RME 3102: Automation & Robotics

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RME 3102: Advanced Mechatronics Engineering
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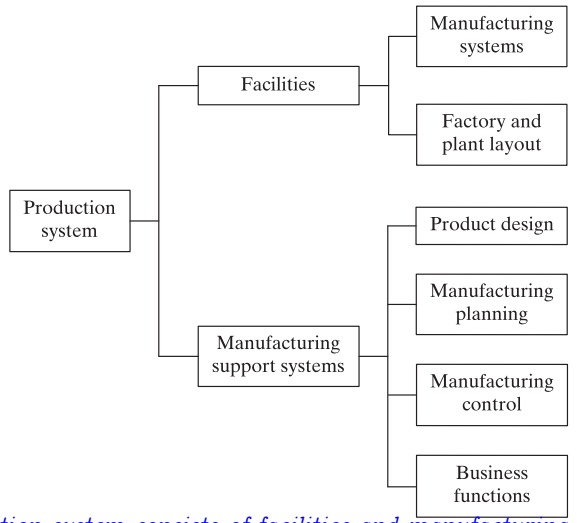
`http://zahurul.buet.ac.bd/RME3102/`

1. Industrial Automation
   - Production Systems
   - Automation
2. Industrial Robotics
   - Robot Applications
   - Robot Structure & Classifications

Production Systems

- Production system is the collection of people, equipment, procedures organized to accomplish the manufacturing activities of a company.
- Production system can be divided into two categories:
  - Facilities:- factory, equipment and their organization.
  - Manufacturing Support Systems:- procedures to manage production, logistic & technical problems in ordering materials, moving work through the factory, & ensuring product quality.



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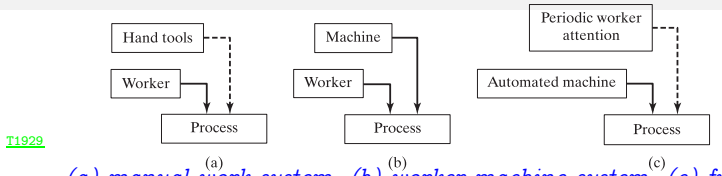
Production system consists of facilities and manufacturing support systems.

Three categories of manufacturing systems



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(a) manual work system, (b) worker-machine system, (c) fully automated system.

(a) Manual work:

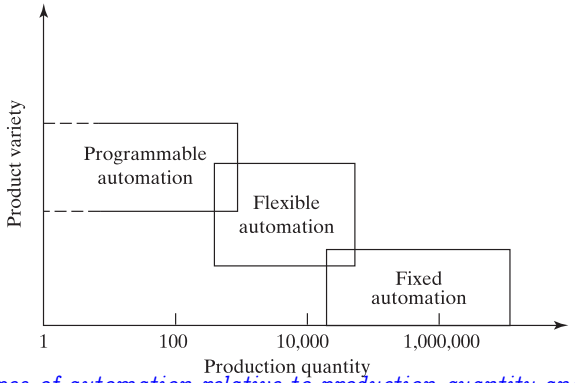
- A machinist using a file to round the edges of a rectangular part,
- A quality control inspector using a micrometer to measure the diameter of a shaft,

(b) Worker-Machine:

- A machinist operating an engine lathe to fabricate a part for a product,
- A fitter and an industrial robot working together in an arc-welding work cell.

Automation & Classifications

Automation technology concerned with the application of mechanical, electronic & computer based systems to operate & control production.



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Three types of automation relative to production quantity and product variety

Typical features of fixed automation

- high initial investment for custom-engineered equipment,
- high production rates,
- inflexibility of the equipment to accommodate product variety.

The high initial cost of the equipment can be spread over a very large number of units, thus minimizing the unit cost relative to alternative methods of production.

Examples of fixed automation include machining transfer lines and automated assembly machines.

Typical features of flexible automation

- high investment for a custom-engineered system,
- continuous production of variable mixtures of parts or products,
- medium production rates,
- flexibility to deal with product design variations.

Examples of flexible automation are flexible manufacturing systems that perform machining processes.

Typical features of programmable automation

- high investment in general-purpose equipment,
- lower production rates than fixed automation,
- flexibility to deal with variations and changes in product configuration,
- high suitability for batch production.

Examples of programmable automation include numerically controlled (NC) machine tools, industrial robots, and programmable logic controllers.

Reasons for Automation in Production System

- To increase labor productivity
- To reduce labor cost
- To mitigate the effects of labor shortage
- To reduce or eliminate routine manual or clerical tasks
- To improve worker safety
- To improve product quality
- To reduce manufacturing lead time
- To accomplish processes that cannot be done manually

Where is all these leading to?

- Reduced engineering design cost
- Decrease overall lead time
- Increase productivity of manufacturing operations
- Reduced work in progress.

Manual Labor in Factory Operations & Manufacturing

A number of situations in which manual labor is preferred:

- Task is technologically difficult to automate,
- Short product life cycle,
- Customized product,
- To cope with the ups and downs in demand,
- Lack of capital.

Relative Strengths and Attributes of Humans and Machines

Humans	Machines
Sense unexpected stimuli	Perform repetitive tasks consistently
Develop new solutions to problems	Store large amounts of data
Cope with abstract problems	Retrieve data from memory reliably
Adapt to change	Perform multiple tasks simultaneously
Generalize from observations	Apply high forces and power
Learn from experience	Perform simple computations quickly
Make decisions based on incomplete data	Make routine decisions quickly

T1931

Even if all the manufacturing systems in the factory are automated, there will still be a need for the following kinds of work to be performed

- Equipment maintenance
- Programming and computer operation
- Engineering project work
- Plant management

USA Strategy for Automation

1. Understand the existing process
2. Simplify the process
3. Automate the process

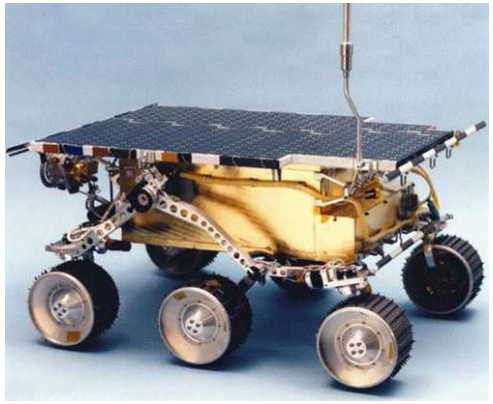
Introduction

- A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.
- True robots should be distinguished from the manually controlled manipulator or telecheric, which is remotely controlled by human operators and not programmed to operate automatically and unattended.
- Robotics is the art, knowledgebase, and the know-how of designing, applying, and using robots in human endeavours.
- Situations to promote the use of robots:
  - Hazardous environment for humans
  - Repetitive work cycle
  - Difficult handling for humans
  - Multi-shift operations
  - Infrequent changeovers

Robot Applications

- Industrial Applications:
  - Material handling
  - Processing operations
  - Assembly and inspection
- Field Applications: Robots are deployed in areas where human being could not survive or be exposed to unsustainable risks.
- Service Applications: Robots are used in civil applications such as intelligent transportations, patient rehabilitation system, medical applications, domestic aid, entertainments etc.

Field Robot Applications



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Sojourner rover, deployed by Pathfinder in 1997 by NASA

Service Robot Applications

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Autonomous car Stanley completed a path of 132 miles in record time of 6 h and 53 min in DARPA Grand Challenge 2005

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The EndoAssistant manipulates a laparoscopic camera at the command of the surgeon

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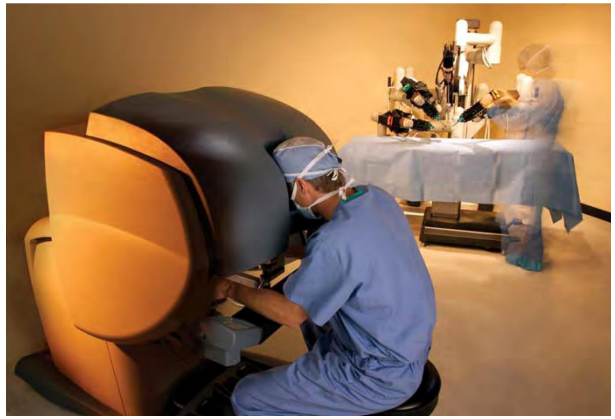

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The da Vinci robotic surgical system comprising of a surgeon's console and a patient side cart

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Asimo by Honda

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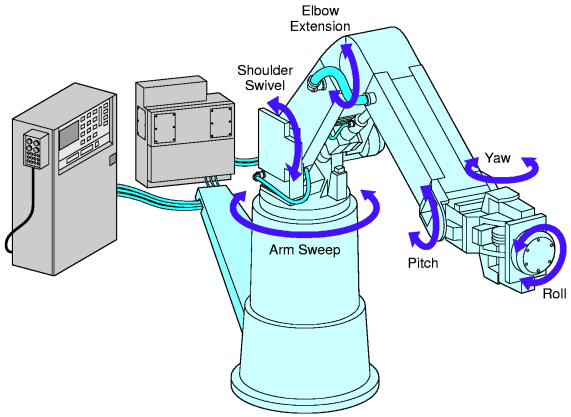
AIBO by Sony Corp

Robot Structure & Classifacations

- Robots can be classified as:
  1. robot manipulators (robots with fixed base)
  2. mobile robots (robots with mobile base)
- Robot manipulators are classified as:
  1. Cartesian (3P): 20% of industrial robots
  2. Cylindrical (R2P): 12%
  3. Spherical / Polar (2RP)
  4. Articulated / Anthropomorphic (3R): 59%
  5. Selective Compliance Assembly Robot Arm (SCARA): 8%
- Mobile robots are classified as:
  1. Wheeled mobile robots
  2. Legged mobile robots

6 DOF Industrial Robot Example



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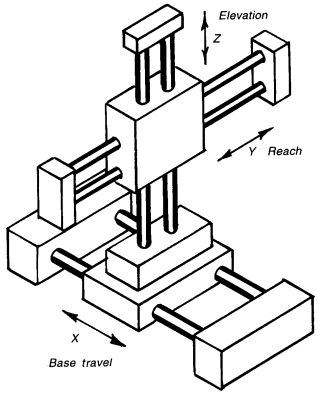
In most general case of arbitrarily positioning and orienting an object in 3D space 6 DOFs are required

Carteisan (3P) Robot



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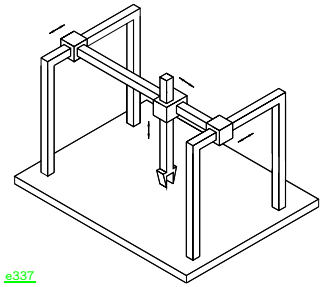
- *Cartesian roots have 3 prismatic joints whose axes typically are mutually orthogonal and thus it is natural to perform straight motions in space.*

Gantry Robot



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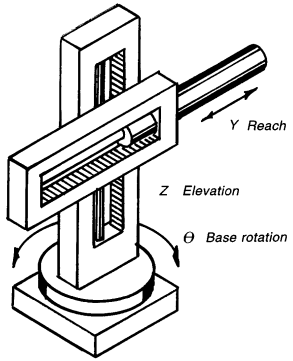
Ganty robots can approach an object from the top. Such a structure offers large volume workspace and enables the manipulation of objects of large dimensions and heavy weight.

Cylindrical (R2P) Robot



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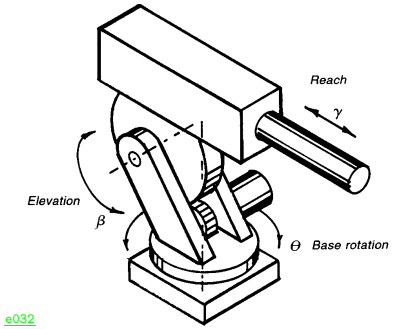
- *Cylindrical geometry differs from Cartesian in that the first prismatic joint is replaced with a revolute joint.*
- *Cylindrical manipulators are mainly employed for carrying objects of large dimensions.*

Spherical (2RP) Robot



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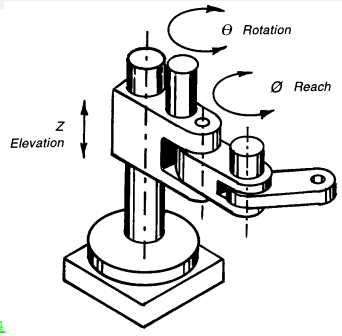
- *Spherical geometry differs from cylindrical in that the second prismatic joint is replaced with a revolute joint.*
- *Spherical manipulators are mainly employed for machining. Electric motors are typically used to actuate the joints.*

SCARA Robot



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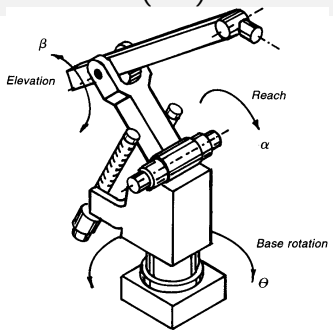
- *Selective Compliance Assembly Robot Arm (SCARA) has two revolute joints and one prismatic joint in such a way that all the axes of motion are parallel.*
- *SCARA manipulator is suitable for manipulation of small objects; joints are actuated by electric motors.*

Articulated (3R) Robot



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- *Articulated robots have three revolute joints; by virtue of its similarity with the human arm, the second joint is called the shoulder joint and the third joint the elbow joint since it connects the 'arm' with the 'forearm'.*
- *Joints are typically actuated by electric motors. The range of industrial applications is wide.*

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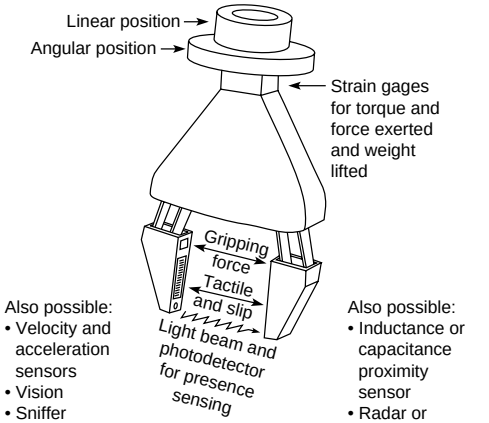
Robot Gripper



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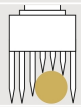
mechanical grippers		suction grippers	magnetic grippers	adhesive grippers	mold grippers	nail grippers
scissors gripper	fork gripper		electromagnet	adhesive foil		
						
parallel jaw gripper	three-point gripper		permanent magnet			
						

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- Mechanical grippers:- consisting of two or more fingers that can be actuated by the robot controller to open and close to grasp the work-piece.
- Vacuum grippers:- such cups are used to hold flat objects.
- Magnetized devices:- for holding ferrous work-pieces.
- Adhesive devices:- where adhesive substances are used to hold flexible materials like fabric.
- Simple mechanical devices:- such as hooks and scoops.

Robot Drives

	pneumatic	hydraulic	electric
translatory drive movement with limited travel	pneumatic cylinder	hydraulic czylinder	electromotor
translatory drive movement with unlimited travel			linear motor
rotary drive movement with limited rotary angle	swivel/rotary cylinder	swivel/rotary cylinder	
rotary drive movement with unlimited rotary angle	air-pressure motor	hydromotor	stepping motor DC motor AC motor

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1. Pneumatic drive:- pressurized air is supplied through lines to cylinders, causing air pressure to be transformed into mechanical work.
2. Hydraulic drive: pressurized fluid entering into cylinders causes the cylinder to extend or retract.
3. Electric drive:- electric drive systems either use AC or DC electric motors. Motors are connected to the manipulator's axes through gear reduction mechanisms to develop necessary torque for the robot to lift heavy payloads.

Robot Sensors

tactile	non-tactile		
force/torque	**video-visual**	**ultrasonic**	**other**
• multicomponent force/ torque sensor • gripping force measure • active wing/blade gripper • RCC • IRCC	• linear sensor • image processing (binary, gray scale value) • 3 D stereo imageprocessing • image processing with active illumination	• proximity switch • sonic barrier • distance measuring • scanner • acoustic correlation sensor	• microwave • pneumatic • radioactive • chemical
tactile	**visual**	**inductive, capacitive, magnetic and piezoelectric**	
• switch • distance measuring • touch line • touch matrix • flat-top switch • slip sensor	• light barriers • reflection light master • distance measuring • 2 D scanner • 3 D scanner • light stripe sensor • visual correlation sensor	• proximity switch • distance measuring • welding seam tracking • vibration analysis	

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Robot Programming Modes

1. Physical setup:- an operator sets up switches and hard stops that control the motion.
2. Lead through or teach mode:- the robot's joints are moved with a teach pendant.
3. Continuous walk-through mode:- all robot joints are moved simultaneously, while the motion is continuously sampled and recored by the controller.During playback, the recorded motion is executed.
4. Software mode:- a program is written off-line/on-line and is executed by the controller to control the motion.

Robot Specifications

- Payload: the weight a robot can carry and still remain within it other specifications.
- Reach: the maximum distance a robot can reach within work envelope.
- Precision: how accurately a specified point can be reached.
- Repeatability: how accurately the same position can be reached if the motion is repeated many times.