WHAT IS A ROBOT?

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

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

What is a Robot

- The difference between a robot and a manipulator
  - Run by a computer or microprocessor not a human
  - Controlled by feedback devices
  - Mostly autonomous

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.
- *Webster's Dictionary*
  - An automatic device that performs functions ordinarily ascribed to human beings ➔washing machine = robot?

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, e.g.) 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 (Class 3)
  - Playback Robot (Class 4)
  - Numerical Control Robot (Class 5)
  - Intelligent Robot (Class 6)

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.

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.

HISTORY OF ROBOTICS

…1750 Swiss craftsmen create automatons with clockwork mechanisms to play tunes and write letters.

1917 The word "robot" first appears in literature, coined in the play Opilek by playwright Karel Capek, who derived it from the Czech word "robotnik" meaning "slave."

1921 The term robot is made famous by Capek's play R.U.R. (Rossum's Universal Robots).

1938 Isaac Asimov coins the term robotics in his science fiction novels, and formulates the Three Laws of Robotics which prevent robots from harming humans.

HISTORY OF ROBOTICS

The Three Laws, quoted from the "Handbook of Robotics, 56th Edition, 2058 A.D.", are:

0. A robot may not harm humanity, or, by inaction, allow humanity to come to harm.

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 it by human beings 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 or Second Laws.

HISTORY OF ROBOTICS

1954 The first United Kingdom robotics patent, No. 781465, is granted in England on March 29.
1956 The Logic Theorist, an artificial intelligence machine capable of proving logical propositions point-by-point, is unveiled at Dartmouth College.
1958 Joseph F. Engelberger sets up a business in his garage called Consolidated Controls, making aircraft components. Joseph F. Engleberger and George C. Devol name their first robot "Unimate."

The first Unimate is installed at a General Motors plant to work with heated die-casting machines. Unimation is founded, the first commercial company to make robots. Unimation stood for Universal automation.

HISTORY OF ROBOTICS

1960 Artificial intelligence teams at Stanford Research Institute in California and the University of Edinburgh in Scotland begin work on the development of machine vision.
1961 George C. Devol obtains the first U.S. robot patent, No. 2,998,237.
1961 First production version Unimate industrial robot is installed in a die-casting machine.
1961 The MH-1, Mechanical Hand with sensors, is developed at MIT by Ernst.
1962 Consolidated Diesel Electric Company (Condec) and Pullman Corporation enter into joint venture and form Unimation, Inc. (Unimation stood for "Universal Automation").

HISTORY OF ROBOTICS

1963 The Versatran industrial robot became commercially available.

1964 The first Tralfa robot is used to paint wheelbarrows in a Norwegian factory during a human labor shortage.

1966 The first prototype painting robots are installed in factories in Byrne, Norway.

1966 The robotic spacecraft "Surveyor" (United States) lands on the moon.

1968 "Shakey," the first complete robot system is built at Stanford Research Institute, in California.

1968 Unimation takes its first multi-robot order from General Motors.

1969 Robot vision, for mobile robot guidance, is demonstrated at the Stanford Research Institute.

1969 Unimate robots assemble Chevrolet Vega automobile bodies for General Motors.

HISTORY OF ROBOTICS

1970 General Motors becomes the first company to use machine vision in an industrial application. The Consight system is installed at a foundry in St. Catherines, Ontario, Canada.
1970 The Russian lunar rover Lunakhod, wheels about on the moon.
1970 The first American symposium on robots meets in Chicago.
1971 Japan establishes the Japanese Industrial Robot Association (JIRA), and becomes the first nation to have such an organization.
1972 The SIRCH machine, capable of recognizing and orienting randomly presented two-dimensional parts, is developed at the University of Nottingham, England.
1972 Kawasaki installs a robot assembly line at Nissan, Japan, using robots supplied by Unimation, Inc.

HISTORY OF ROBOTICS

1973 "The Industrial Robot," the first international journal of robotics, begins publication.

1973 The ASEA Group of Vasteras, Sweden, introduces its all electric IRb 6 and IRb 60 robots, designed for automatic grinding operations.

1974 Hitachi uses touch and force sensing with its Hi-T-Hand robot, allowing the robot hand to guide pins into holes.

1974 The Robotics Industries Association is founded.

1975 Cincinnati Milacron introduces its first T3 robot for drilling applications. The ASEA 60kg robot is the first robot installed in an iron foundry; the Cincinnati Milacron T3 becomes the first robot to be used in the aerospace industry.

HISTORY OF ROBOTICS

1976 The Trallfa spray-painting robot is adapted for arc welding at the British agricultural implement firm of Ransome, Sims and Jefferies.

1976 Remote Center Compliance evolves from research at Charles Stark Draper Labs, Cambridge, Mass. Dynamics of part mating are developed, allowing robots to line up parts with holes both laterally and rotationally.

1976 The robotic spacecraft "Viking" (United States) lands on the Martian surface.

1977 California Institute of Technology's Jet Propulsion Laboratory (JPL) demonstrates a robotic hand-eye system can be integrated with a self-propelled vehicle for planetary exploration. (Mars Rover)

HISTORY OF ROBOTICS

1977 The British Robotics Association (BRA) is founded.

1978 The first PUMA (Programmable Universal Assembly) robot is developed by Unimation for General Motors.

1978 The Machine Intelligence Company is organized by Charles A. Rosen and associates. **1979** Japan introduces the SCARA (Selective Compliance Assembly Robot Arm); Digital Electronic Automation (DEA) of Turin, Italy, introduces the PRAGMA robot, which is licensed to General Motors.

1979 Japan introduces the SCARA (Selective Compliance Assembly Robot Arm); Digital Electronic Automation (DEA) of Turin, Italy, introduces the PRAGMA robot, which is licensed to General Motors.

HISTORY OF ROBOTICS

1980 Robotics languages are developed to ease programming bottlenecks.

1981 IBM enters the robotics field with its 7535 and 7565 Manufacturing Systems.

1982 The Pedesco robot (Pedesco, Scarborough, Ontario) is used to clean up after a nuclear fuel spill at an atomic power plant. A task too dangerous for direct human contact.

1982 Stan Mintz and five co-employees of Hewlett-Packard Company left to form Intelledex Corporation, a manufacturer of light assembly robots, for such tasks as installing integrated circuits.

1981-1984 Rehabilitation robots are enhanced by mobility, voice communication, and safety factors. Greater emphasis is placed on machine vision, tactile sensors, and languages. Battlefield and security robots are developed.

HISTORY OF ROBOTICS

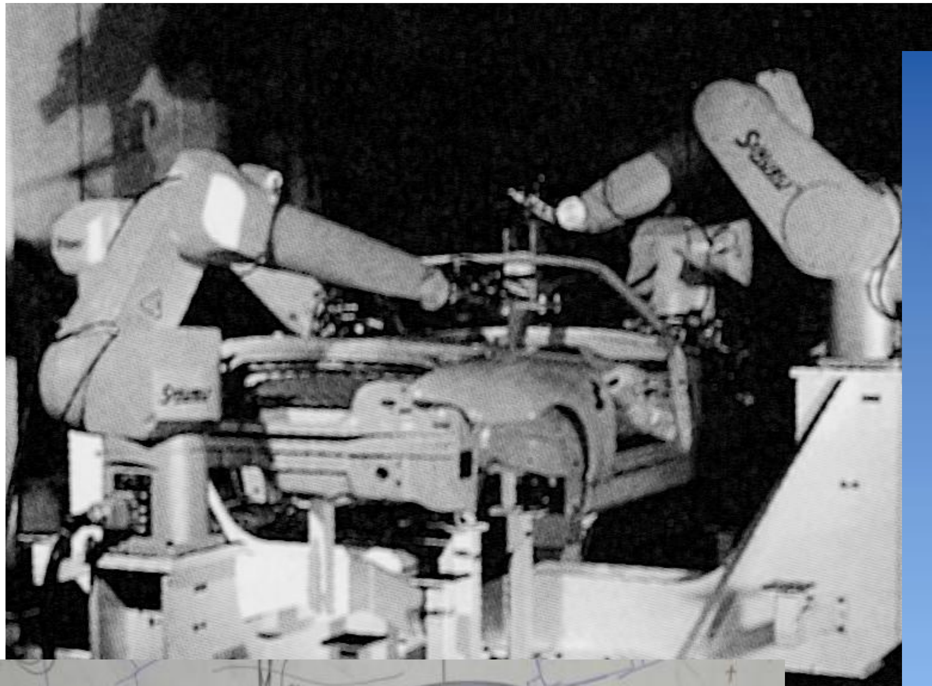
1983 Westinghouse Electric Corporation buys Unimation, Inc., which becomes part of its factory automation enterprise. Westinghouse later sells Unimation to AEG of Pennsylvania.
1984 Robot Defense Systems introduces the Prowler ("Programmable Robot Observer with Local Enemy Response"), the first in a series of battlefield robots.
1984 Intelledex Corporation introduces the Model 695 lite assembly robot, based on the Intel 8086 and 8087 microprocessor chips. Its software is called Robot Basic, a specialized version of Microsoft's Basic.
1993 The University of Michigan's CARMEL robot wins first place at the 1992 Robot Competition sponsored by the American Association for Artificial Intelligence (AAAI). CARMEL stands for computer-aided robotics for maintenance, emergency, and life support. The SRI International's robot "FLAKEY" wins second place. Both microcomputer- controlled machines use ultrasonic sonar sensors.

HISTORY OF ROBOTICS

21C:

- Mobile Robots (Walking Robots, Mobile/Wheeled, Underwater, Flying)
- Humanoid Robots

*




HISTORY OF ROBOTICS

ROBOTICS SUBFIELDS

IEEE Robotics & Automation Society Technical Committees

http://www.ieee-ras.org

1. **Aerial Robotics and Unmanned Aerial Vehicles**
2. Agricultural Robotics and Automation
3. **Algorithms for Planning and Control of Robot Motion**
4. Automation in Health Care Management
5. Automation in Logistics
6. **Autonomous Ground Vehicles and Intelligent Transportation Systems**
7. Bio Robotics
8. Cognitive Robotics
9. **Computer & Robot Vision**
10. Cyborg & Bionic Systems
11. Energy, Environment, and Safety Issues in Robotics and Automation
12. **Haptics**
13. Human Movement Understanding
14. Human-Robot Interaction & Coordination
15. Humanoid Robotics
16. **Marine Robotics**
17. Mechanisms and Design
18. **Micro/Nano Robotics and Automation**
19. **Mobile Manipulation**
20. Model-Based Optimization for Robotics
21. **Multi-Robot Systems**
22. Neuro-Robotics Systems
23. Performance Evaluation & Benchmarking of Robotic and Automation Systems
24. Rehabilitation and Assistive Robotics
25. RoboCup
26. **Robot Ethics**
27. Robot Learning
28. **Robotic Hands, Grasping and Manipulation**
29. Robotics and Automation in Nuclear Facilities
30. Safety, Security and Rescue Robotics
31. Semiconductor Manufacturing Automation
32. Smart Buildings
33. Soft Robotics
34. Software Engineering for Robotics and Automation
35. Space Robotics
36. **Surgical Robotics**
37. Sustainable Production Automation
38. Telerobotics
39. Wearable Robotics
40. Whole-Body Control

ROBOTICS SUBFIELDS

IEEE Robotics & Automation Society

- **Aerial Robotics and Unmanned Aerial Vehicles**
- **Algorithms for Planning and Control of Robot Motion**
- **Autonomous Ground Vehicles and Intelligent Transportation Systems**
- **Computer & Robot Vision**
- **Haptics**
- **Marine Robotics**
- **Micro/Nano Robotics and Automation**
- **Mobile Manipulation**
- **Multi-Robot Systems**
- **Robot Ethics**
- **Robotic Hands, Grasping and Manipulation**
- **Surgical Robotics**

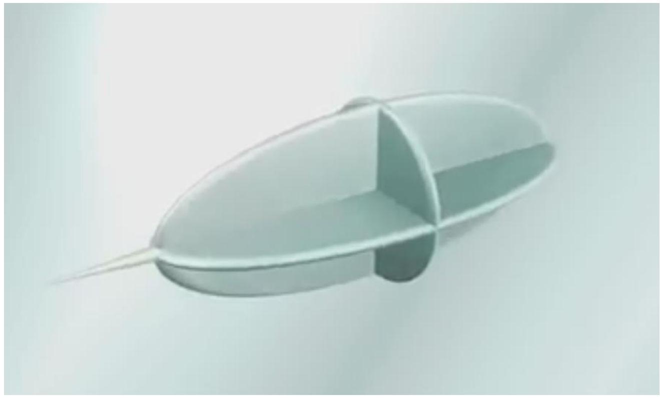
http://www.ieee-ras.org

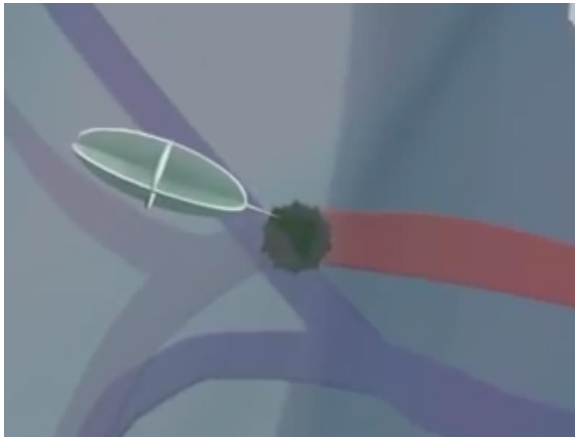
NANOROBOTICS

- At the micro/nano scale
- Can be guided through electromagnetic fields or ultrasound, etc.

NANOROBOTICS

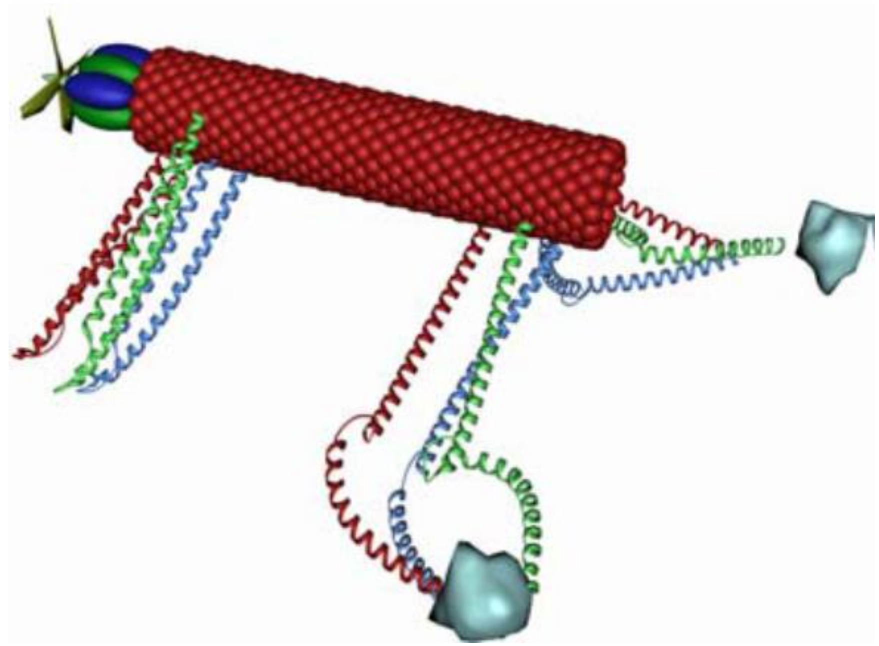
- Not mechanical necessarily



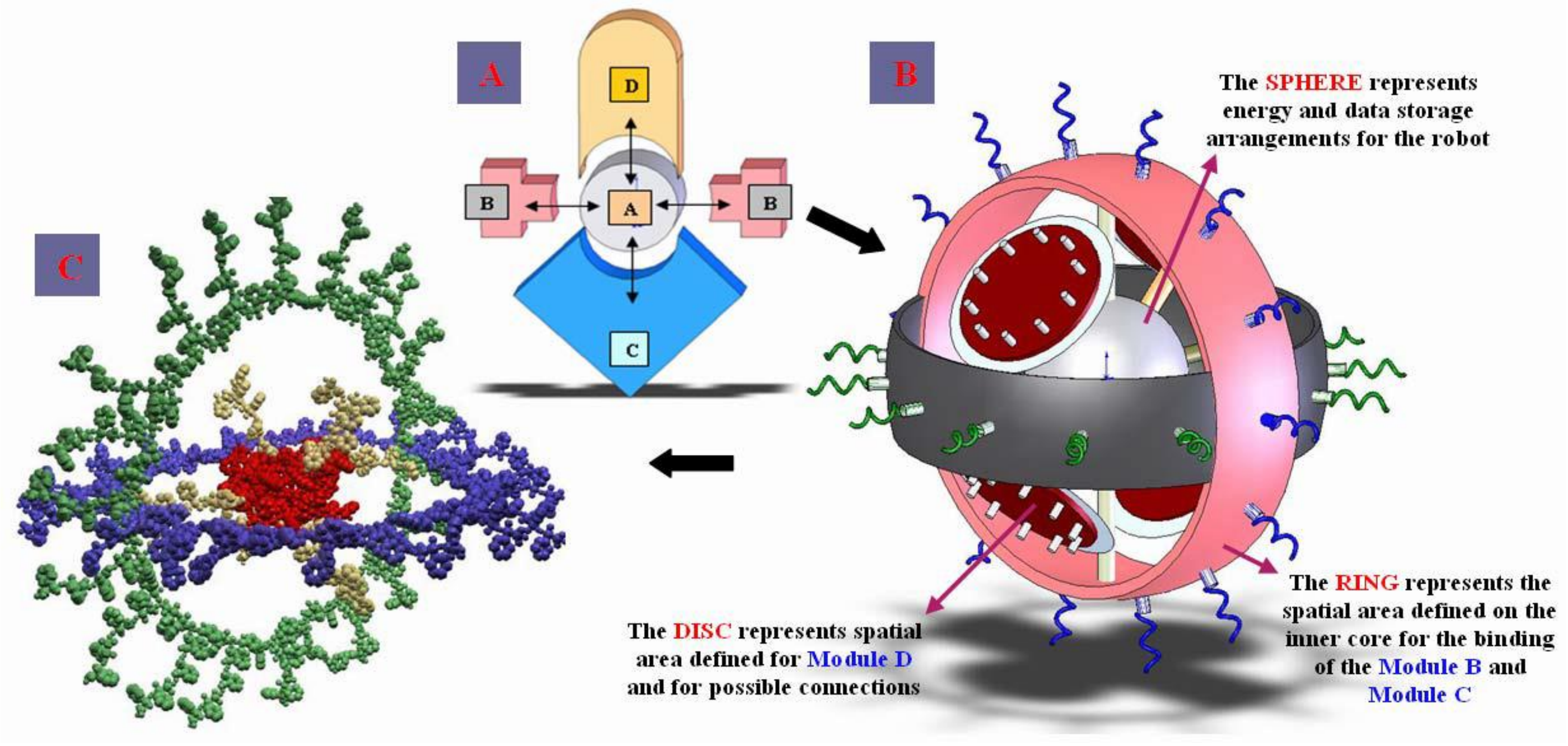


BIO-NANOROBOTICS

- Bio-nano scale
- Also made out of biomaterial
- Example:
  - ❑ Carbon nanotubes, main body
  - ❑ peptide limbs for locomotion and object manipulation
  - ❑ biomolecular motor located at the head for propelling



BIO-NANOROBOTICS

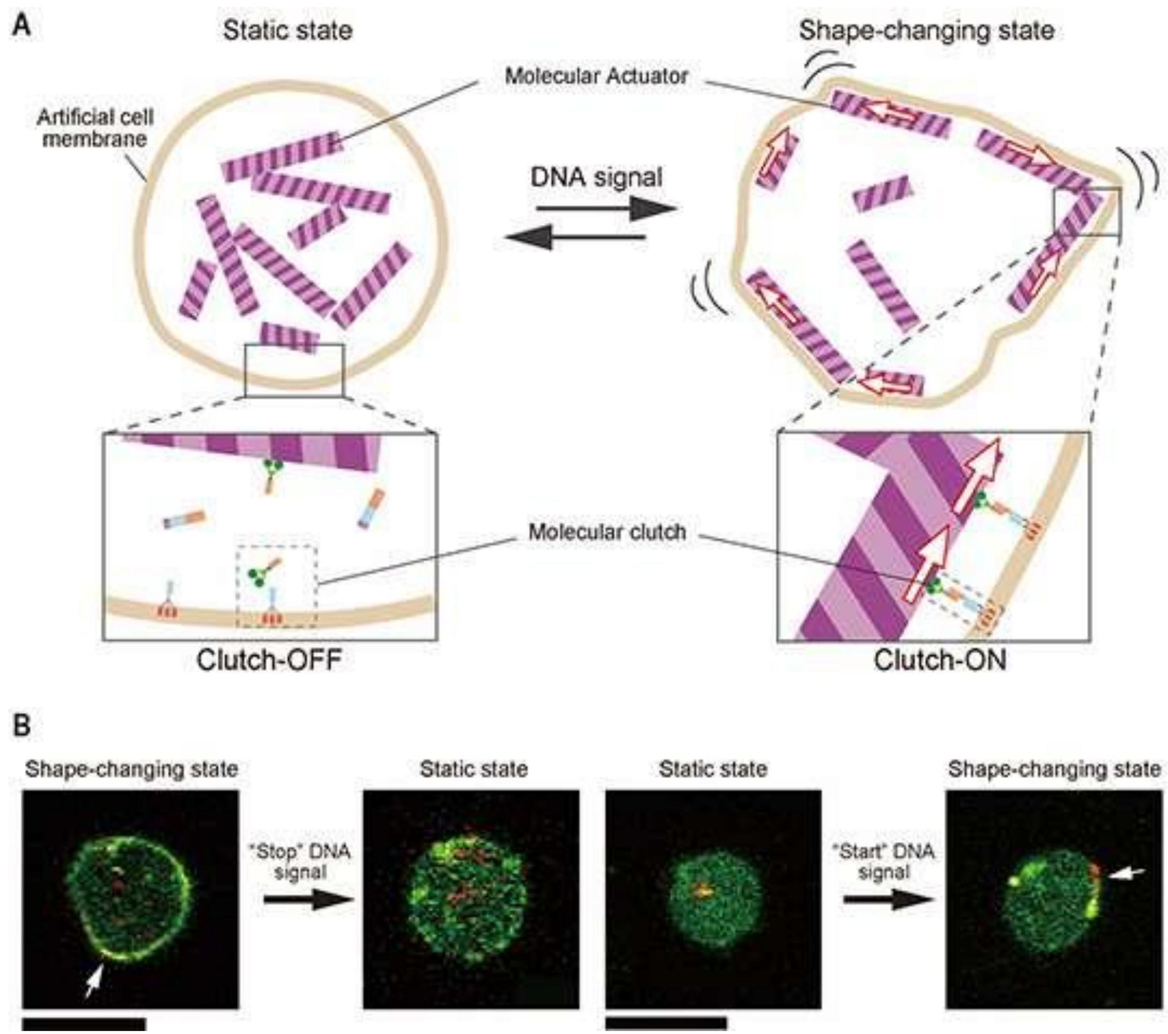


A. Bio-Nano-Robotic Entity ‘ABCD’: Bio Modules constitute the bio-nano-robot. **B.** A Bio-Nano-Robot (representative), as a result of Modular Organization. They preserve the basic behavior (self-assembly, self-replication and self organization)

BIO-NANOROBOTICS

Shape-shifting molecular robots respond to DNA signals

March 2, 2017



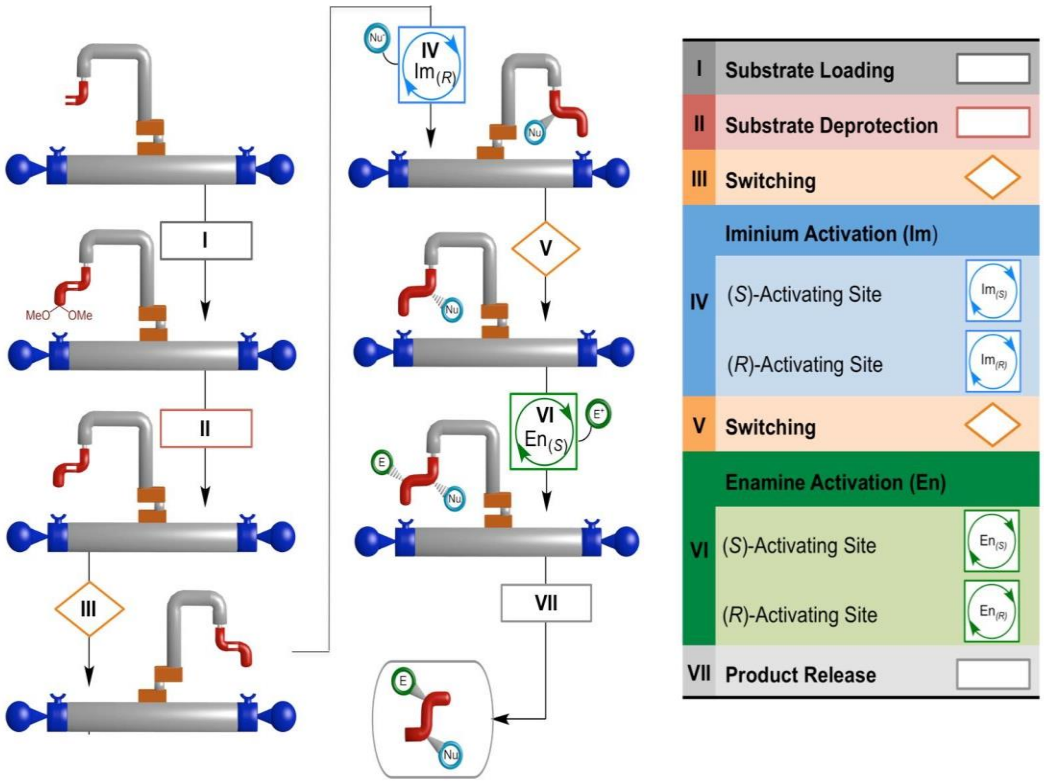
BIO-NANOROBOTICS

20 September 2017

Scientists create world's first 'molecular robot' capable of building molecules

The tiny robots, which are a millionth of a millimetre in size, can be programmed to move and build molecular cargo, using a tiny robotic arm.

"molecular factories"



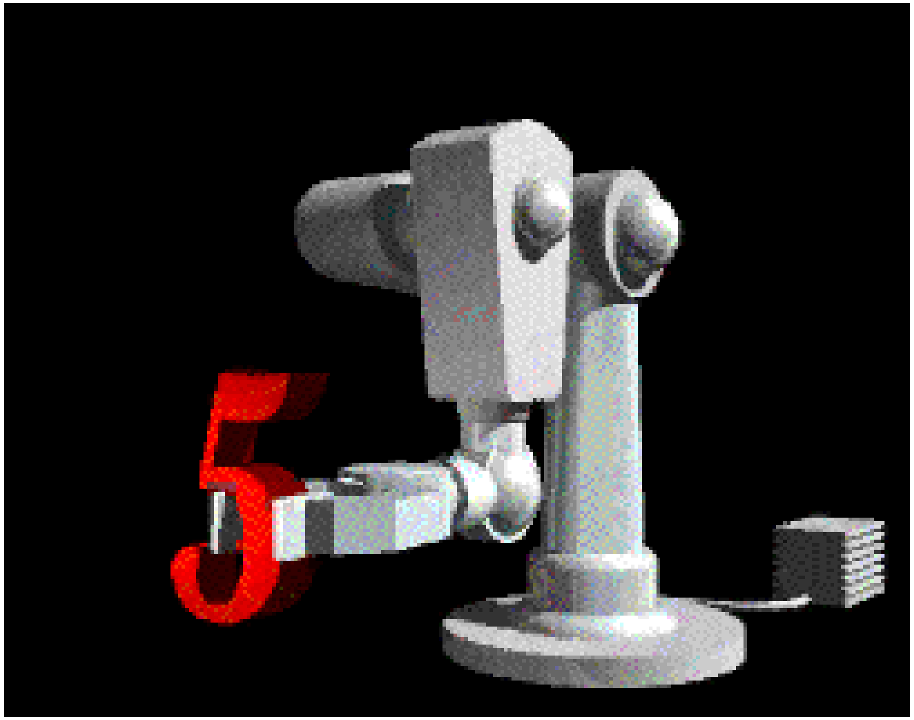
BIO-NANOROBOTICS

CLASSICAL ROBOTICS

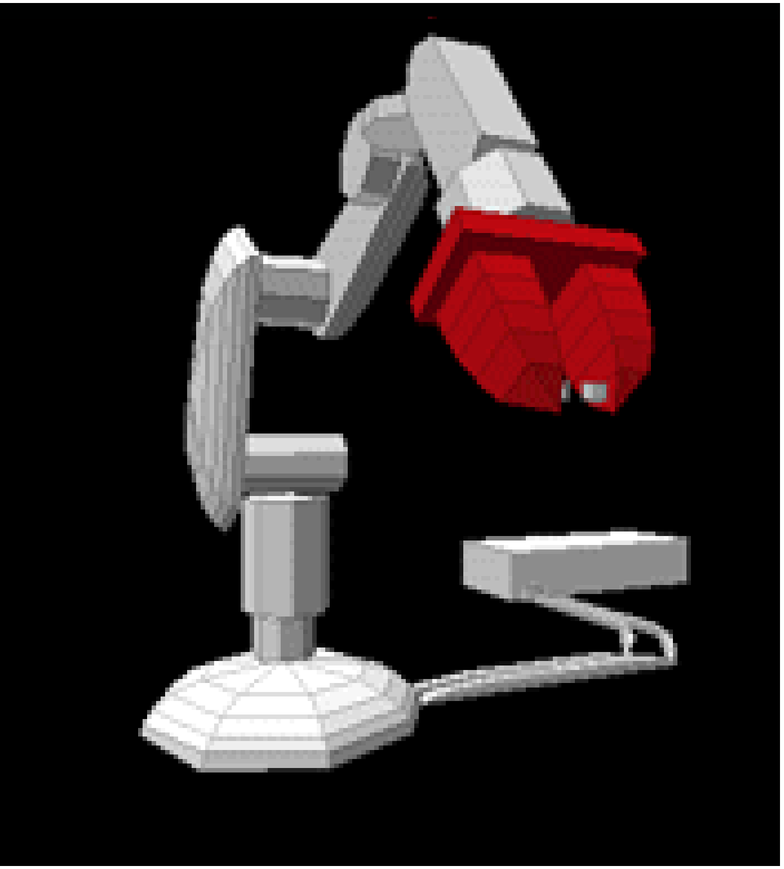
THE BASICS

WHAT ARE THE PARTS OF A ROBOT?

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

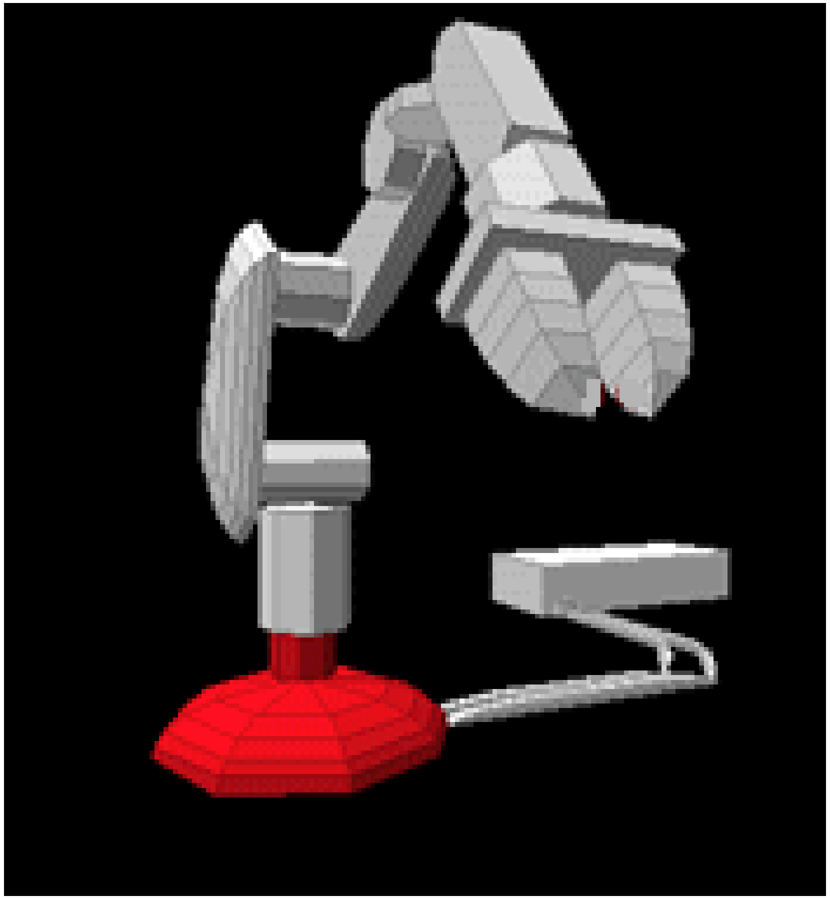


Manipulator



- Base
- Appendages
  - Shoulder
  - Arm
  - Grippers

Pedestal

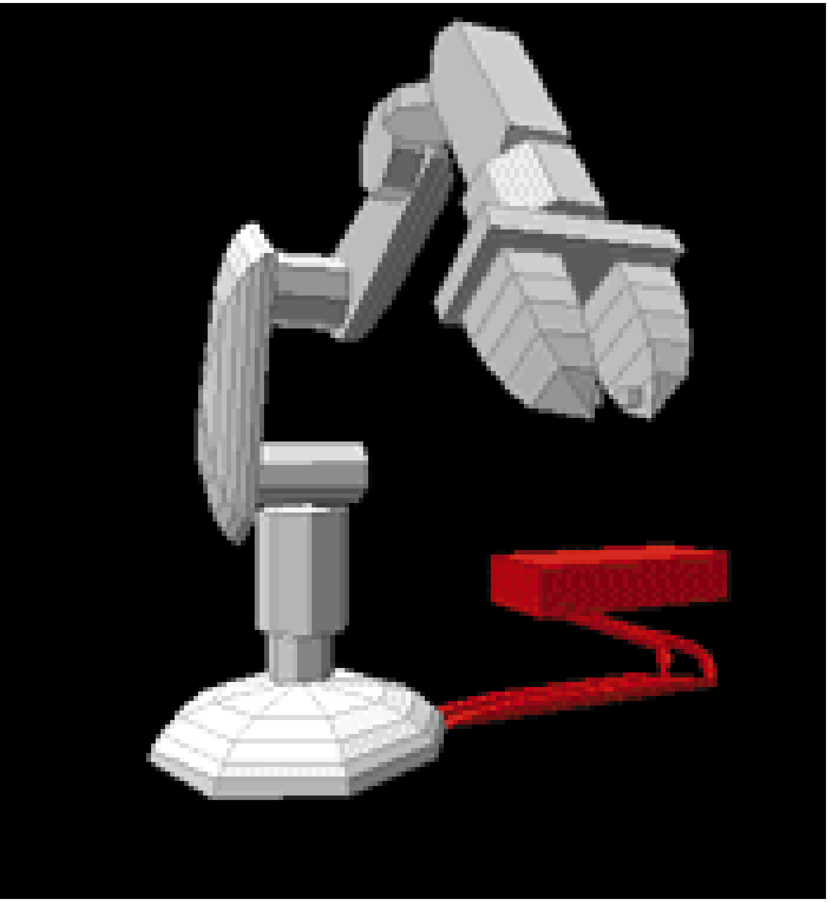


(Human waist)

- Supports the manipulator.
- Acts as a counterbalance.

Controller

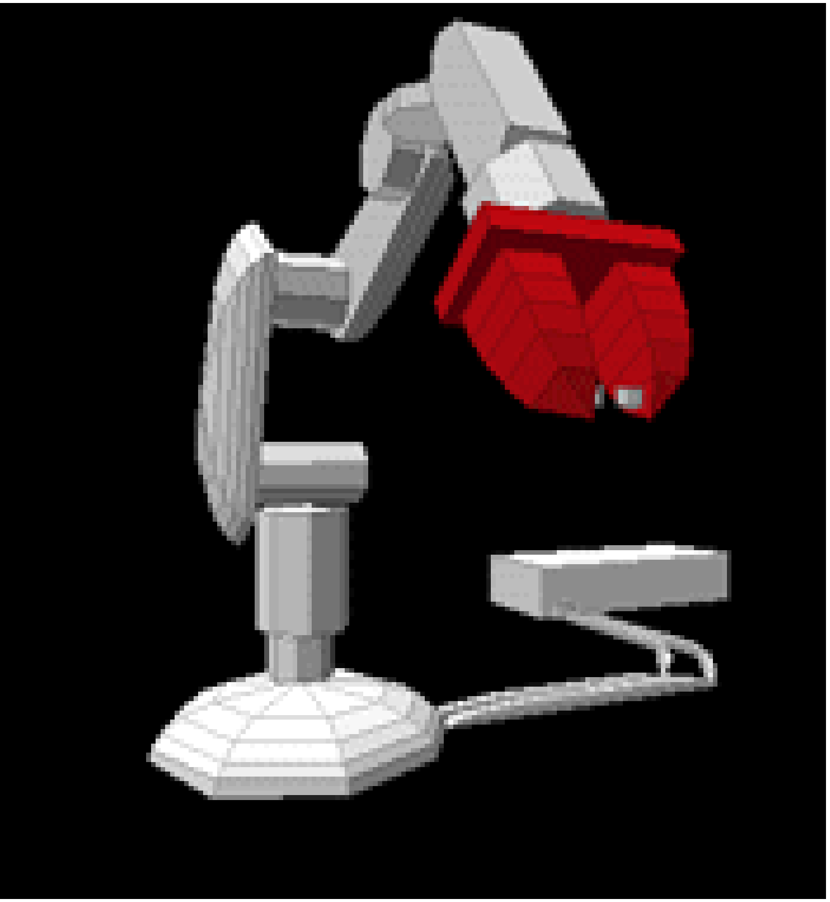
(The brain)



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

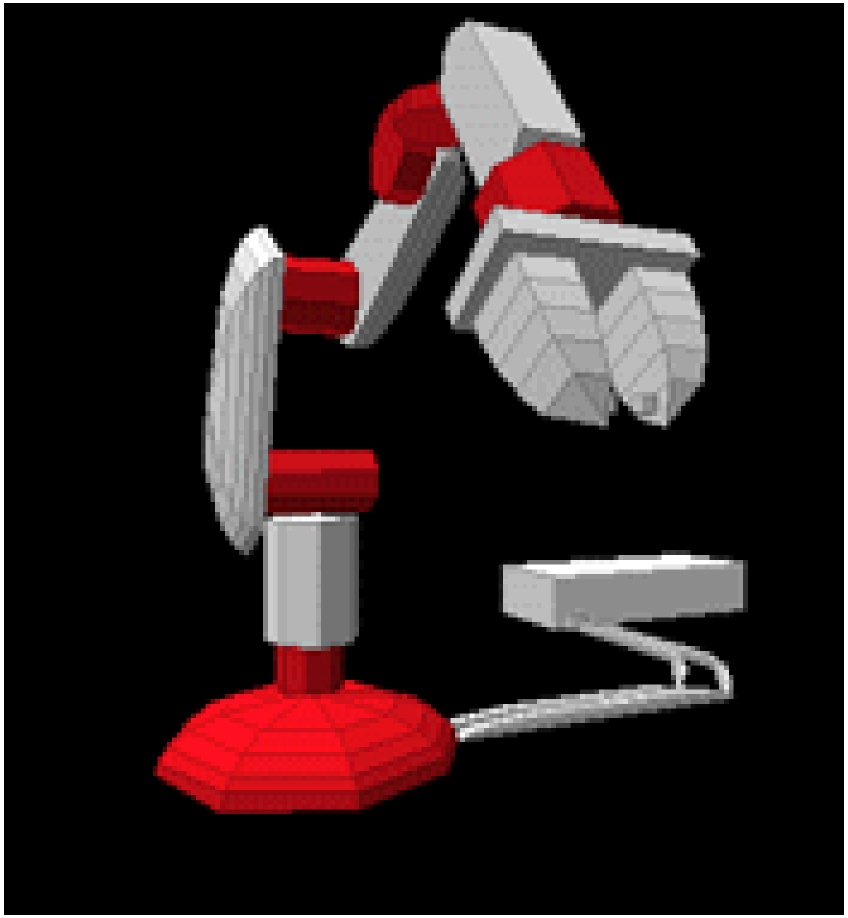
End Effectors

(The hand)

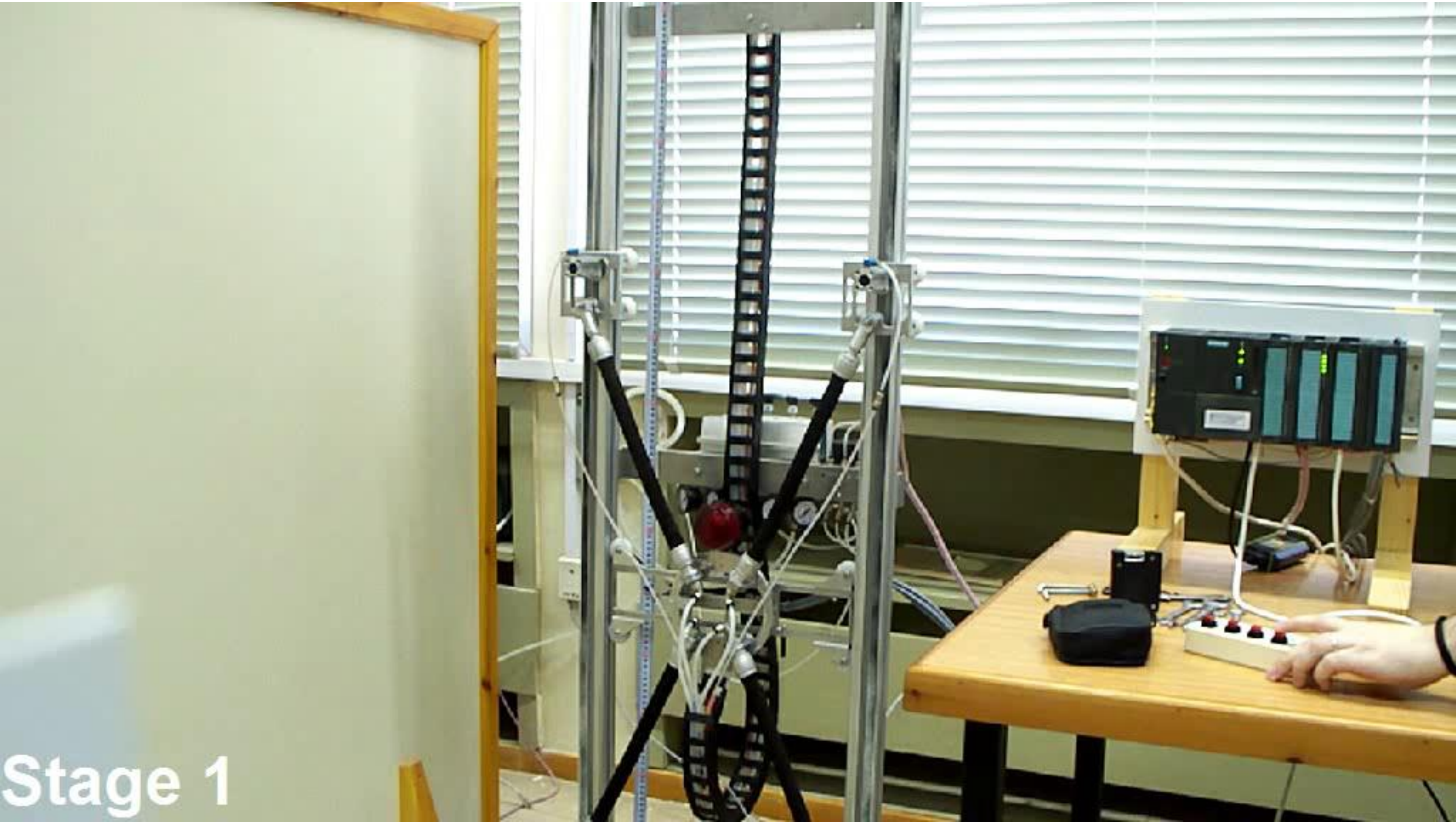


- Spray paint attachments
- Welding attachments
- Vacuum heads
- Hands
- Grippers

Power Source



- Electric
- Pneumatic
- Hydraulic


Stage 1

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

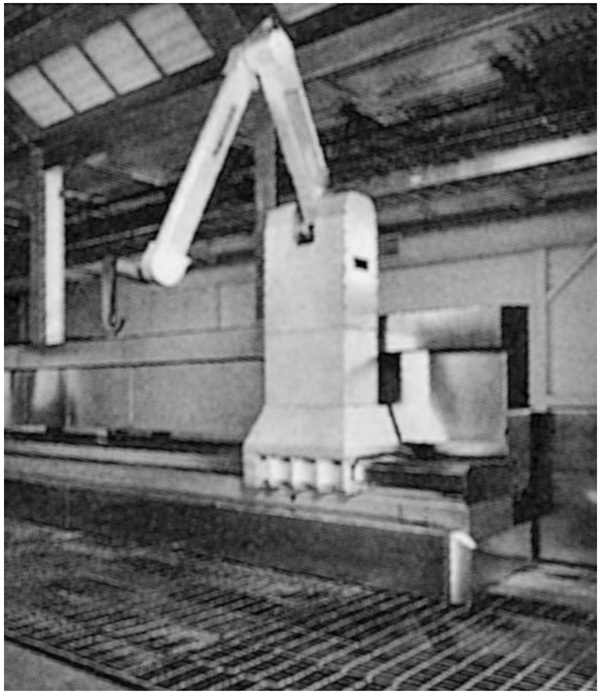
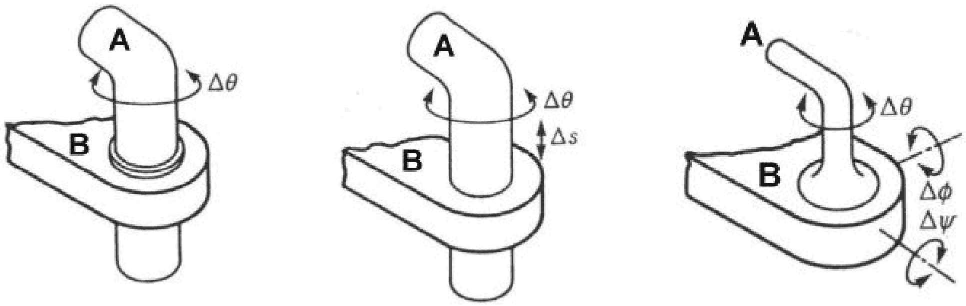


Fig. 1.3

Consider what is the degree of Fig. 3



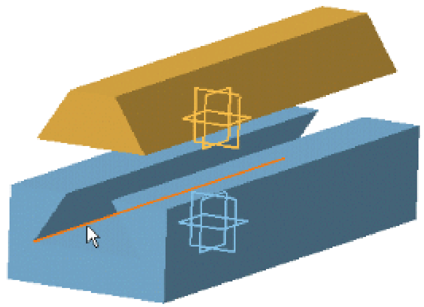
1 D.O.F.

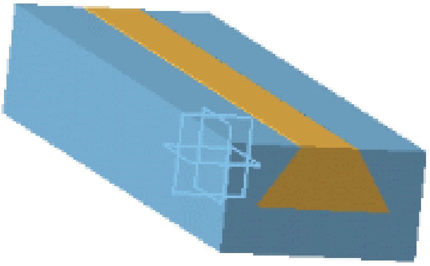
2 D.O.F.

3 D.O.F.

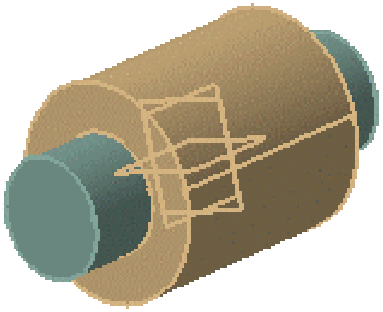
Robot Joints

Prismatic Joint





Revolute Joint



Robot Coordinates

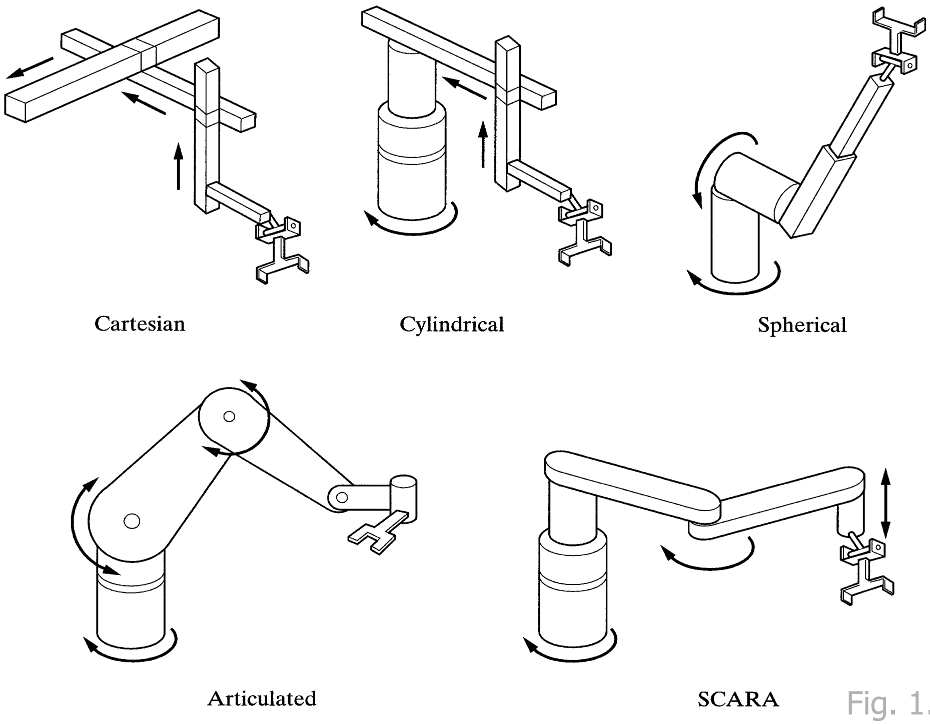
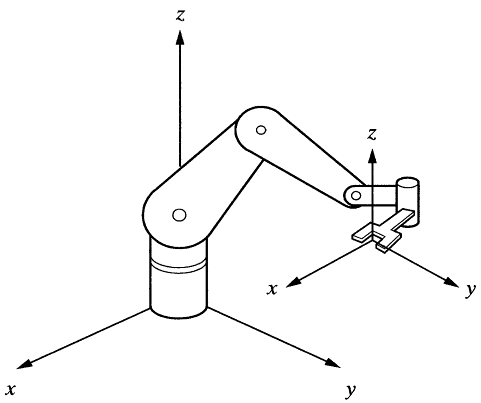


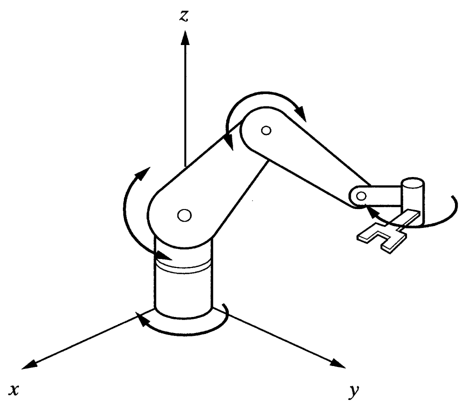
Fig. 1.4

- Cartesian/rectangular/gantry (3P) :
- Cylindrical (R2P) :
- Spherical (2RP) :
- Articulated/anthropomorphic (3R) :
- Selective Compliance Assembly Robot Arm (SCARA):

Robot Reference Frames

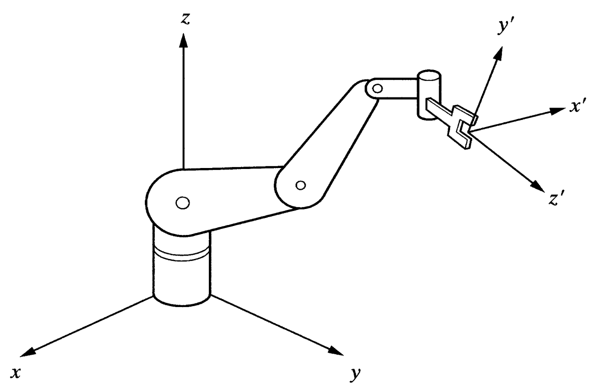


World reference frame



Joint reference frame

Fig. 1.6



Tool reference frame

Robot Workspace

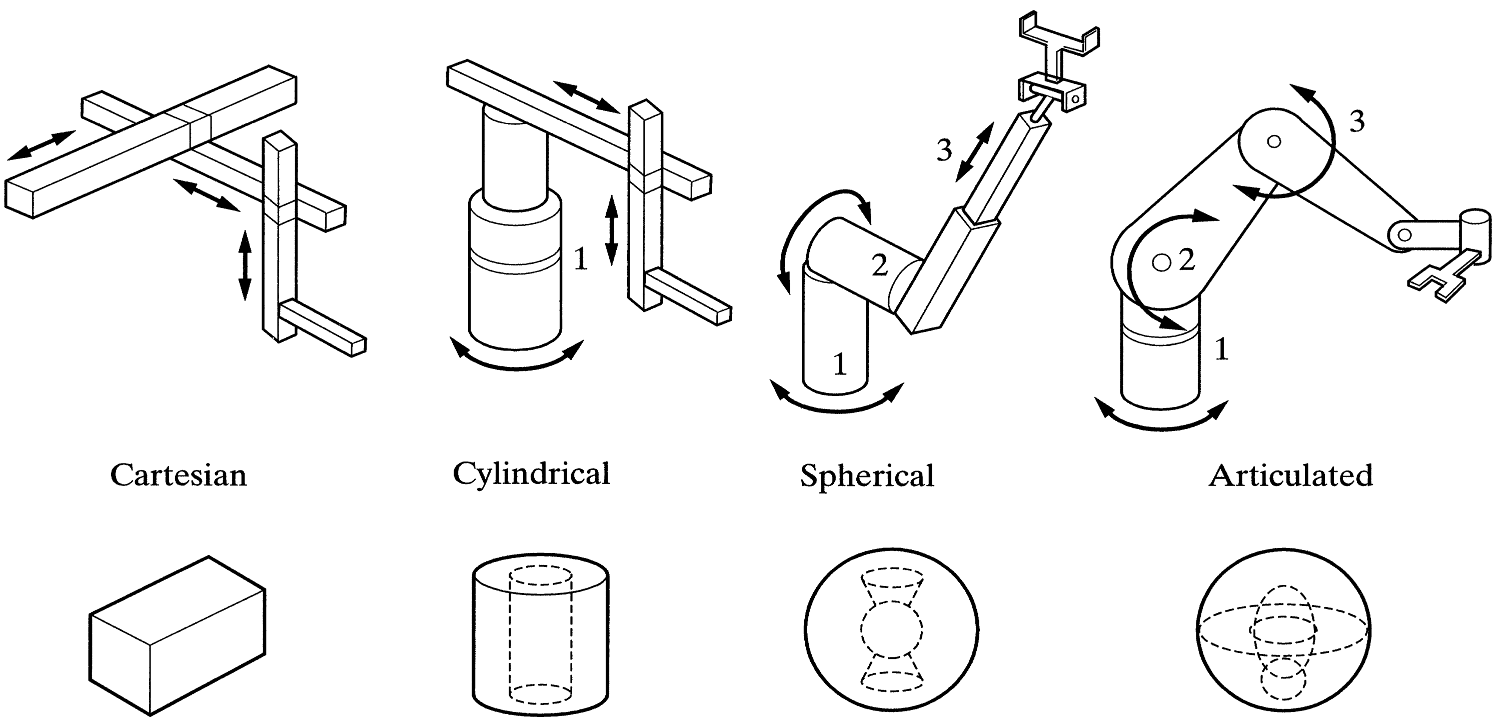


Fig. 1.7

ROBOT CHARACTERISTICS

- **Payload**
  Payload is the weight a robot can carry
- **Reach**
- Reach is the maximum distance a robot can reach within its work envelope.
- **Precision**
  Precision is defined as how accurately a specifies point can be reached
- **Repeatability**
  Repeatability is how accurately the same position can be reached if the motion is repeated many times.

Robot Applications

- 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

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.

Robot Applications

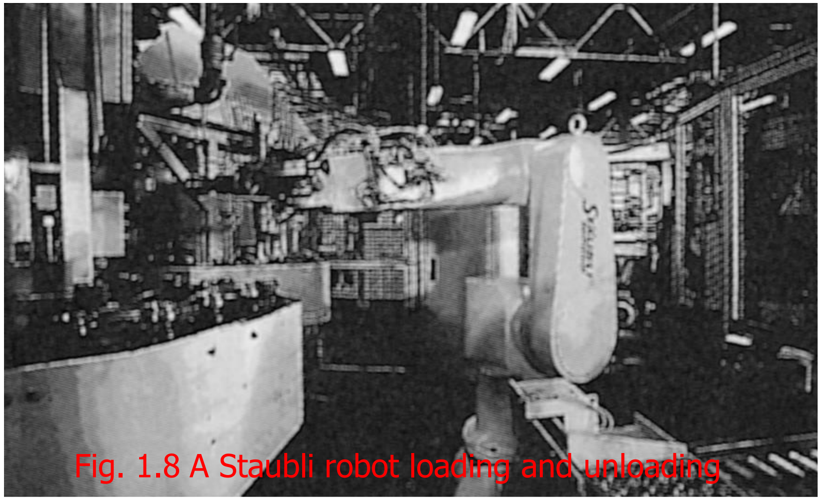
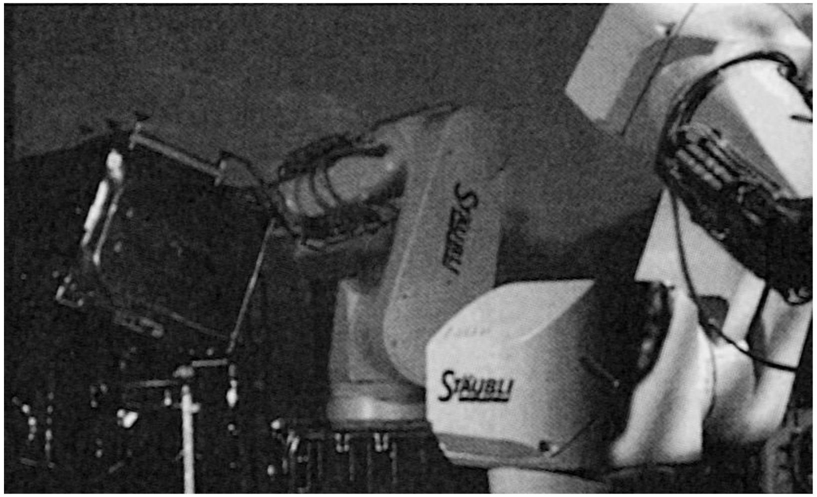


Fig. 1.8 A Staubli robot loading and unloading



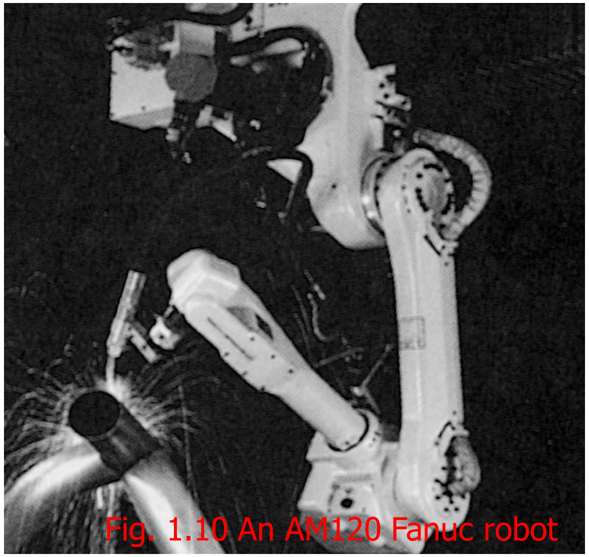


Fig. 1.10 An AM120 Fanuc robot

Fig. 1.11 A P200 Fanuc painting automobile bodies

Robot Applications

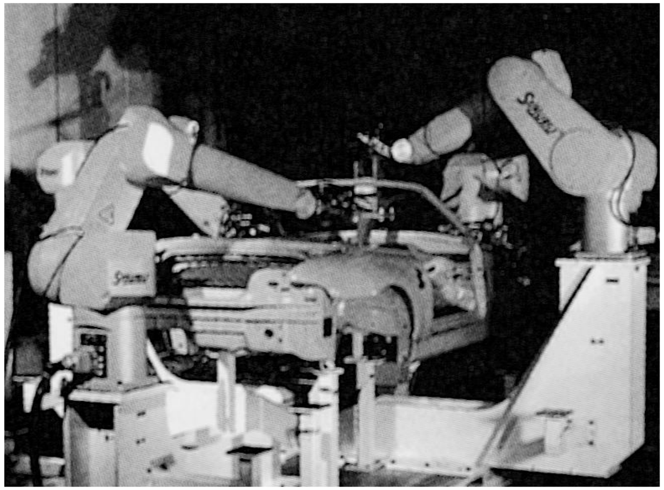


Fig. 1.12 Staubli RX FRAMS robot in a BMW

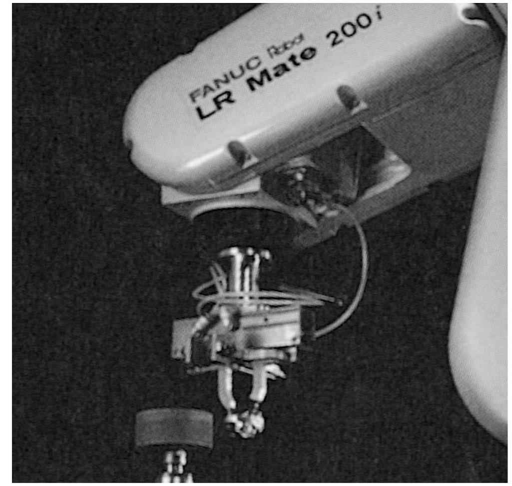


Fig. 1.13 A Fanuc LR Mate 200i robot removal operation

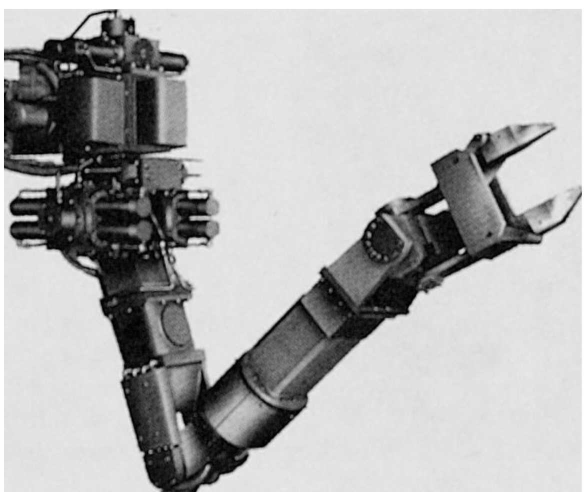


Fig. 1.13 The Arm, a 6 DOF bilateral force-feedback manipulator

Medical Robot

Robots and Art