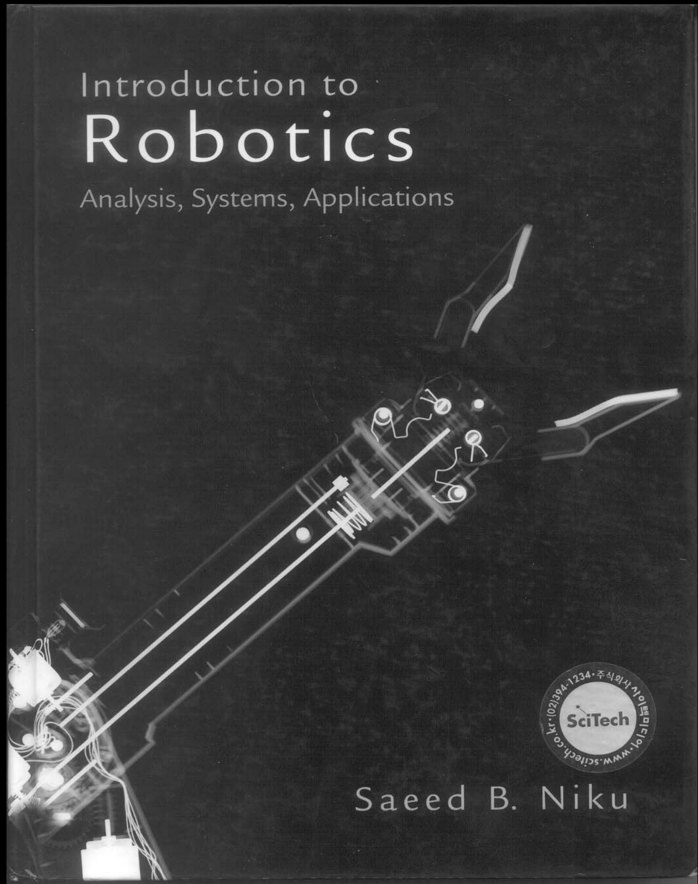
Introduction to Robotics

Analysis, systems, Applications



Saeed B. Niku

Chapter 1
Fundamentals

1. Introduction

Fig. 1.1 (a) A Kuhnezug truck-mounted crane
Reprinted with permission from Kuhnezug Fordertechnik GmbH.

Fig. 1.1 (b) Fanuc S-500 robots performing seam-sealing on a truck.
Reprinted with permission from Fanuc Robotics, North America, Inc.

What is a Robot ?

- *Random House Dictionary* A machine that resembles a human being and does mechanical routine tasks on command.
- *Robotics Association of America* An industrial robot is a re-programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.

What is a Robot ?

- A manipulator (or an industrial robot) is composed of a series of links connected to each other via joints. Each joint usually has an actuator (a motor for eg.) connected to it.
- These actuators are used to cause relative motion between successive links. One end of the manipulator is usually connected to a stable base and the other end is used to deploy a tool.

Classification of Robots

- JIRA (Japanese Industrial Robot Association)
  - Class1: Manual-Handling Device
  - Class2: Fixed Sequence Robot
  - Class3: Variable Sequence Robot
  - Class4: Playback Robot
  - Class5: Numerical Control Robot
  - Class6: Intelligent Robot

Classification of Robots

- RIA (Robotics Institute of America)
  Variable Sequence Robot(Class3)
  Playback Robot(Class4)
  Numerical Control Robot(Class5)
  Intelligent Robot(Class6)

Classification of Robots

- AFR (Association FranÇaise de Robotique)

Type A: Manual Handling Devices/ telerobotics

Type B: Automatic Handling Devices/ predetermined cycles

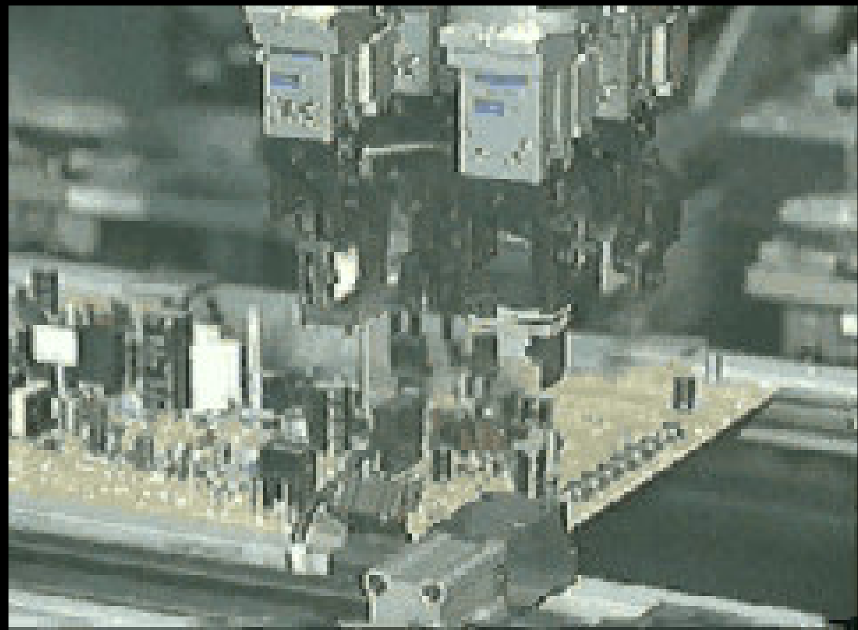
Type C: Programmable, Servo controlled robot, continuous point-to-point trajectories

Type D: Same type with C, but it can acquire information.

Chapter 1
Fundamentals

- Robot in the world

Painting Robot in Motor Company



Assembly Robot in Electronic Company

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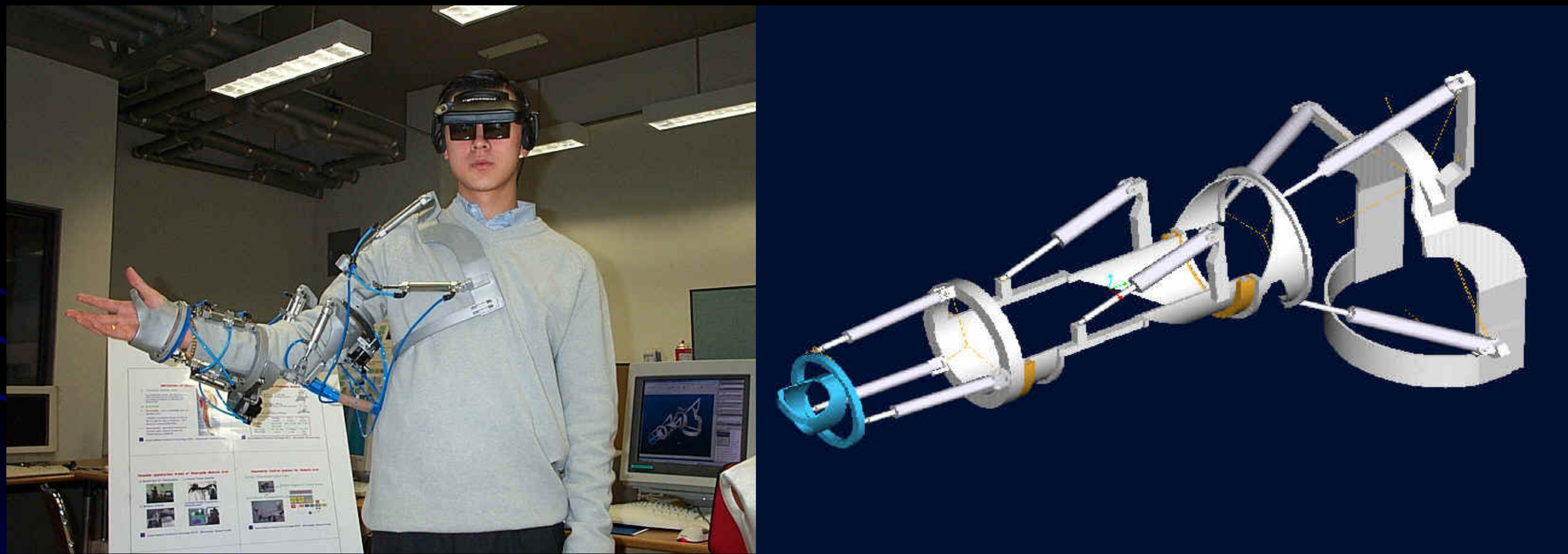
Fundamentals

- Robot in the world

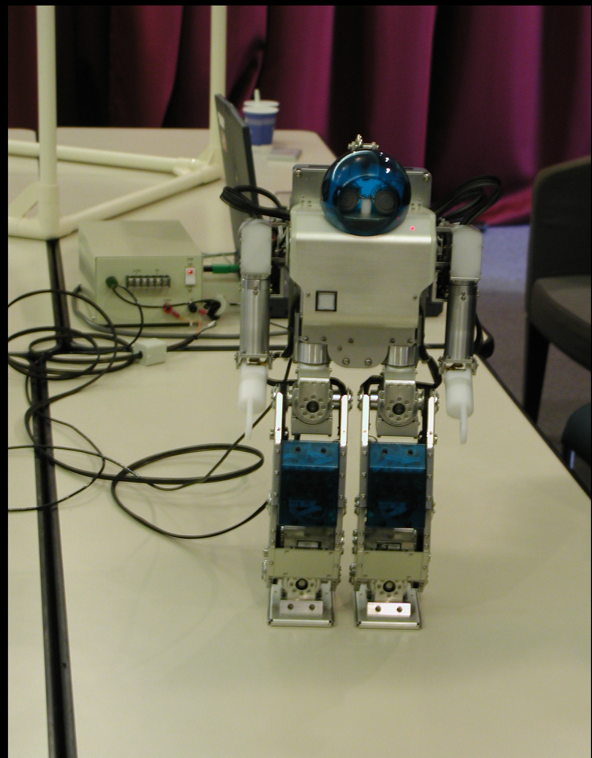


Wearable Robotic Arm and Tele-Operated Robot (KIST)

Chapter 1
Fundamentals

- Robot in the world

HONDA (ASIMO) – Biped Robot



Fujitsu – Biped Robot (Laptop Size)

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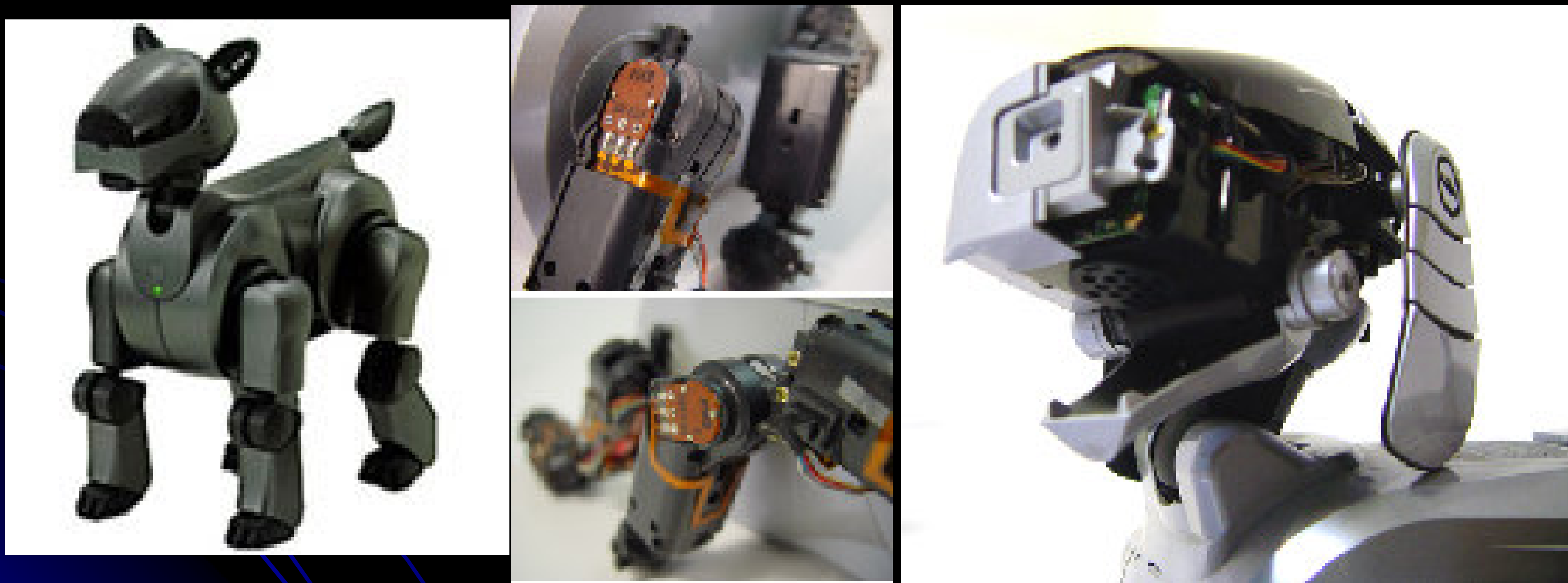
Fundamentals

- Robot in the world



Sony (AIBO) – Toy robot

What is Robotics?

- Robotics is the art, knowledge base, and the know-how of designing, applying, and using robots in human endeavors.
- Robotics is an interdisciplinary subject that benefits from mechanical engineering, electrical and electronic engineering, computer science, biology, and many other disciplines.

What is Robotics

- History of Robotics

1922: Karel Čapek’s novel, Rossum’s Universal Robots, word “Robota” (worker)
1952: NC machine (MIT)
1955: Denavit-Hartenberg Homogeneous Transformation
1967: Mark II (Unimation Inc.)
1968: Shakey (SRI) - intelligent robot
1973: T3 (Cincinnati Milacron Inc.)
1978: PUMA (Unimation Inc.)
1983: Robotics Courses
21C: Walking Robots, Mobile Robots, Humanoid Robots

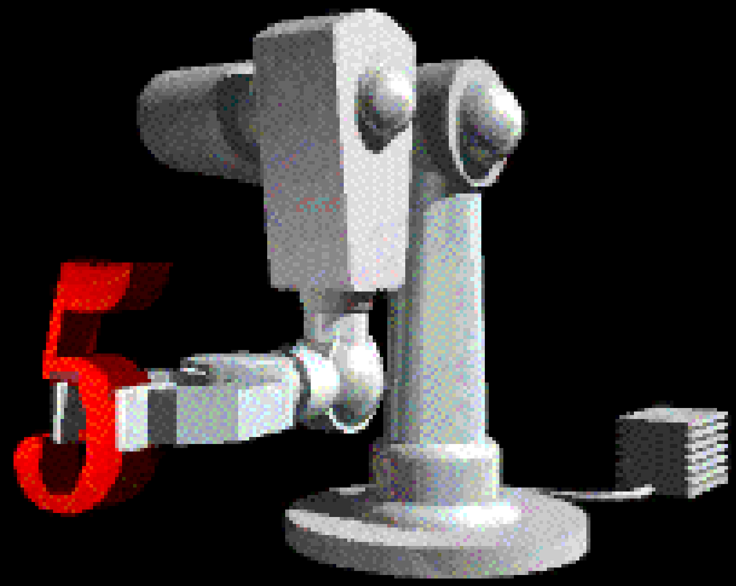
Advantages VS. Disadvantages of Robots

- Robots increase productivity, safety, efficiency, quality, and consistency of products.
- Robots can work in hazardous environments without the need.
- Robots need no environmental comfort.
- Robots work continuously without experiencing fatigue of problem.
- Robots have repeatable precision at all times.
- Robots can be much more accurate than human.
- Robots replace human workers creating economic problems.
- Robots can process multiple stimuli or tasks simultaneously.

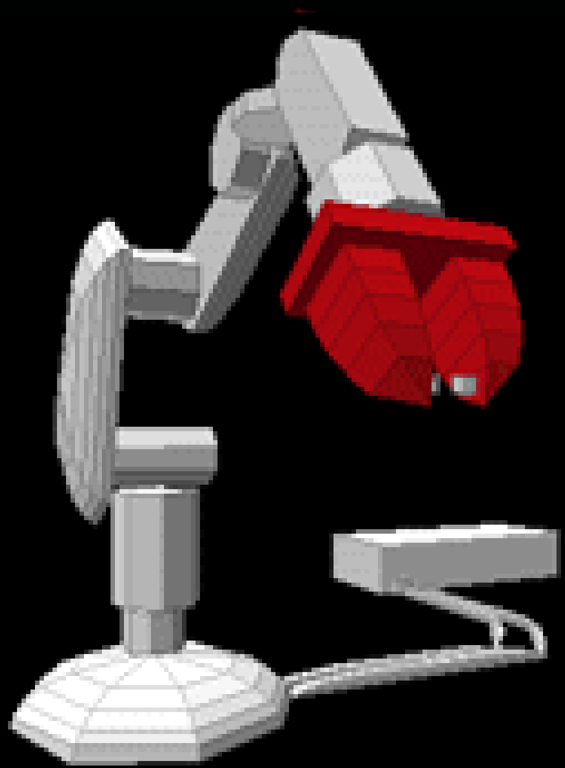
- Robots lack capability to respond in emergencies.
- Robots, although superior in certain senses, have limited capabilities in Degree of freedom, Dexterity, Sensors, Vision system, real time response.
- Robots are costly, due to Initial cost of equipment, Installation costs, Need for Peripherals, Need for training, Need for programming.

What are the parts of a robot?

- Manipulator
- Pedestal
- Controller
- End Effectors
- Power Source



Manipulator



- Base
- Appendages
  - Shoulder
  - Arm
  - Grippers

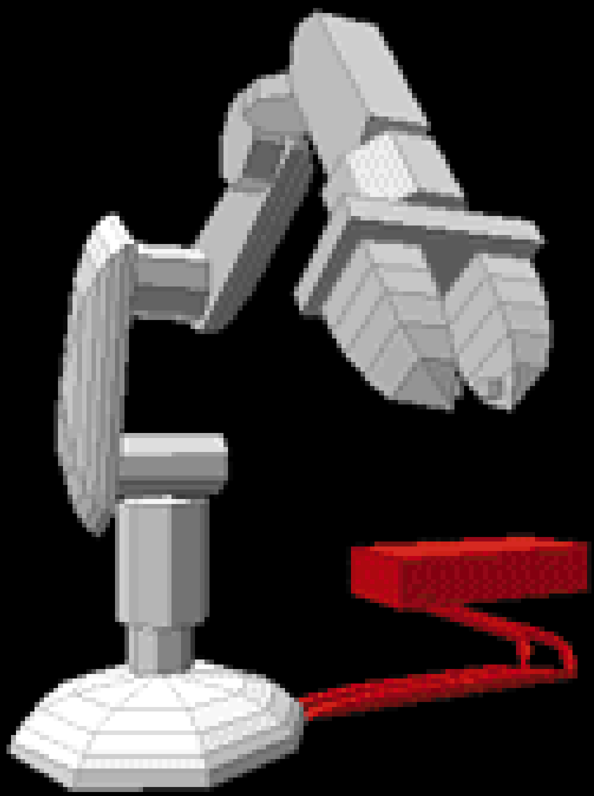
Pedestal

(Human waist)

- Supports the manipulator.
- Acts as a counterbalance.

Controller

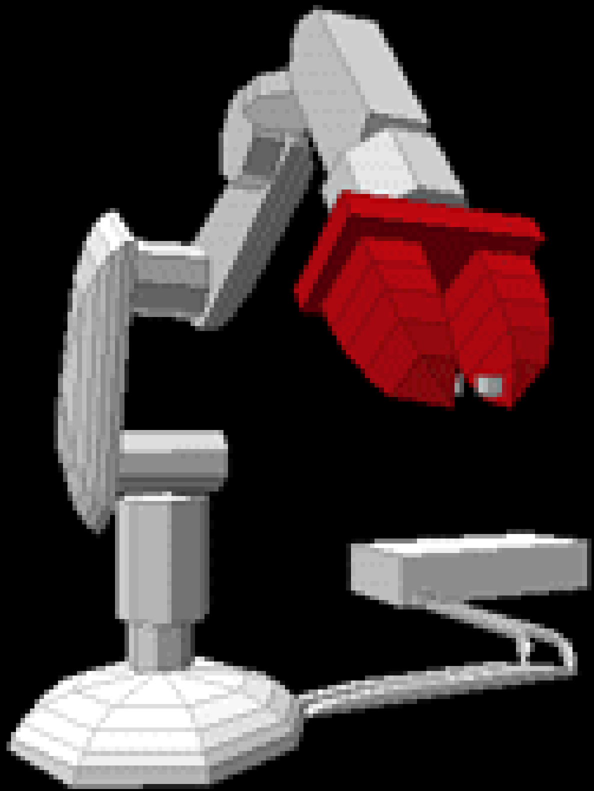
(The brain)



- Issues instructions to the robot.
- Controls peripheral devices.
- Interfaces with robot.
- Interfaces with humans.

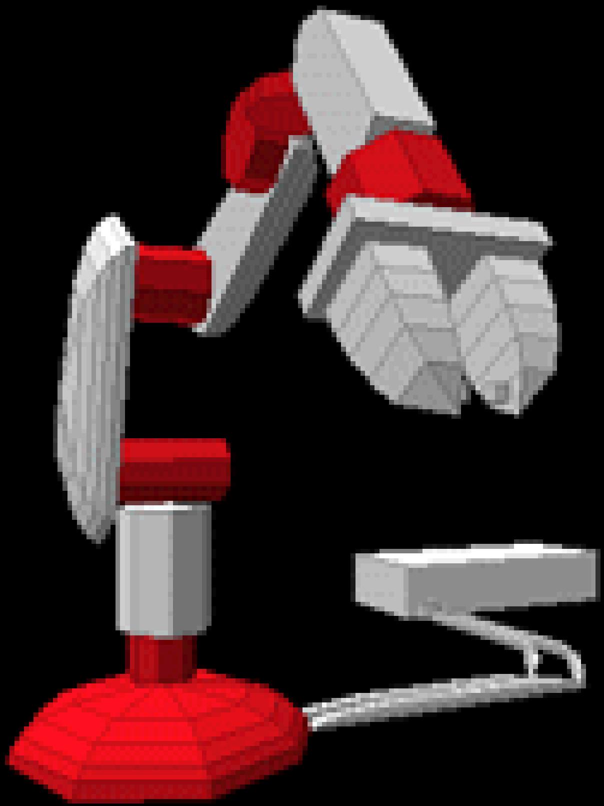
End Effectors

(The hand)



- Spray paint attachments
- Welding attachments
- Vacuum heads
- Hands
- Grippers

Power Source



(The food)

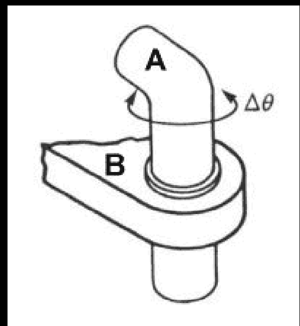
- Electric
- Pneumatic
- Hydraulic

Robots degrees of freedom

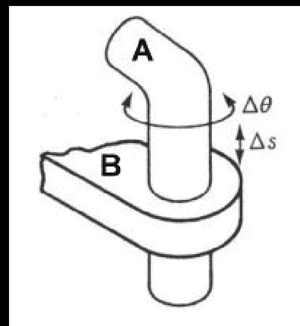
- Degrees of Freedom: Number of independent position variables which would has to be specified to locate all parts of a mechanism.
- In most manipulators this is usually the number of joints.

Robots degrees of freedom

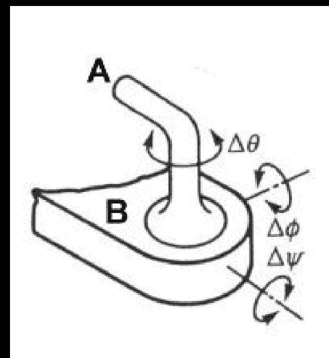
Consider what is the degree of Fig. 3



1 D.O.F.



2 D.O.F.



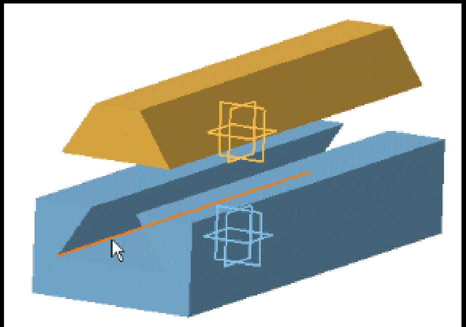
3 D.O.F.

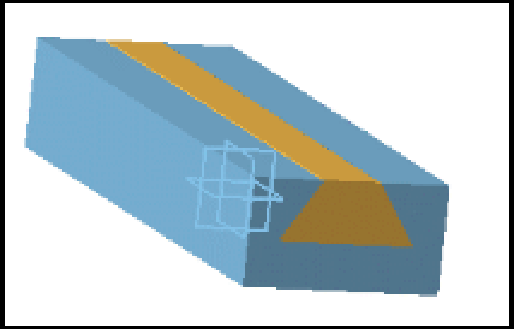
Fig. 1.3 A Fanuc P-15 robot.

Robot Joints

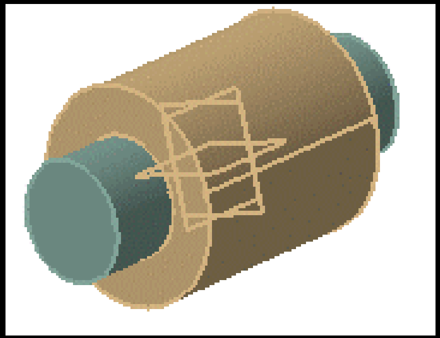
Prismatic Joint: Linear, No rotation involved.

(Hydraulic or pneumatic cylinder)





Revolute Joint: Rotary, (electrically driven with stepper motor, servo motor)



Robot Coordinates

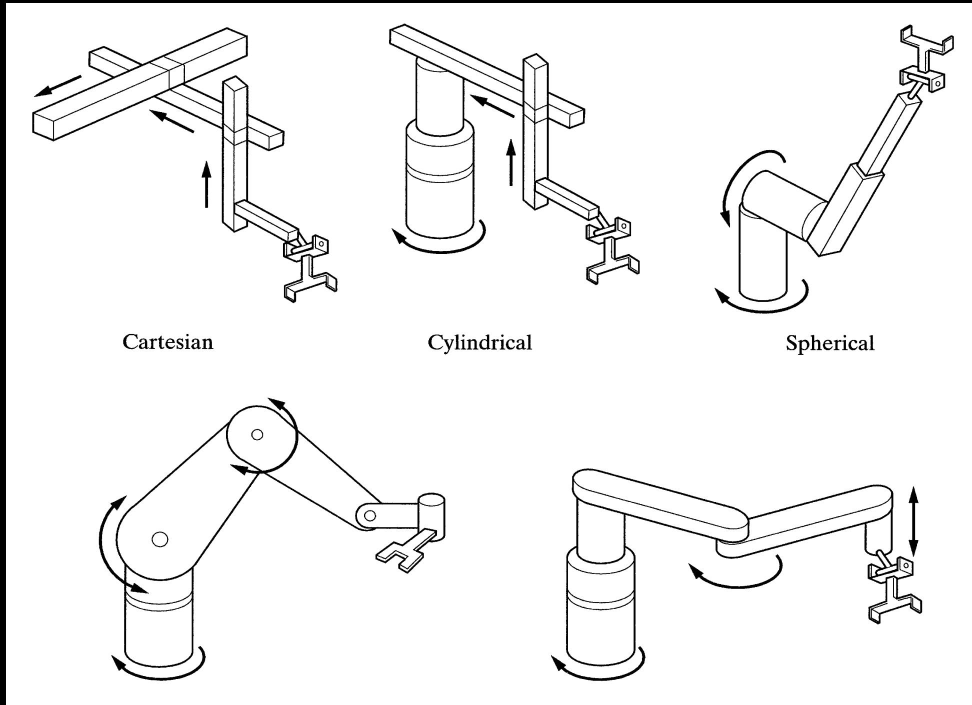


Fig. 1.4

- Cartesian/rectangular/gantry (3P) : 3 cylinders joint
- Cylindrical (R2P) : 2 Prismatic joint and 1 revolute joint
- Spherical (2RP) : 1 Prismatic joint and 2 revolute joint
- Articulated/anthropomorphic (3R) : All revolute(Human arm)
- Selective Compliance Assembly Robot Arm (SCARA): 2 paralleled revolute joint and 1 additional prismatic joint

Robot Reference Frames

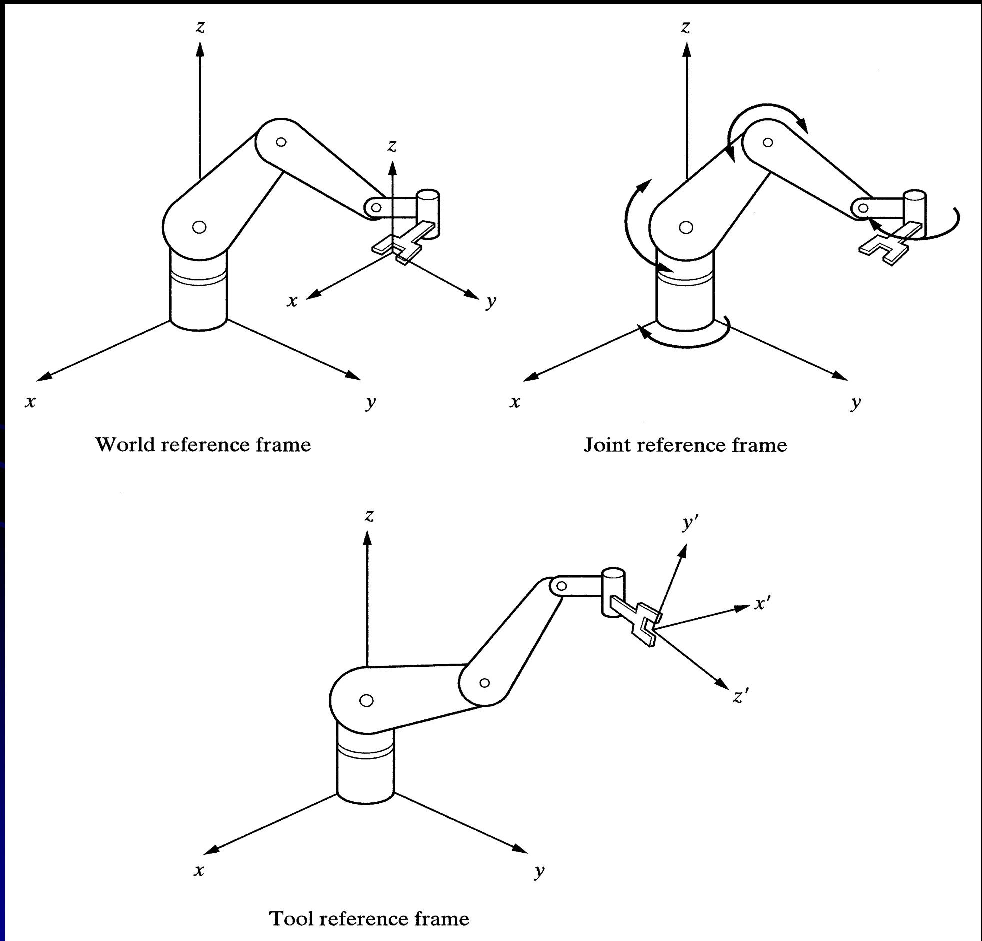


Fig. 1.6 A robot's World, Joint, and Tool reference frames.

Most robots may be programmed to move relative to either of these reference frames.

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- Programming Modes

Physical Setup: PLC
Lead Through/ Teach Mode: Teaching Pendant/ Playback, p-to-p
Continuous Walk-Through Mode: Simultaneous joint-movement
Software Mode: Use of feedback information

- Robot Characteristics

Payload: Fanuc Robotics LR Mate™ (6.6/ 86 lbs), M- 16i ™(35/ 594 lbs)
Reach: The maximum distance a robot can reach within its work envelope.
Precision (validity): defined as how accurately a specified point can be reached… 0.001 inch or better.
Repeatability (variability): how accurately the same position can be reached if the motion is repeated many times.

Robot Workspace

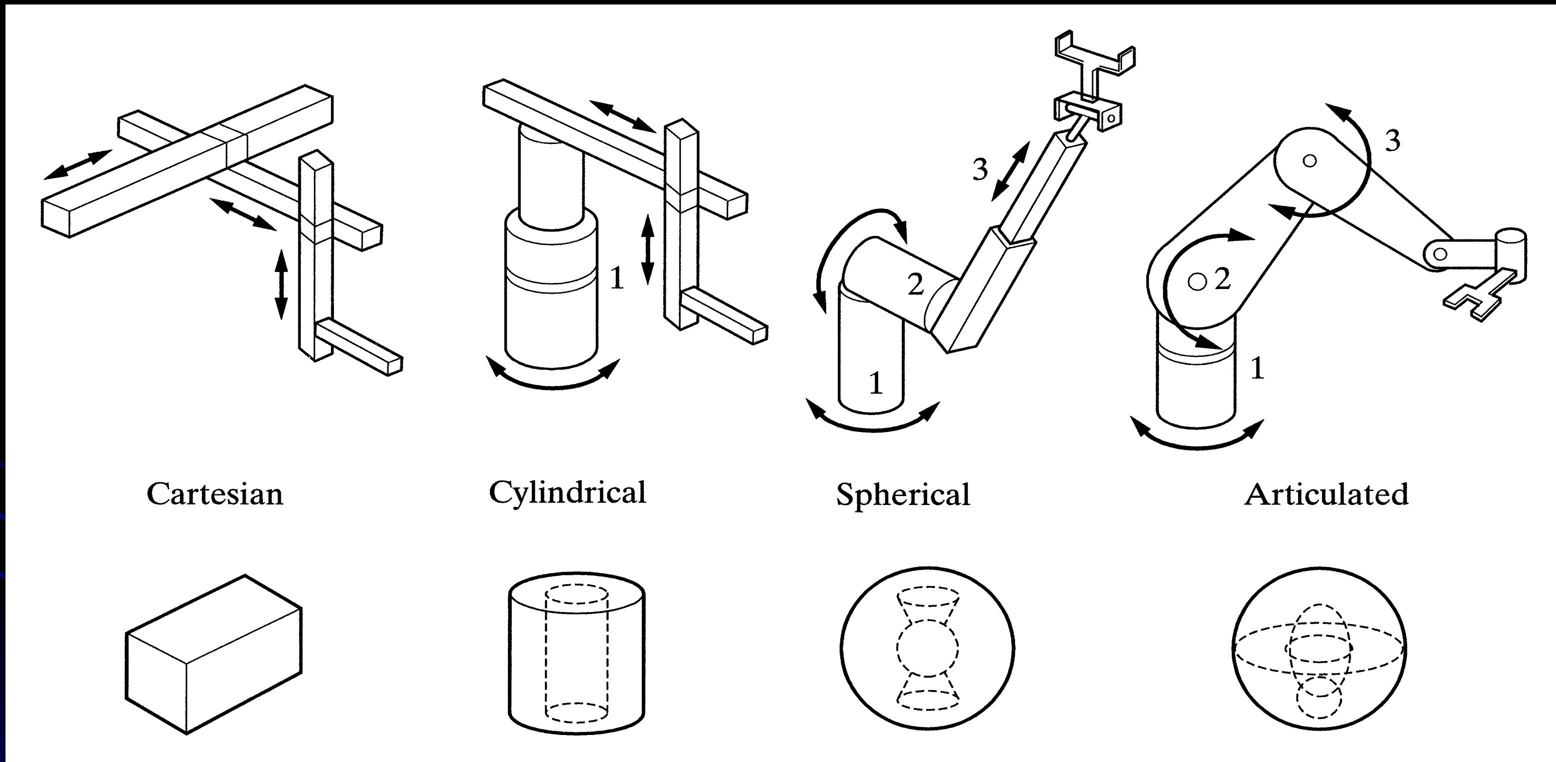

Fig. 1.7 Typical workspaces for common robot configurations

Chapter 1
Fundamentals

- Robot Languages

Microcomputer Machine Language Level: the most basic and very efficient but difficult to understand to follow.

Point-to-Point Level: Funky® Cincinnati Milacron's T3©
It lacks branching, sensory information.

Primitive Motion Level: VAL by Unimation™
Interpreter based language.

Structured Programming Level: This is a compiler based but more difficult to learn.

Task-Oriented Level: Not exist yet and proposed IBM in the 1980s.

Chapter 1
Fundamentals

- Robot Application

  Machine loading
  Pick and place operations
  Welding
  Painting
  Sampling
  Assembly operation
  Manufacturing
  Surveillance
  Medical applications
  Assisting disabled individuals
  Hazardous environments
  Underwater, space, and remote locations

Chapter 1
Fundamentals

- Robot Application

Fig. 1.8 A Staubli robot loading and unloading

Fig. 1.9 Staubli robot placing dishwasher tubs

Fig. 1.10 An AM120 Fanuc robot

Fig. 1.11 A P200 Fanuc painting automobile bodies

Chapter 1
Fundamentals

- Robot Application

Fig. 1.12 Staubli RX FRAMS robot in a BMW

Fig. 1.13 A Fanuc LR Mate 200i robot removal operation

Medical Robot of German

Fig. 1.13 The Arm, a 6 DOF bilateral force-feedback manipulator