Precision and Accuracy

Target এর ভিতরে value আছে.

Specifications of Sensor

① Dynamic Range – কতটুকু পর্যন্ত / max/min কত area/input পর্যন্ত record করতে পারে. নির্দিষ্ট capacity পর্যন্ত sense করতে পারবে

Example : DHT11 - max = 100°C
Min = -10°C

② Linearity – the deviation of the output from a best fit straight line

Physical Existance/ Input Signal

③ Transfer Function (frequency Function) = Frequency domain কে Laplace এর সাহায্যে Algebric Function/ Equation এ convert করে. or electric output Signal's (0's or 1's) এ represent করে.

④ Bandwidth

Machine Vs Robot

Sensing, Planning, Acting

Environmental Attribute

- Temp
- Moisture
- Humidity
- Light

Analog Data → convert → Digital Data

Quantitative Data

Localization → Hidden Map create করে location save রাখতে পারে

Physical Principles → কোন Theory / rule এর উপর base করে physical measure কে quantitave measure এ convert করি

Physical Principles → To describe Physical quantities we have various laws

Types of Sensors

Sensor থেকে কিছু বলে যাওয়া

- Active – IR sensor – Emit Signals to other sensors/devices
- Passive – Thermometer – ~~Recieve~~ Signal emit করবে না. just measure করবে.

Mid Syllabus

→ Introduction (Laws and Characteristics)

→ Working with Sensors

→ Actuators

→ Forward and Inverse Kinematics

Robot as a System

Angular measurement / Move along a certain axis

Mechanical Units — Joints / Links (Rotational joint, Prismatic Joint)

Sensor Units — Physical environment থেকে sense করে

Actuation Units — Motors, Gears — Movement করে

Supervision Units — Programs / Commands (Micro-controller এর ভিতরে) দিয়ে Robot run করব.

Proprioceptive (velocity and position determine করে)

exteroceptive (force and proximity)

Actuation Systems

Power Supply

External Energy Source - Motor ঘুরানোর জন্য লাগবে

1. Mechanical Oils (Petrol, Octane)
2. Current Supply (Power Grid 220v, Dry cell)

Power Applifier - Particular sensor এর জন্য কতটুকু Power দরকার সেটি measure করে

years অনবরত চালানোর পর ক্ষয় / loss হয়

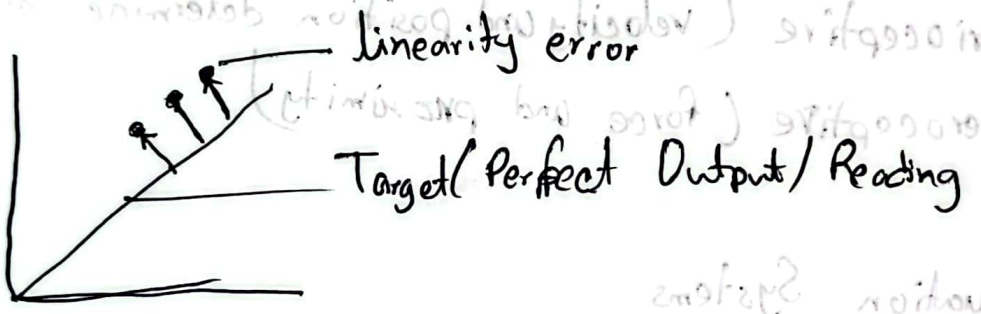
Accuracy – Targeted Outcome এর কত কাছাকাছি যেতে পারি

Calibration – value precise করে আরো accurate করা

Repeatability

Robot এর Output: To Stop at third compartment

Linearity Error



Offset Error

Input = 0

Expected Output 0 আসা উচিত, But System এর কারণে error হয়েছে.

তাই input = 0 হলেও output vary করে.

Normal / Expected	System Error
Input = 0	Input = 0
Output = 0	Output = 0 ← Offset error

External কোনো issue ~~like~~ e

Resolution Error

Input = 1
Output = 3

Input = 1.1
Output = 3.1

Input = 1.2
Output = 3.2

Input = 1.3
Output = 3.2

কিছু নির্দিষ্ট Input এর পর output বাড়ে না, output এর range এর মধ্যে output দেয়

Force / Torque and Deformation

Deformation (Original State থেকে কোনো এটি changes আসছে

↑

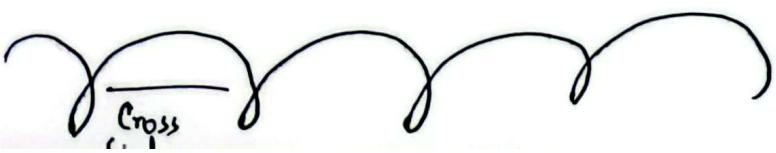
External Environment

Force এর কারণে হতে পারে

— wire এর resistance - R = 10Ω

— Force দিয়ে লম্বা করা হলো R=30Ω

Length ↑ Resistance ↑



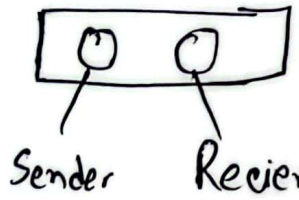
— resistance কমে যাবে
R = 5Ω

Cross

Torque - Angular Force

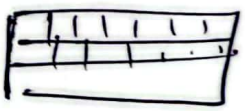
Time of flight & distance

Object কে hit করে
back করার time



Types of Camera Structure

CCD (Charge Coupled Device) - Semiconductor Material দিয়ে
যার কারণে free charge / free electron ঘুরাঘুরি করত, free electron
ক্যামেরার cell কে ফুটত, photoelectric effect create হতো.



Robot Kinematics (10 mark)

Robot Kinematics (Arm)

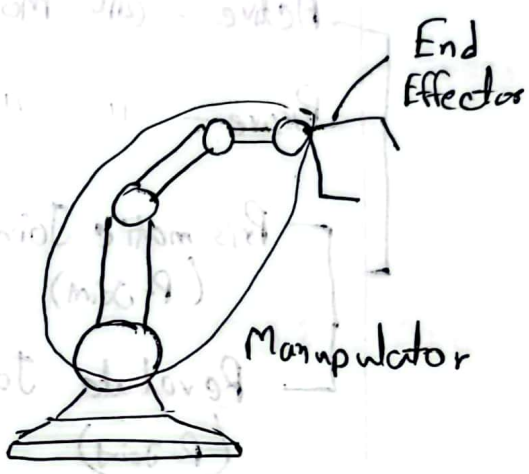
Motivation

Robotic Arm এর (x, y, z) বের করতে হবে

Movable Portion (Joints)

Structural Portion (Links)

Geometry of motion (x, y, z)



Goal

End effector এর x, y, z বের করতে হয়.

Types of Kinematics

① Forward

দেয়া থাকবে -

Length of Arms

Joint Angle

বের করতে হবে -

end effector এর x, y, z

② Inverse

দেয়া থাকবে -

x, y, z

Length of Arms

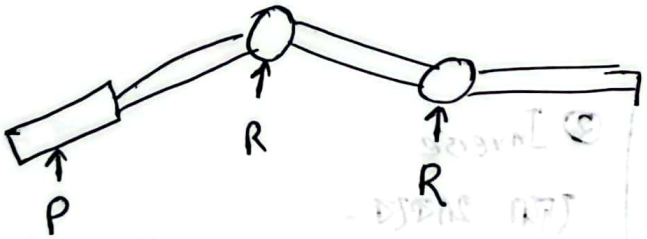
বের করতে হবে -

Joint Angles

Types of Joint (Depends on Mobility)

- Active – যেটি move করতে পারি
- Passive – " " " " না
  - Prismatic Joint (P-Joint) – একটি axis এর উপর move করতে পারে (like প্রশ্ন এর মত করে Hand Move) | No Angle 0°—0°
  - Revolute Joint (R-Joint) – Rotational motion create করে একটি single axis এ | 0—180°

#যতগুলো number of active joints = degree of freedom



3 degree of freedom

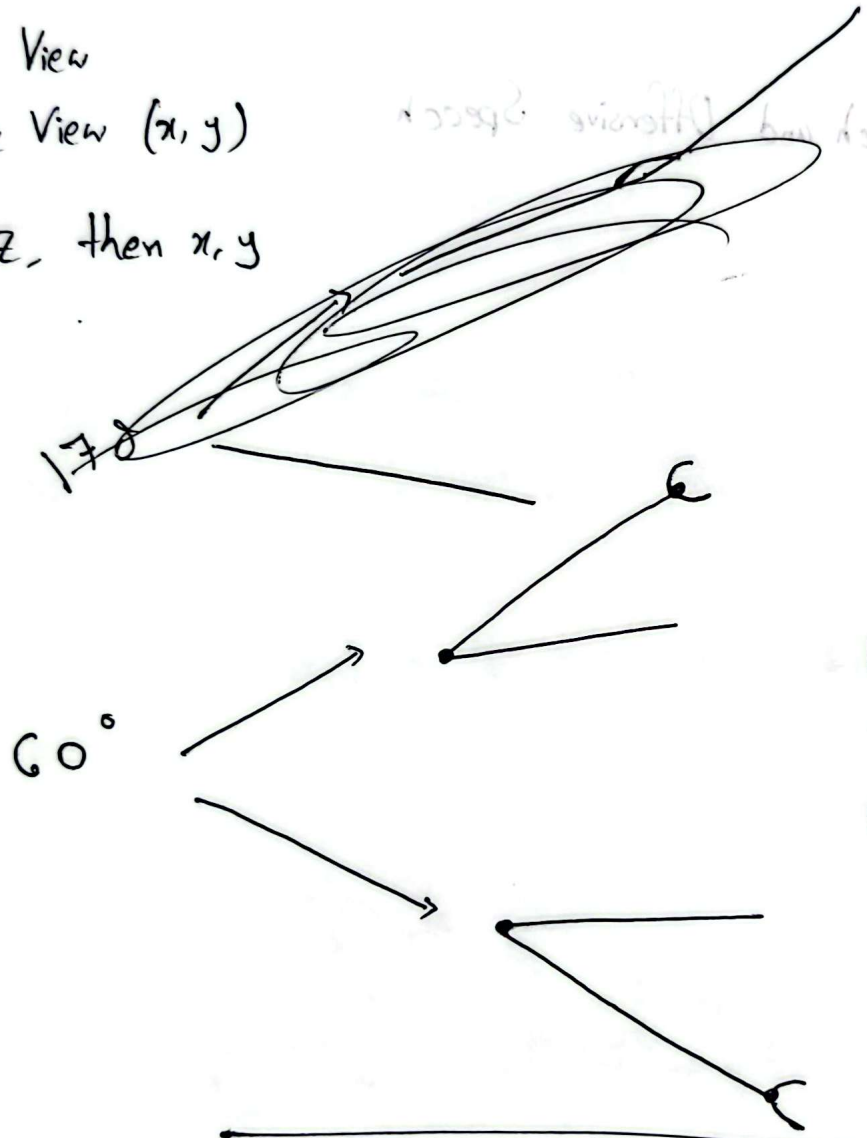
Forward Kinematics using Trigonometry

(x, y, z) → এই z এর কারণে 3D perspective এ imagine করতে হবে

② Top View

① Side View (x, y)

Find z, then x, y



① $d3 = 20 \sin 60°$

② $d6 = 14 \cos 65°$

③ z

④ $d_1 + l_3$

⑤ $d_1 = d_4 + d_5$

⑥ $d_4 = 20 \cos 60°$

⑦ $d_5 = 14 \sin 65°$

⑧ $x = (d_1 + l_3) \times \cos\theta_1$

⑨ $y = (d_1 + l_3) \times \sin\theta_1$

Platform

$$z = \text{base height} + [l_1 \times \sin\theta_2 - l_2 \times \cos\theta_{3y}]$$

$$= \text{base height} + [l_1 \times \sin\theta_2 - l_2 \cos[\theta_3 + \theta_2 - 270]$$

65
20
153

180
155
25

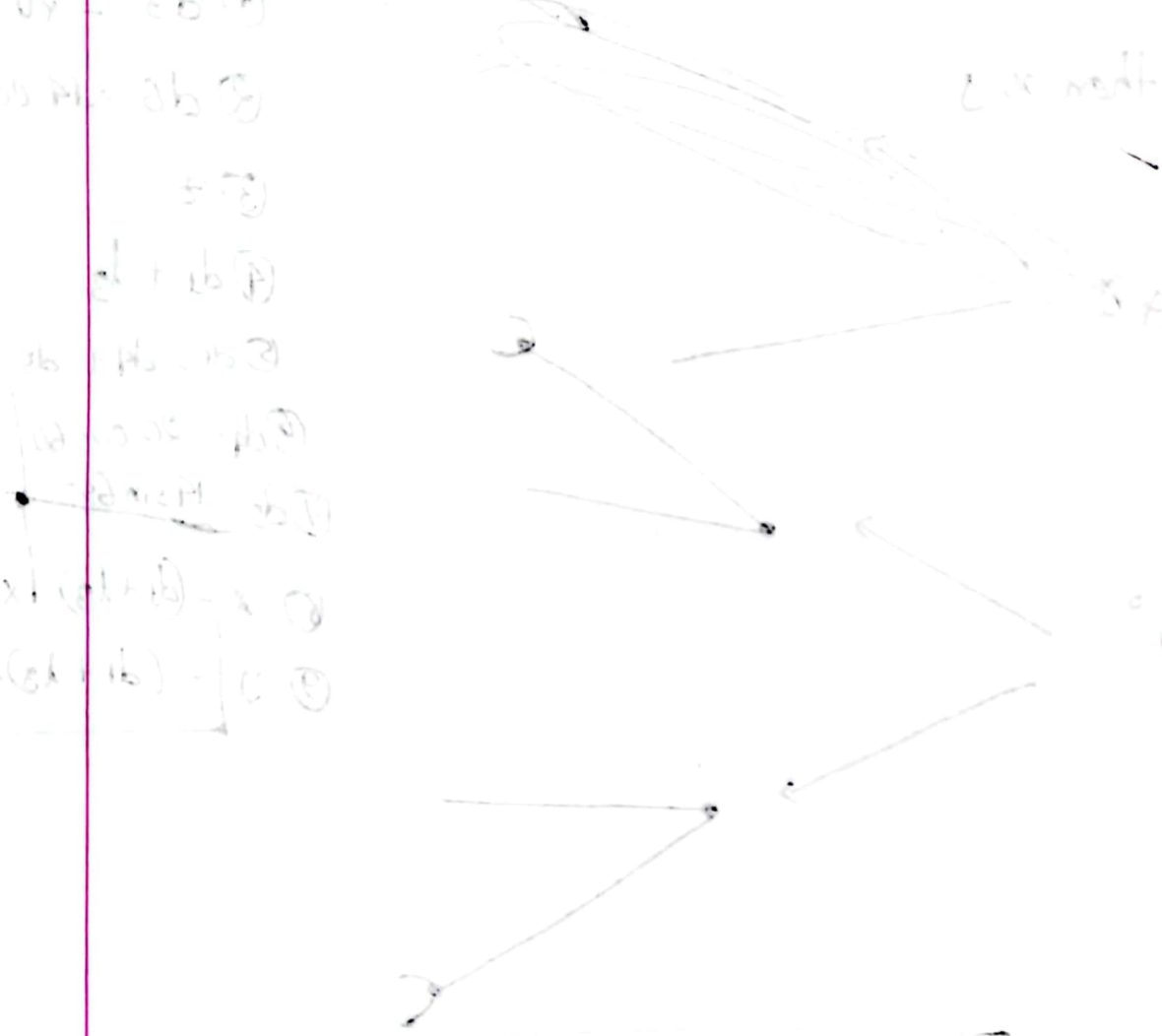
z = height of arm end point

Social and Professional Issues in Computing

Benefits

Privacy

Free Speech and Offensive Speech



Principle of Robotics

Monday Quiz

Kinematics, Sensors, Introduction (Characteristics, Robot Laws)

Reverse Kinematics Example

Arm length, $(x, y, z) \longrightarrow$ Angle

① — Top View
② — Side View

Step-1

Top View থেকে d_1 এর value বের করব

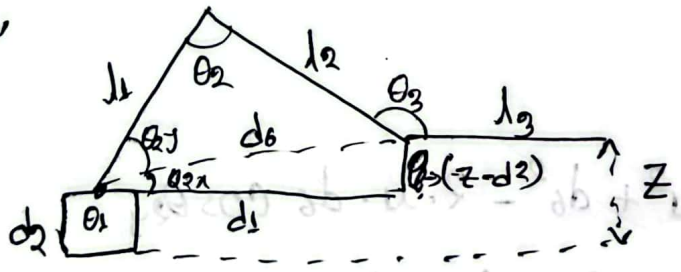
দেয়া আছে, $l_3, x, y, 90° \angle, d_1 = 24.02,$

Step-2

tan এর formula দিয়ে θ_1 বের করব $\theta_1 = 51.34$

Step-3

Side View

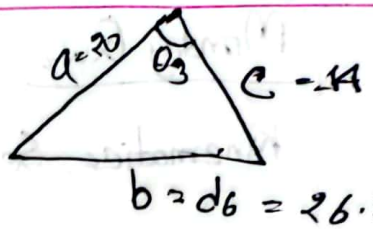


Imaginary Right Angle create করে d_6 এর value বের করব

$$d_6^2 = d_1^2 + l_2^2$$
$$d_6 = \sqrt{d_1^2 + l_4^4}$$
$$= 26.85$$

$$\theta_{2x} = \sin^{-1}\left(\frac{l_2}{26.85}\right)$$
$$= 26.54°$$

Step-4. Find θ_3



Cosine Rule:

$$b^2 = a^2 + c^2 - 2ac\cos\theta$$

$$d_6^2 = l_1^2 + l_2^2 - 2 l_1 l_2 \cos\theta_3$$

$$\cos\theta_3 = \frac{l_1^2 + l_2^2 - d_6^2}{2 l_1 \cdot l_2}$$

$$\theta_3 = \cos^{-1}\left(\frac{l_1^2 + l_2^2 - d_6^2}{2 \cdot l_1 \cdot l_2}\right)$$

$$= \cos^{-1}\left(\frac{20^2 + 14^2 - 26.85^2}{2 \times 20 \times 14}\right)$$

$$= 102.71^\circ$$

Step-5

Find θ_{2y}

Cosine Rule:

$$l_2^2 = l_1^2 + d_6^2 - 2 \cdot l_1 \cdot d_6 \cos\theta_{2y}$$

$$\cos\theta_{2y} = \frac{l_1^2 + d_6^2 - l_2^2}{2 l_1 d_6}$$

$$\theta_{2y} = \cos^{-1}\left(\frac{l_2^2 + d_6^2 - l_2^2}{2 l_1 d_6}\right)$$

$$= 30.69^\circ$$

Step - 6

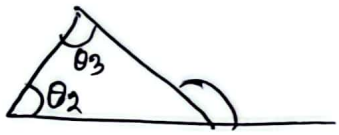
$$\theta_2 = \theta_{2x} + \theta_{2y}$$

$$= 26.54^\circ + 30.69^\circ$$

$$= 57.23^\circ$$

Step - 7

$$\theta_4 = \theta_2 + \theta_3$$



Sum of two interior angle = 1 external angle

$$\theta_4 = 57.23 + 102.71$$

$$= 159.94^\circ$$

The Arm with end effector

The last arm

14

is horizontal with the ground

Horizontal with the groud