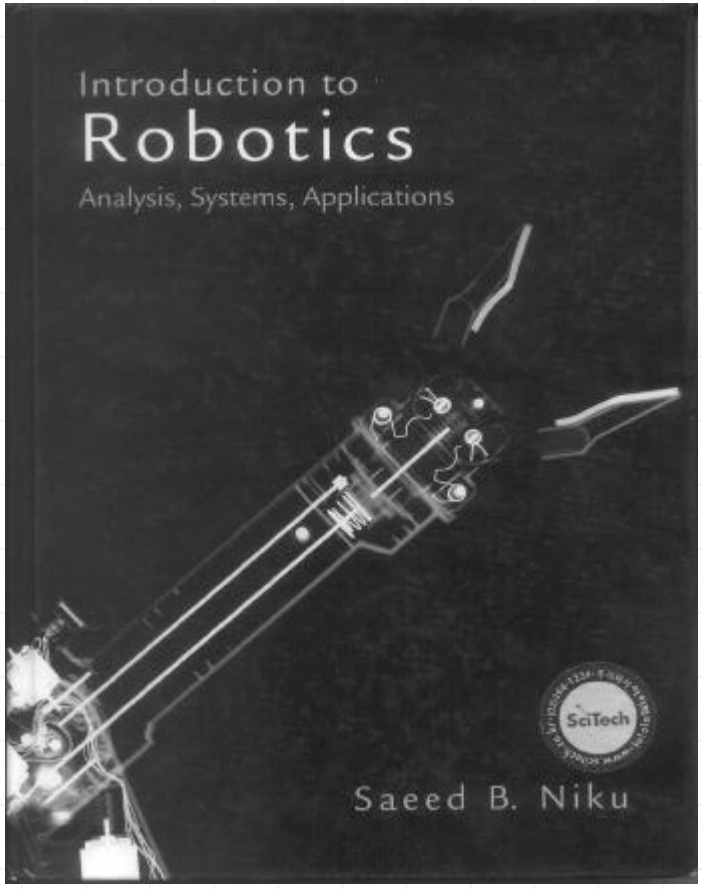
Introduction to Robotics

Analysis, systems, Applications



Saeed B. Niku

Chapter 1
Fundamentals

1. Introduction

Fig. 1.1 (a) A Kuhnezug truck-mounted crane

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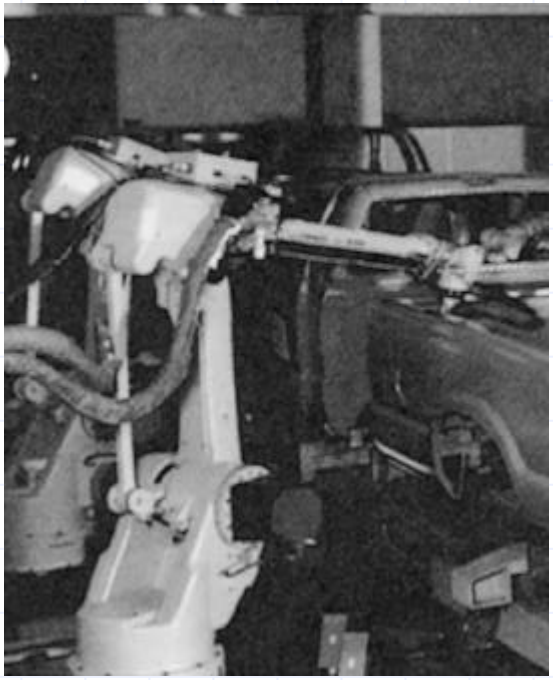

Fig. 1.1 (b) Fanuc S-500 robots performing seam-sealing on a truck.

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Chapter 1
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? What is a Robot?

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

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? What is a Robot?
Classification of Robots

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

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? What is a Robot?
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.

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- History of Robotics

1922: Karel Capek'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

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? 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.

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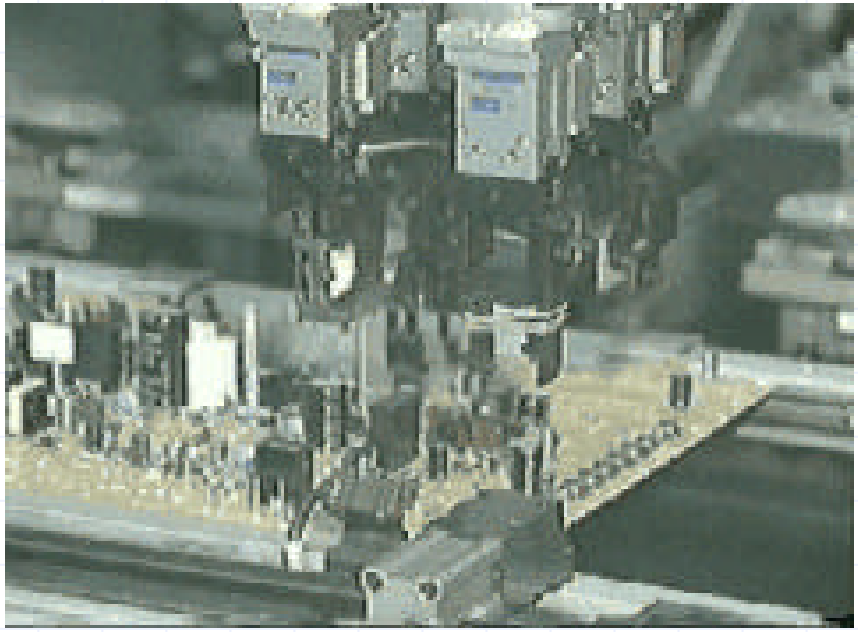
- Robot in the world

Painting Robot in Motor Company



Assembly Robot in Electronic Company

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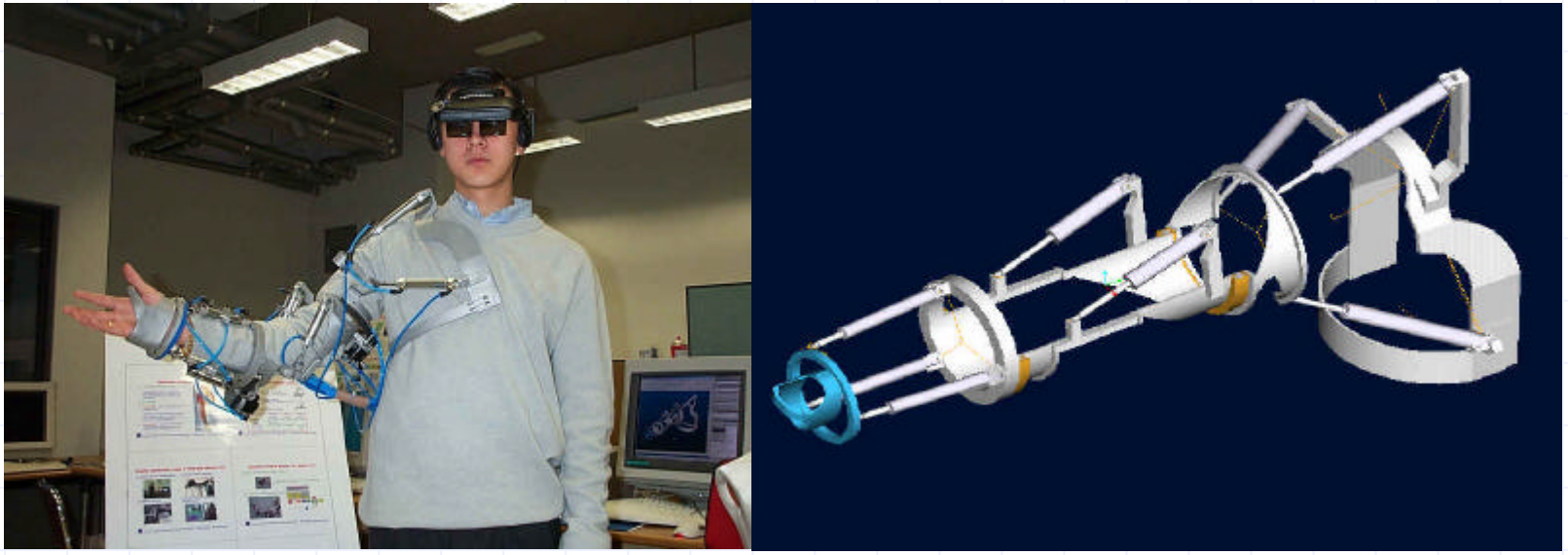
- Robot in the world



Wearable Robotic Arm and Tele-Operated Robot (KIST)

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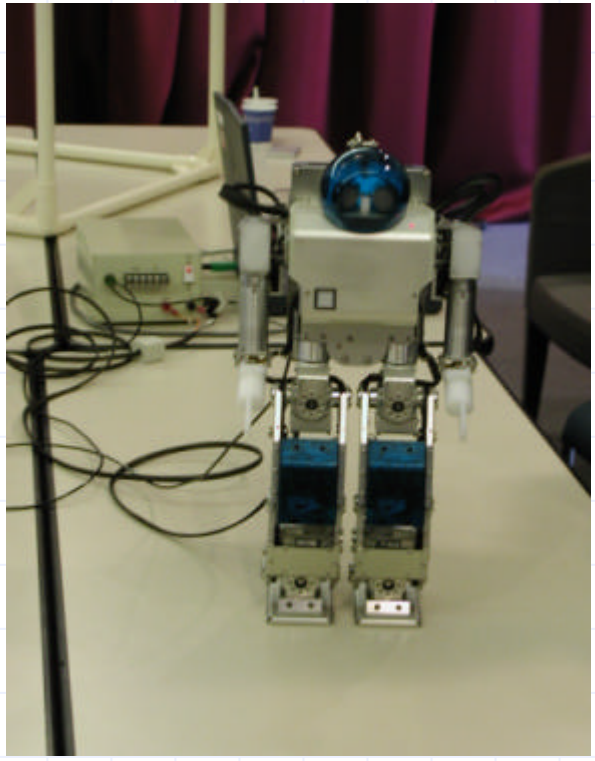
- Robot in the world

HONDA (ASIMO) – Biped Robot



Fujitsu – Biped Robot (Laptop Size)

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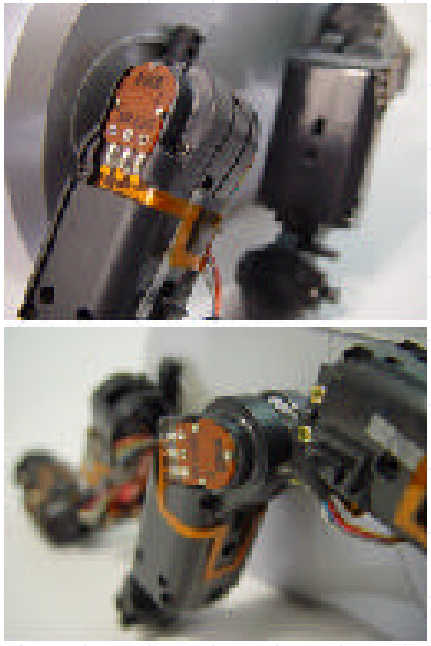
- Robot in the world



Sony (AIBO) – Toy robot

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Fundamentals

Fig. 1.2

? Robot Components

- ? Manipulator or Rover: Main body of robot
  (Links, Joints, other structural element of the robot)
- ? End Effector: The part that is connected to the last joint(hand) of a manipulator
- ? Actuators: Muscles of the manipulators
  (servomotor, stepper motor, pneumatic and hydraulic cylinder)
- ? Sensors: To collect information about the internal state of the robot or
  To communicate with the outside environment
- ? Controller: Similar to cerebellum.
  It controls and coordinates the motion of the actuators.
- ? Processor: The brain of the robot.
  It calculates the motions and the velocity of the robot's joints, etc.
- ? Software: Operating system, robotic software and the collection of routines.

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? Robot Degree of Freedom

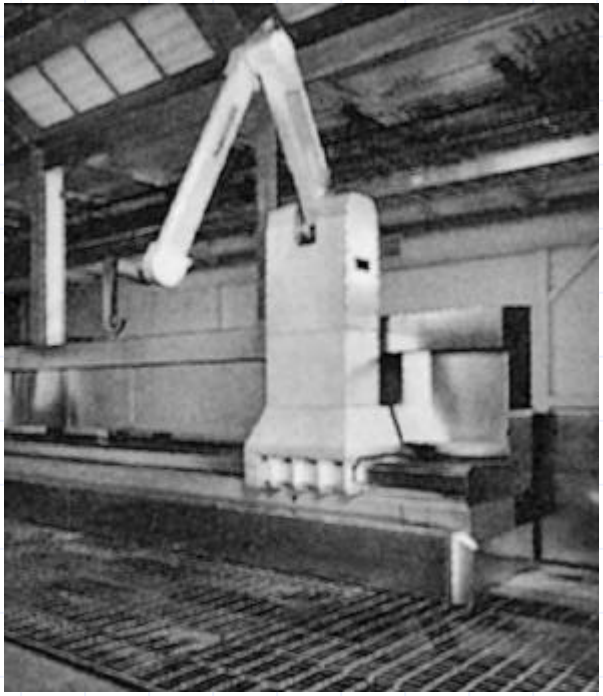

Fig. 1.3 A Fanuc P-15 robot.

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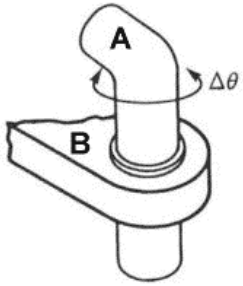
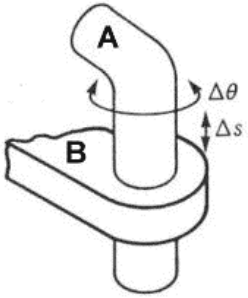
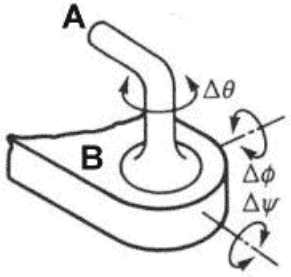
Consider what is the degree of Fig. 3



1 D.O.F.



2 D.O.F.



3 D.O.F.

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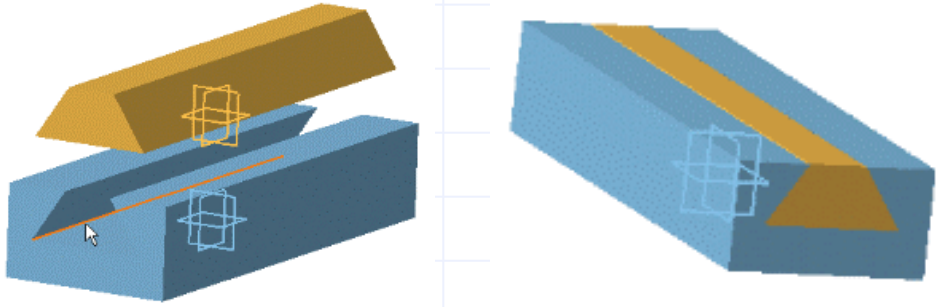
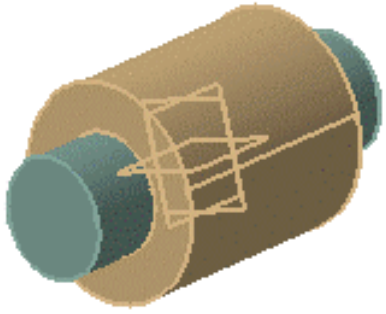
? Robot Joints

Prismatic Joint: Linear, No rotation involved.

(Hydraulic or pneumatic cylinder)



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



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? Robot Coordinates

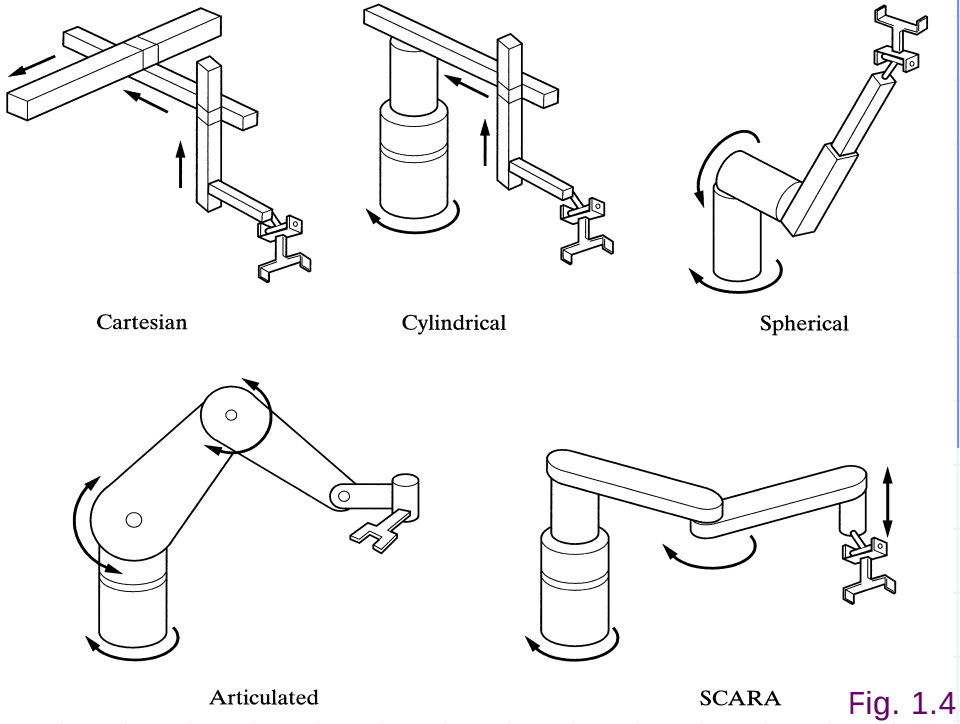

Fig. 1.4

? 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

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- Robot Reference Frames

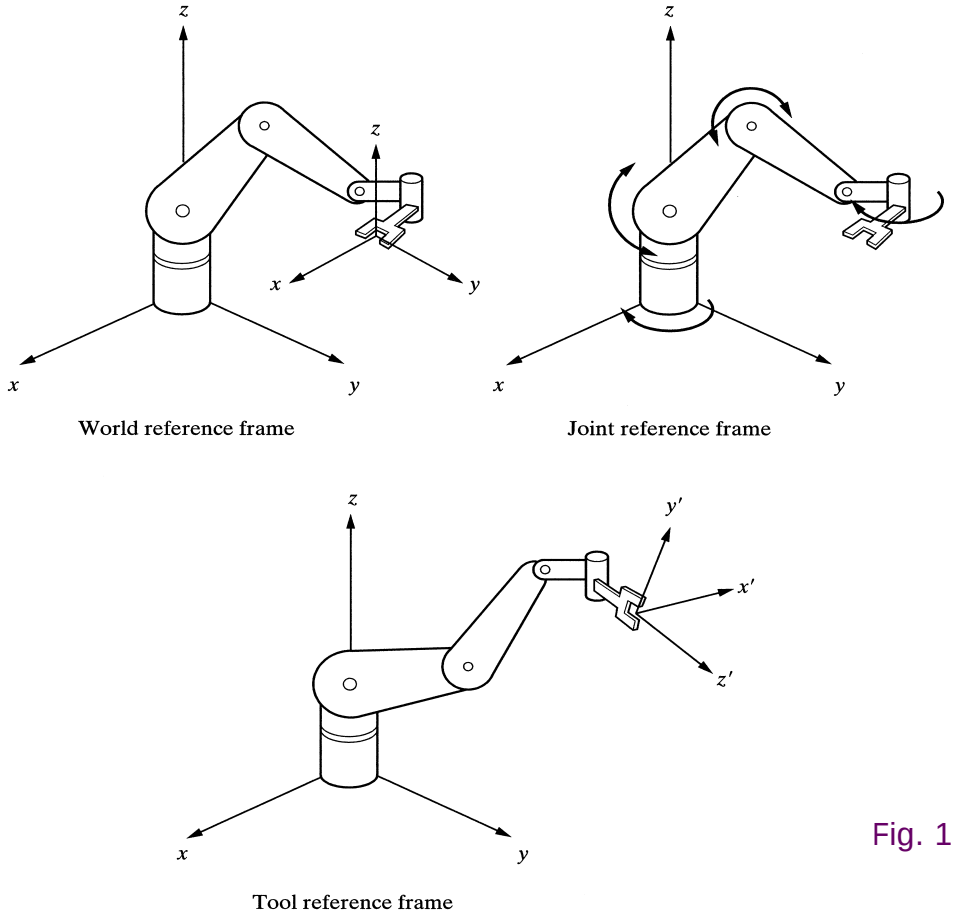

Fig. 1.6 A robot's World, Joint, and Tool reference frames. Most robots may be programmed to move relative to either of these reference frames.

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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.

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Fundamentals

- Robot Workspace

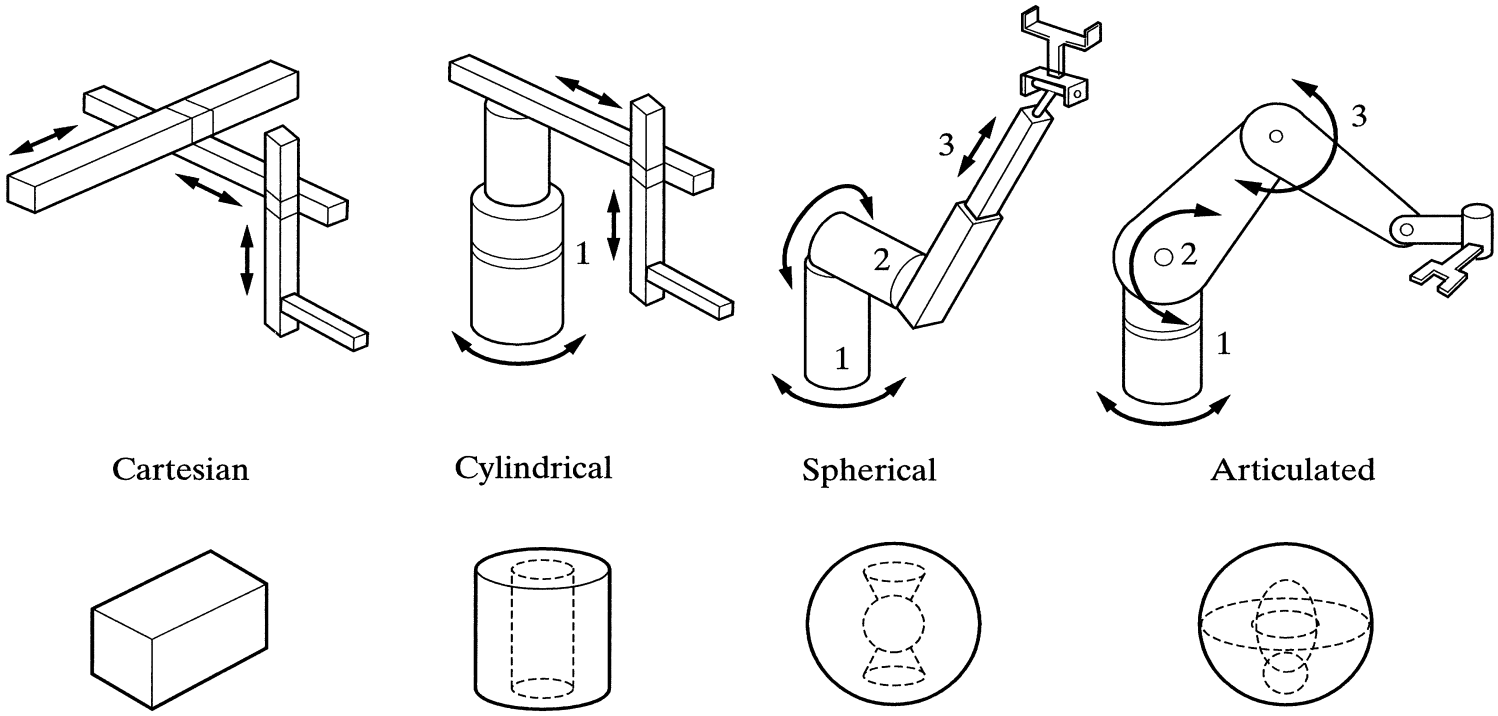

Fig. 1.7 Typical workspaces for common robot configurations

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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.

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- 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:

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- Robot Application

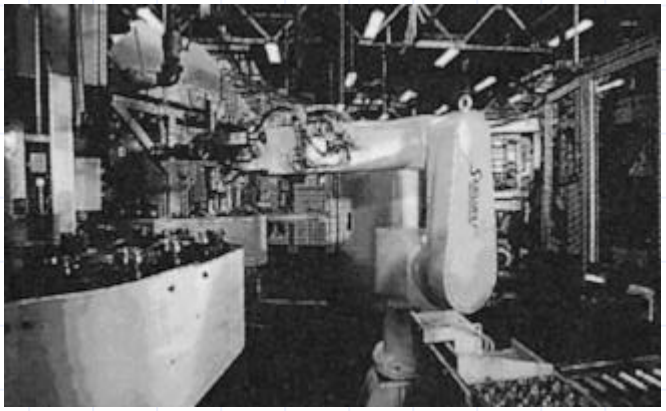

Fig. 1.8 A Staubli robot loading and unloading

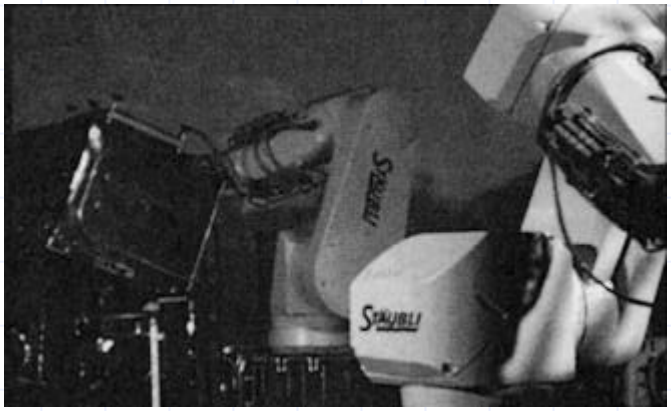

Fig. 1.9 Staubli robot placing dishwasher tubs

Fig. 1.10 An AM120 Fanuc robot

Fig. 1.11 A P200 Fanuc painting automobile bodies

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- Robot Application

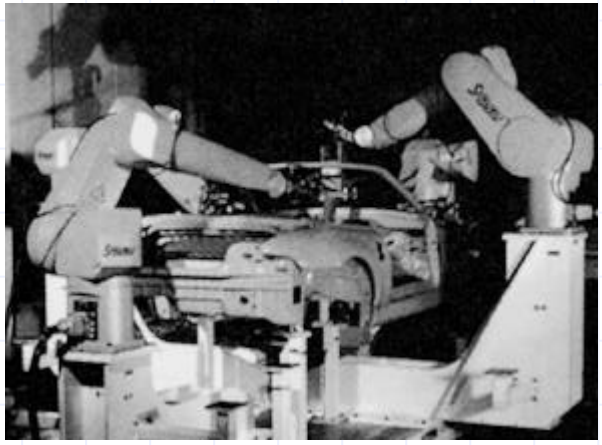

Fig. 1.12 Staubli RX FRAMS robot in a BMW

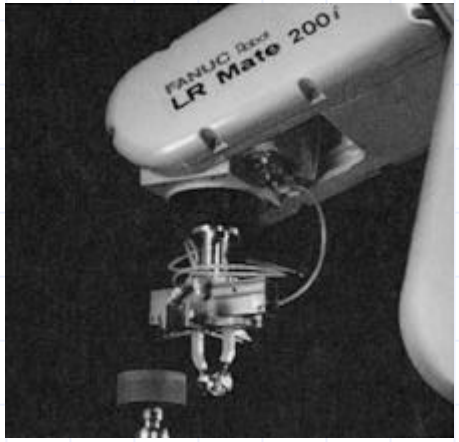

Fig. 1.13 A Fanuc LR Mate 200i robot removal operation

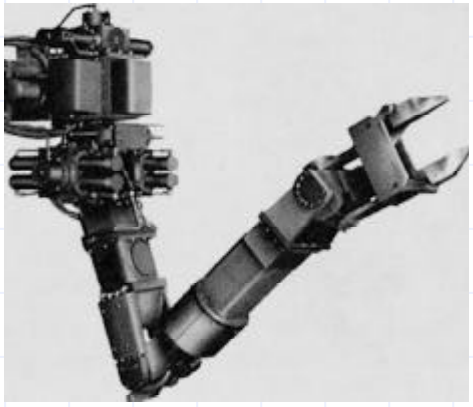

Fig. 1.13 The Arm, a 6 DOF bilateral force-feedback manipulator

Medical Robot of German