Lecture 02

Robot Applications

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Outline

- **Introduction**
- **Industrial applications**
- **Other applications**
- **Summary**

Introduction

- 90% robots in factories: Industrial robots
- Finding way into
  - Warehouses (e.g., Flipkart, Amazon)
  - Laboratories (e.g., IIT Delhi's PAR Lab.)
  - Research and exploration sites (e.g., oil, gas)
  - Power plants (e.g., NTPC's inspection)
  - Hospitals (e.g., as nurse)
  - Undersea (e.g., search and rescue)
  - Outer space (e.g., Chandrayan, Pathfinder)
  - Entertainment (e.g., RoboMuse@IIT Delhi)

Advantages

- Never gets sick, or needs rest
- Can work 24 hours a day, 7 days a week
- Dangerous for a person, give to robot
- Robots do not get bored.

Repetitive and unrewarding → Use robot

Material Handling

- 95% in manufacturing a part is composed of transfer and waiting time
- 5% is actual processing
- Processing time was reduced by automation
- One needs to reduce in handling and loading

- Fully automatic: Transfer lines in automobile industry → Hard automation
- Not suitable for batch production (50 to 100,000/year)
- Flexible automation → Frequent changes in production is needed (~75% parts)

- Industrial robots is a solution: Handling and m/c tool loading of small/medium parts

- Robots are utilised to load and unload m/c tools for
  - tending a single machine, and
  - serving several machines

Welding

- Spot-welding Robots
  - A spot-welding robot has to carry the welding gun
  - A gun consists of the electrodes, cables to conduct high current, and sometimes water-cooling system
  - The welding gun is heavy (10 to 80 kg)
  - DC motor driven robots cannot handle
  - Hydraulically powered
  - Point to point (PTP) with high positional accuracy
  - Positional repeatability: $\pm$ 1 mm

- Repeatability is better than humans
- Robotised spot welding is very fast
- Positioning of welds is accurate
- For fabrication of structural metal products, domestic appliances, metal furniture, etc.
- Car assembly line (50 to 90 cars/hour)
- Work is performed while the car bodies are moving on conveyors
- Weld locations synchronized by the task programs

Arc-welding Robot

- Robotic arc welding uses a consumable wire as electrode (i.e., MIG welding)
  - Uses an automatic wire feeder
  - Welding with non-consumable tungsten electrodes under shielding gas (i.e., in TIG welding)
- Robot uses the welding gun as a tool
- Welding gun is not heavy (unless the water-cooled) → DC servomotors are used

- Welding speeds: ~0.25 to 3 m/min.
- Robot is to lead welding gun along the programmed trajectory
- Control system in arc welding is continuous path (CP) type
- To synchronized robot’s controller is interfaced with control unit of welding equipment

Spray Painting

- Spray painting is unhealthy and unpleasant → Good to use robots
- Solvent materials are toxic → Operators use masks and provided with fresh-air ventilation
- Painting area: Dust-free and temperature-controlled → Painting booth is small and inconvenient
- Noise from air discharge can cause irreversible damage to ears

Spray painting is one of the first applications of robots

- Spray painting robots: CP type, and have
  - high level of manipulator dexterity
  - large working volume
  - compact wrist
  - small payload, and
  - low accuracy and repeatability.
- Repeatability: 2 mm

Assembling and Palletizing

- Assembling is for small products, e.g., electrical switches and small motors.
- Robots
  - Cartesian
  - Cylindrical
  - Spherical, or
  - Articulated

By Coordinate System

(a) Cartesian

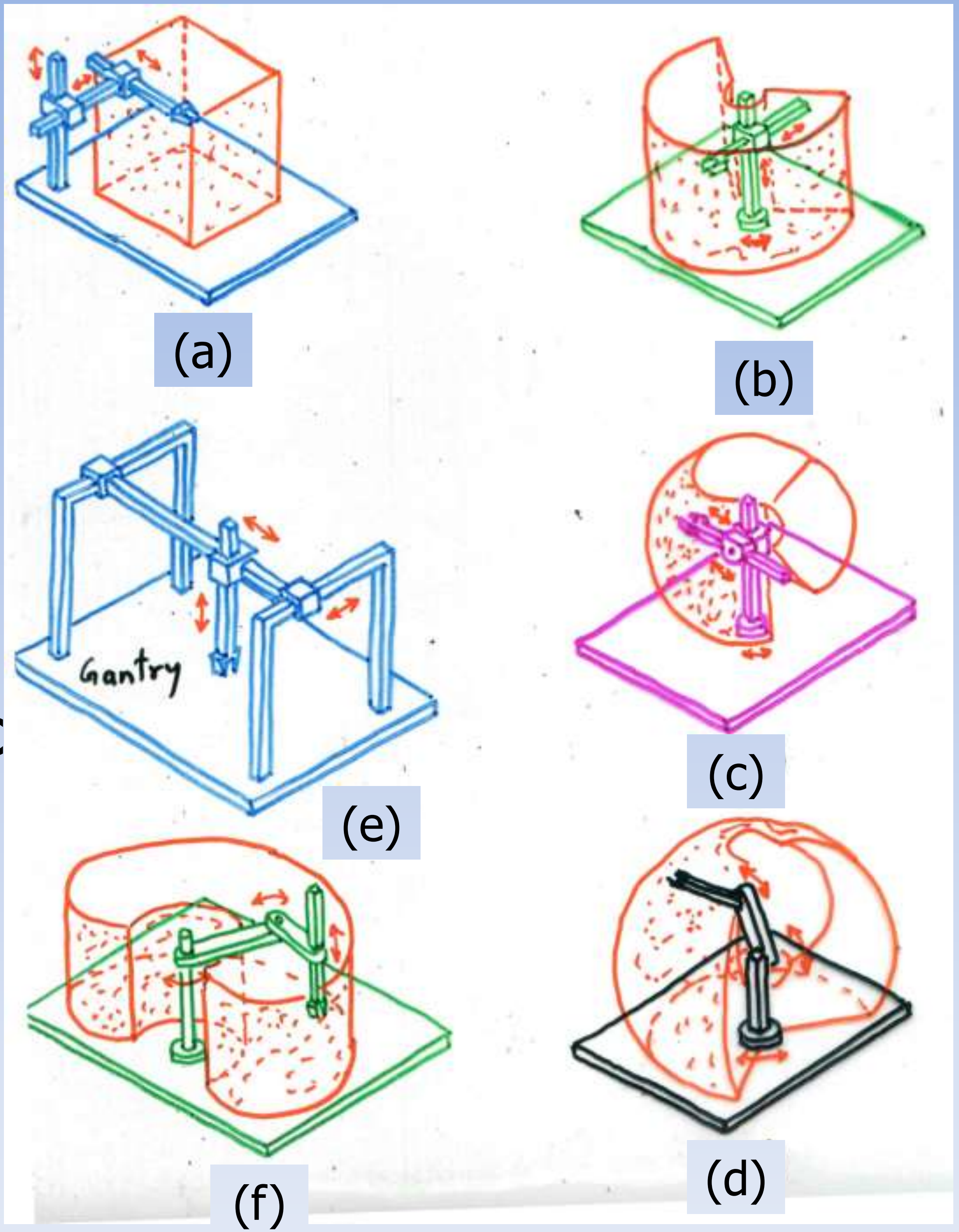
(b) Cylindrical

(c) Spherical

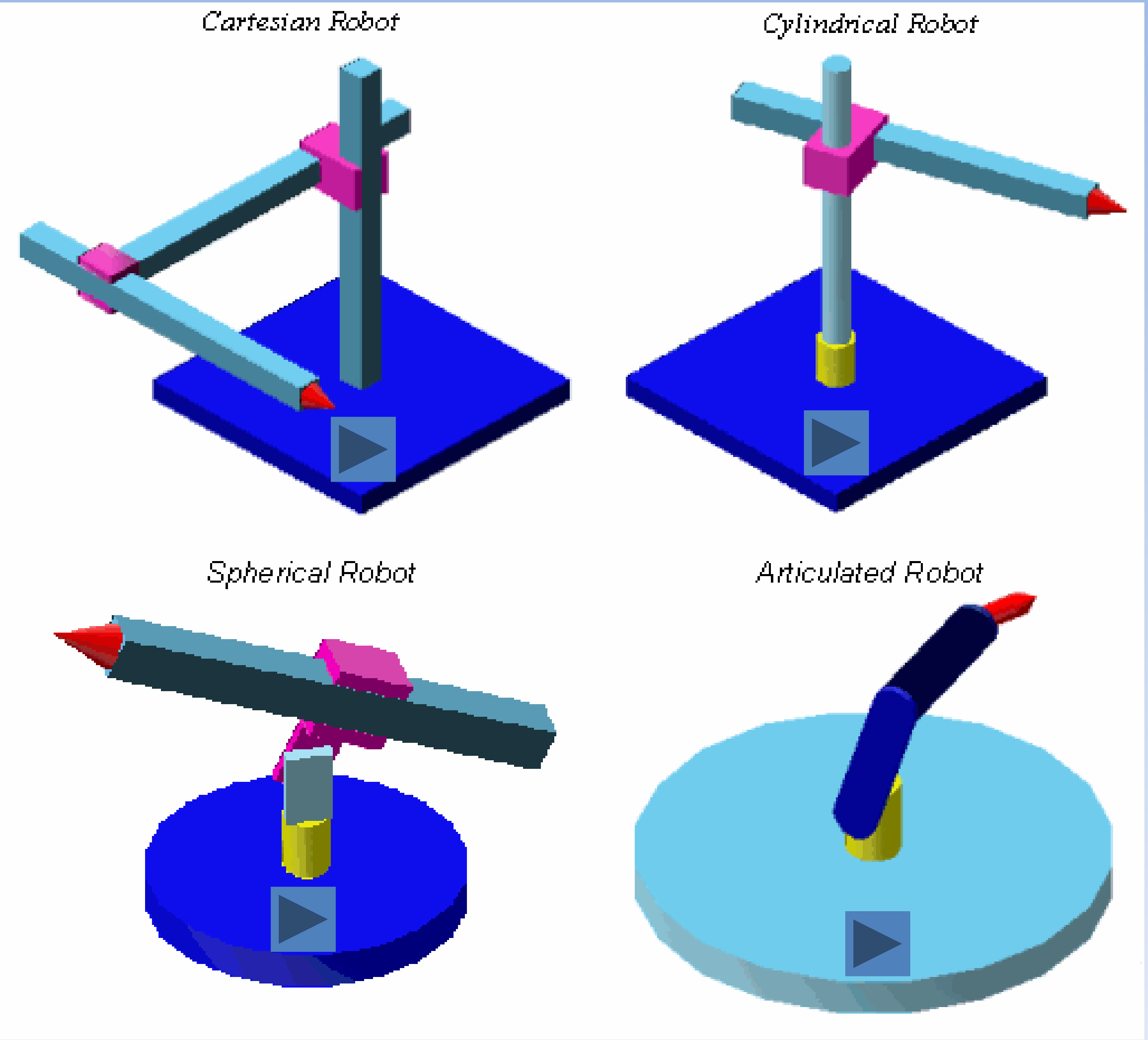
(d) Anthropomorphic

(e) Gantry ≡ (a)

(f) SCARA



Virtual Robotics Lab. (VRL) in ADAMS



Fundamental Configurations

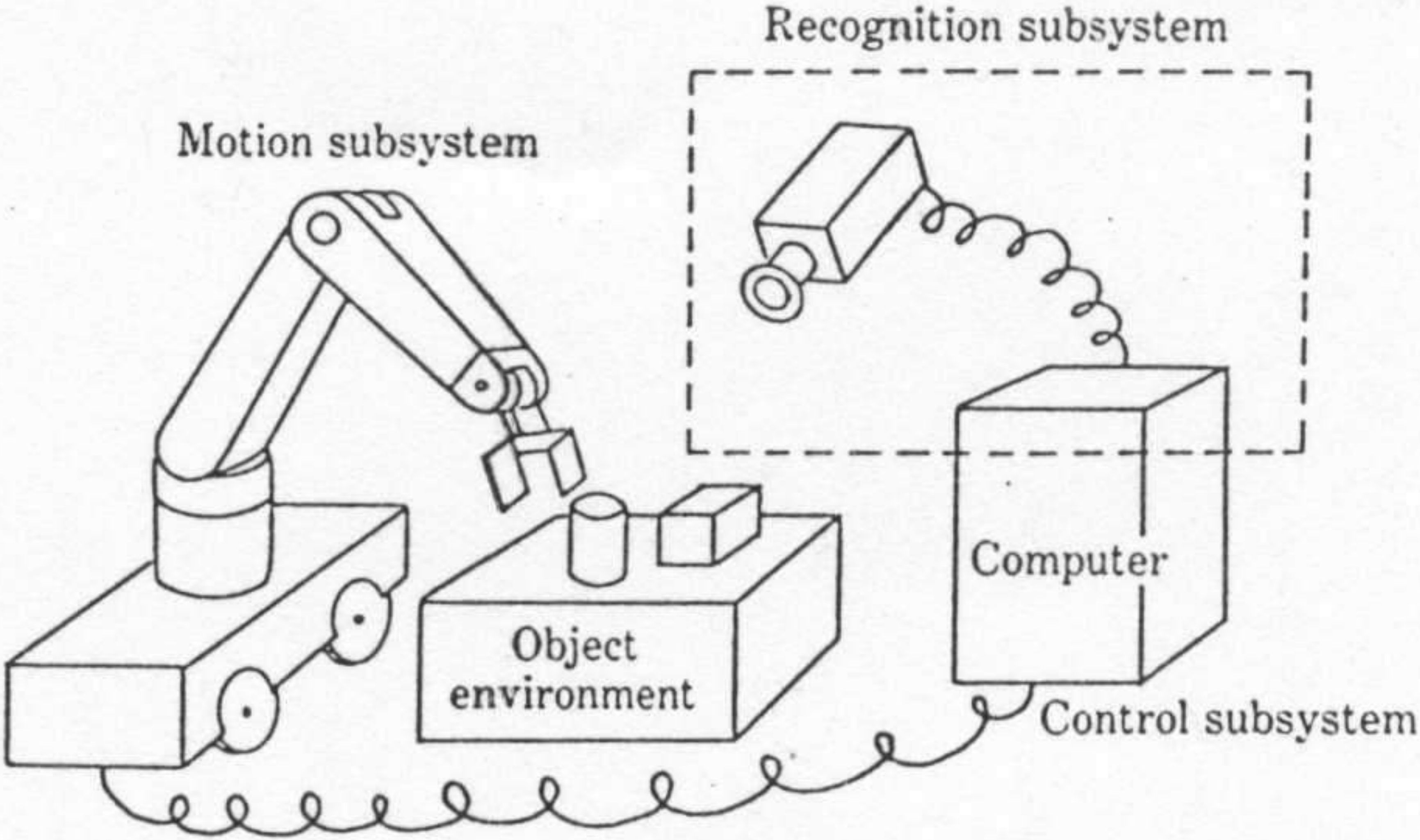
Type	Joints		
	1 (base): Motion	2 (elevation): Motion	3 (reach): Motion
Cartesian	P: travel, x	P: height y	P: reach z
↓	↓ -P+R+90^0@Z	↓	↓
Cylindrical	R: rotation θ	P: -do-	P: -do-
↓	↓	↓ -P+R+90^0@Z	↓
Spherical	R: -do-	R: angle φ	P: -do-
	↓	↓	↓ -P+R+90^0@Z
Revolute	R: -do-	R: -do-	R: angle ψ

Comparison (For selection)

Fundamental Robots

Configuration	Advantages	Disadvantage
Cartesian (3 linear axes) x: base travel y: height z: reach	- Easy to visualize - Rigid structure - Easy offline programming - Easy mechanical stops	- Reach only front and back - Requires large floor space - Axes are hard to seal - Expensive
Cylindrical (1 rotation and 2 linear axes) θ: base rotation y: height z : reach	- Can reach all around - Rigid y, z-axes - θ-axes easy to seal	- Cannot reach above itself - Less rigid θ-axis - y, z-axes hard to seal - Won't reach around obstacles - Horizontal motion is circular
Spherical (2 rotating and 1 linear axes) θ: base rotation φ: elevation angle z: reach	- Can reach all around - Can reach above or below obstacles - Large work volume	- Cannot reach above itself - Short vertical reach
Articulated (3 rotating axes) θ: base rotation φ: elevation angle ψ: reach angle	- Can reach above or below objects - Largest work area for least floor space	- Difficult to program off-line - Two or more ways to reach a point - Most complex robot

Robot Subsystems [Serial Robots]



Subsystems (Contd.)

- Motion: Manipulator (Arm & Wrist), End-effector, Actuators (Set in motion), and Transmission
- Recognition: Sensors (Measure status), and ADC
- Control (Supervision): DAC, and Digital Controller

Motion Subsystem

i) Manipulator: Mechanical arm + wrist

(Difference between Robot and Manipulator?)

ii) End-effector

- Welding torch, painting brush, etc.
- Robot hand
- Simple grippers

(iii) Actuator

- Pneumatic, Hydraulic, Electric

(iv) Transmission

- Belt and chain drives
- Gears
- Link mechanisms

Recognition Subsystem

(i) Sensors (Essentially transducers)

- Converts a signal to another

(ii) Analog-to-Digital Converter (ADC)

- Electronic device

Control Subsystem

(i) Digital Controller

- CPU, Memory, Hard disk (to store programs)

(ii) Digital-to-Analog Converter (DAC)

(iii) Amplifier

- Amplify weak commands from DAC

Classifications

- By Applications (already explained)
- By Coordinate System (already explained)
- By Actuation System
- By Control Method
- By Programming Method

By Actuation System

- Pneumatic (in factory floors)
- Hydraulic (for heavy applications)
- Electric (more common these days)

By Control Method

- Servo/Non-servo control
  - Servo ≡ closed-loop (Hydraulic & Electric)
  - Non-servo ≡ open-loop (Pneumatic)
- Path control
  - Continuous path ≡ trajectory (welding etc)

By Programming Method

- Online programming
  - Direct use of the robot
  - Teach pendant
- Offline programming (saves time)
  - Using a computer on a new task
  - Download when ready

Summary

- Focus on Serial-type robots (not parallel or mobile, etc.)
- Different applications were explained
- Robot subsystems
- Five ways to classify a robot
  - Animations for coordinate based robots are shown

Thank You

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