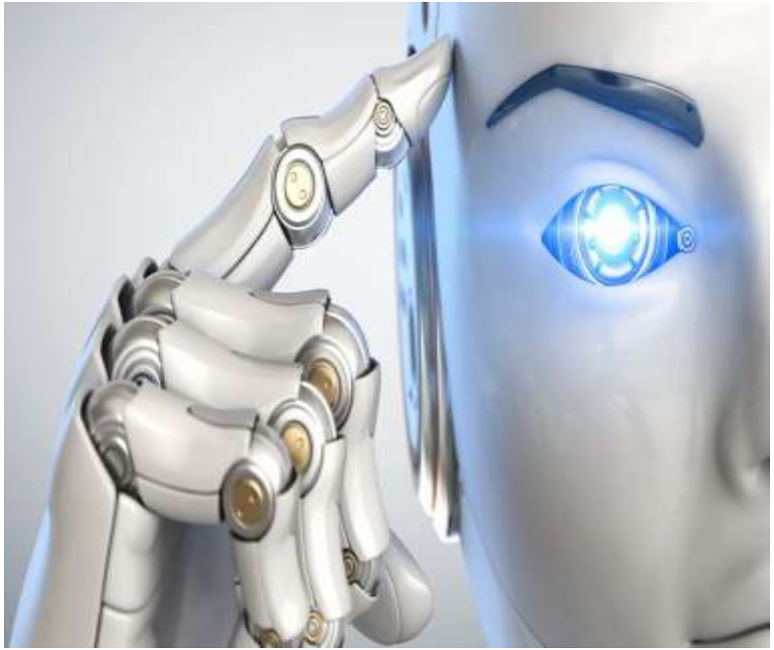
ROBOTICS (17130705)

Unit-I Automation and Robotics
IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:
Dr T Jayananda Kumar
Professor
Mechanical Engineering
GIET(A) , Rajahmundry.

Course Outline …

- Why should Robotics be studied?
- What is Automation?
- What is a Robot?
- How the Robot Works?
- Productivity in manufacturing industries – Role of Robots



Course Outcomes

After completion of this course, a successful student will be able to:

- CO-1. Identify various robot configuration and components. (PO4)
- CO-2. Select appropriate actuators and sensors for a robot based on specific application. (PO6)
- CO-3. Solve kinematic and dynamic problems for simple serial kinematic chains. (PO7)
- CO-4. Plan trajectory for a manipulator for avoiding obstacles. (PO5)

UNIT – I

Syllabus

INTRODUCTION:

<u>Automation and Robotics</u>, CAD/CAM and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system. Robot applications in manufacturing

Automation:

There are several examples of automation one come across daily

- Sewing Machine
- Packaging Machines
- Copying Lathe Machines etc.,

https://www.youtube.com/watch?v=jB8pKR2Nnb4

- Generally equipped to perform in a specific way or to execute specific tasks

- When stitch lengths or product size change

- some parts of the machine are to be manually changed to accommodate the new size

special purpose machines

Machines essentially designed to produce / package millions of products of a specific size, shape

cost of such a machine is distributed over large sales volumes.

Recently there is a huge demand for variety

Change in dimensions leads to

- Stoppage of the machine
- Readjust and/or Replace and/or reset some of the links or components to handle the new product
- Time consuming but also requires skill

Automation is the only solution to meet the ever changing demand

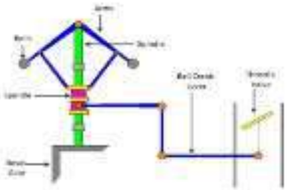
Automation defined :

International Society of Automation defines automation as "the creation and application of technology to monitor and control the production and delivery of products and services."

- Autonomous Machine
- Mechanical Automation – Many Constraints

Examples of Mechanical Automation

- A Governor



- An automaton writing a letter in Swiss Museum CIMA.

- The Antikythera mechanism from 150–100 BC was designed to calculate the positions of astronomical objects

- A cuckoo clock

- Tea-serving Japanese automaton, "karakuri ningyō"

- One of the most advanced automata proposed to date is NASA's Automaton Rover for Extreme Environments (AREE)

Robotics:
An important part of the automation

A Brief History of Robotics

- The clepsydra water clock introduced by the Babylonians (1400 BC) - First automated mechanical artefacts'.
- A fantasy world - Inspiration to convert fantasy into reality.
- Cinematic creativity
- Scientific ingenuity
- Entrepreneurial vision

1921 : The term “robota ” was used the first time by the Czech writer Karel Capekin in his play “Rossum`s Universal Robot”.

1941 : The science fiction writer Isaac Asimov (1920–1992) first used the word “robotics” to describe the technology of robots. He proposed also the “Laws of Robotics”

The definition of a robot is controversial, even among roboticists.

- The International Organization for Standardization defines a robot as "an automatically controlled, reprogrammable, multipurpose manipulator with three or more axes."

- The Robot Institute of America designates a robot as "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks."

- Merriam- Webster, stating that a robot is "a machine that looks like a human being and performs various complex acts (as walking or talking) of a human being."

Video-References

- **VIDEO 1.1.2** Robots – A 50 year journey
- available from http://handbookofrobotics.org/view-chapter/01/videodetails/805
- **VIDEO 1.1.3** Robots – The journey continues
- available from http://handbookofrobotics.org/view-chapter/01/videodetails/812

References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York

Introduction to Robotics, Craig John J., Addison Wesley, New Delhi

“Robotics and Control” R K & Nagrath I J / Tata McGraw-Hill,india,edition, 2003

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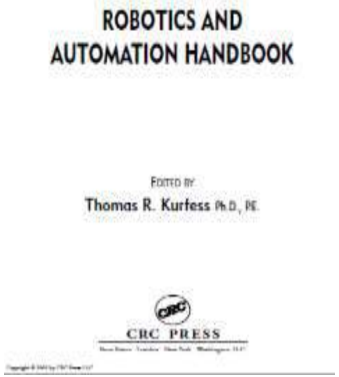

In this lecture you have been briefly introduced to:

- Automation
- Robots

Congratulations, you have finished Lecture 1

Review Questions

State any five examples of mechanical automation.

Who among the following first coined the word Robot :

(a) A scientist (b) A Fiction Writer (c) An Industrial Engineer

Who proposed Laws of robots.

State Laws of robots.

Design a procedure to implement automation Robot garden for any one existing ne manufacturing unit of your choice

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UNIT – I

Syllabus

INTRODUCTION:

Automation and Robotics, **CAD/CAM and Robotics** – An over view of Robotics – present and future applications – classification by coordinate system and control system. Robot applications in manufacturing

Industrial Production 1950 -1960

Started questioning ...

- How to improve the working conditions of the work forces in production?
- How to release human workers from hard and unhealthy work like welding, riveting, or die-casting?
- How to reduce dangerous work by introduction of appropriate machinery?

Mechanization and Automation found to be the only solution

First industrial robots (1950-1979)

- The first industrial robot, called ***UNIMATE***, was created by **George Devol** and **Joseph Engelberger** in the 1950s

- In **1956** the **first robot company** *UNIMATION* produced and marketed ***Unimate*** robots

George Devol

- First **UNIMATE‘ robots (**hydraulic actuators) were installed at General Motors in **1961**.

- In **1969 Victor Scheinman** invented an all electric 6-axis robot arm at Stanford University and named **“Stanford Arm”.** Birth to the class of articulated robots.

- In **1966 FORD** and **CHRYSLER** were introducing **UNIMATEs** into their plants
- Welding, spray painting and other jobs
- Being dangerous, difficult, unhealthy, and very repetitive for the human workers .. The age of **Industrial Automation** started!!

Need for CAD/CAM

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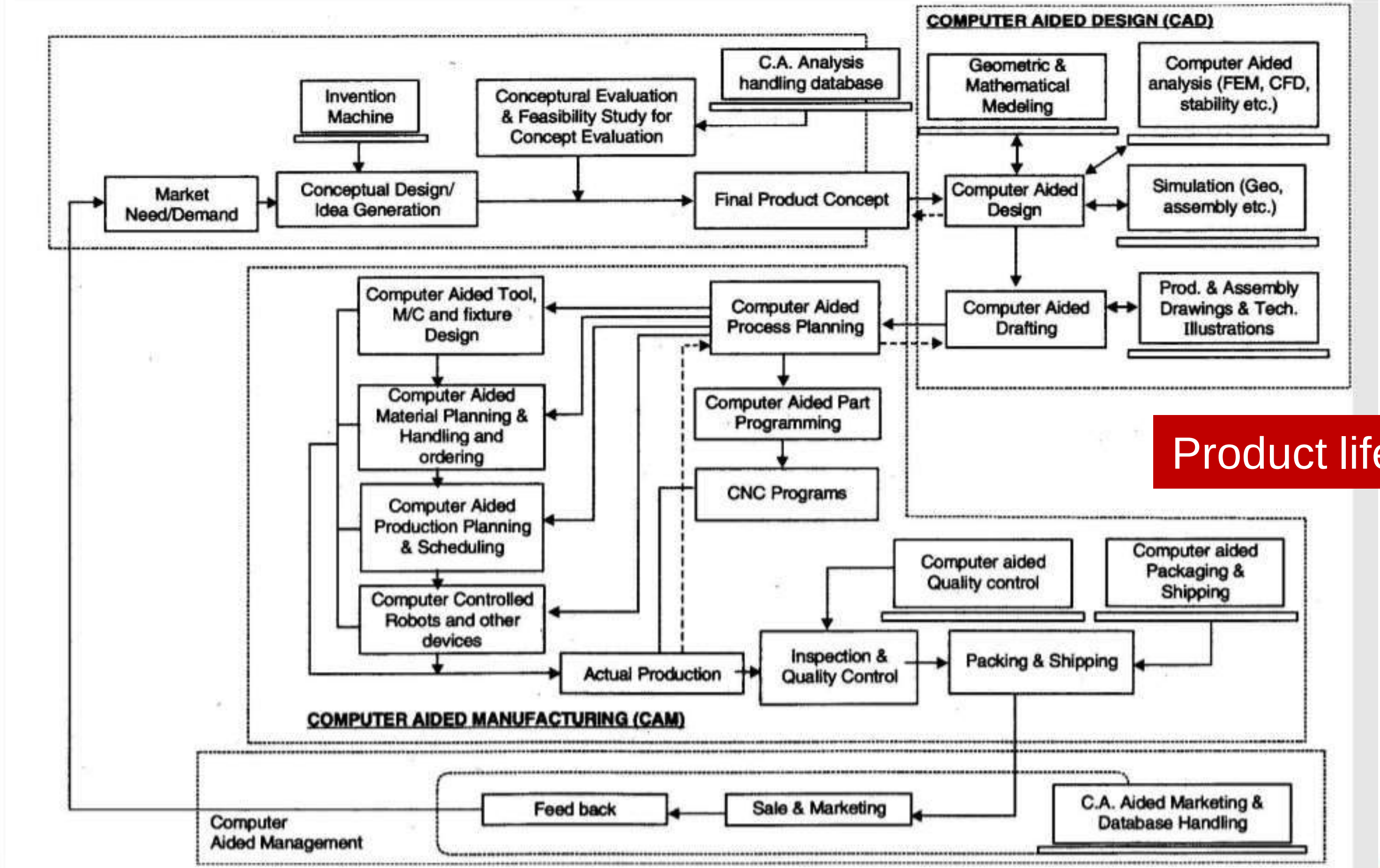
- Design and manufacturing forms the core of engineering
- To remain competitive in global economy
- New products with enhanced features at competitive costs
- Mass customization
- High flexibility in the manufacturing system
- Reduction in manufacturing cost and delivery time
- Reduction in product life cycle

Computer Aided Manufacturing

Types of manufacturing

1. Continuous process industries – Sugar industry, chemical industry etc.
2. Mass production industries – Automobiles, Consumer goods etc.
3. Batch production industries – machines, aircrafts etc.
4. Job production industries – Prototypes, heat exchangers , chemical reactors etc.

- Automation is focused on reducing unit production time
- In plant material handling



Product life cycle

Characteristics of computerized numerical control (CNC) and robot controller (RC)

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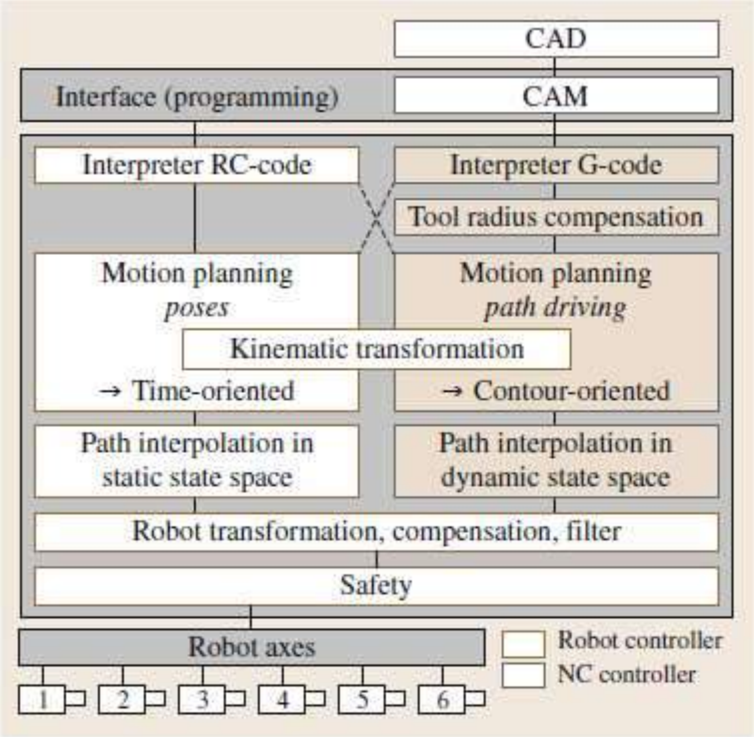
Category	CNC	RC	Interpretation
Targeted application	Machining, material removal	Handling, assembly	A CNC machine tool is single purpose; generally robots are universal machines
Motions	Path-based, complex contour-oriented	Point- or path-based and motion time-oriented	Extended look-ahead of CNC controllers allows detailed path description and adaption on $\gg$ 100 via points ($<$ 10 via points in most robot controllers)
Programming	On-site programming based on standardized programming language (G-code), ISO (International Organization for Standardization) 6983, use of computer aided manufacturing (CAM) tools	On-site teaching (teach pendant, editor) based on supplier specific languages, use of typical robot simulation environments	Whereas robots are traditionally programmed manually on site, CNC controllers use CAM technology to generate complex paths automatically based on CAD data
Command reading	Online interpreter, continuous loading of instruction	Initial loading of programs, which are usually interpreted, sometimes compiled)	Program size in robot controllers limited by memory, CNC interprets programs online, may execute an unlimited number of commands

Structure of an NC-kernel integrated into a robot controller (courtesy of ISG Stuttgart)



References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York

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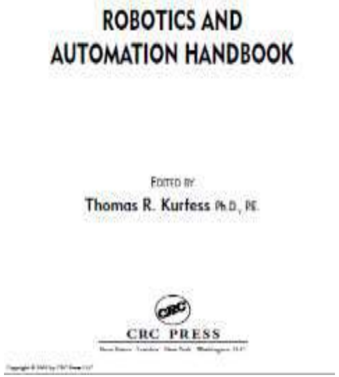

In this lecture you have been briefly introduced to:

- CAD/CAM
- Robots
- Integration of the above

Congratulations, you have finished Lecture 2

Review Questions

Who created first industrial robot.

Name the first industrial robot.

Name the robot with all electric actuators .

Which industry has implemented industrial robots.

List any five robot manufacturing establishments.

What is the role of robots in manufacturing.

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Unit-I An over view of Robotics – Present and future applications

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UNIT – I

Syllabus

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- 1971: First Unimation robots installed by KUKA for welding in a production line at Daimler-Benz AG, Stuttgart

- 1973: KUKA entered into robotic business

with their own FAMULUS robot

- 1974: First computer-controlled ASEA Robot IRb6 for polishing of steel tubes.
- KAWASAKI started with Unitmate robots on the Japanese market.
- 1975: First ASEA IRb 6 in welding automation
- 1977: First ASEA robots in France and Italy (FIAT). The Japanese company YASKAWA introduced the first MOTOMAN robot on the market.

- 1977: UNIMATION started to market the famous PUMA robot (programmable universal machine for assembly)
- 1979: First ASEA robots for spot welding (IRb 60)
- 1977: First ASEA robots in France and Italy (FIAT).
- The Japanese company YASKAWA introduced the first MOTOMAN robot on the market.
- 1977: UNIMATION started to market the famous PUMA robot (programmable universal machine for assembly)
- 1979: First ASEA robots for spot welding (IRb 60)

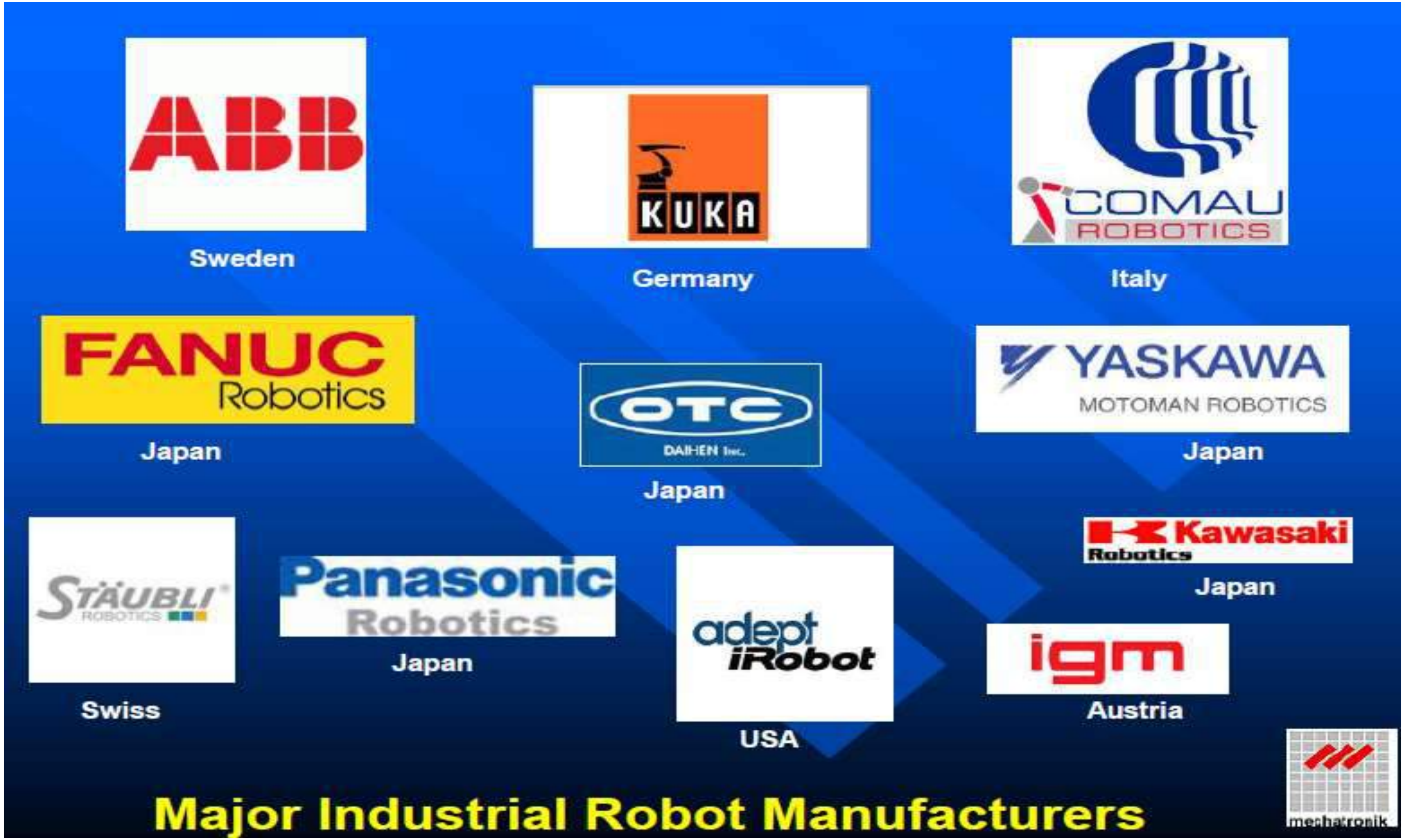
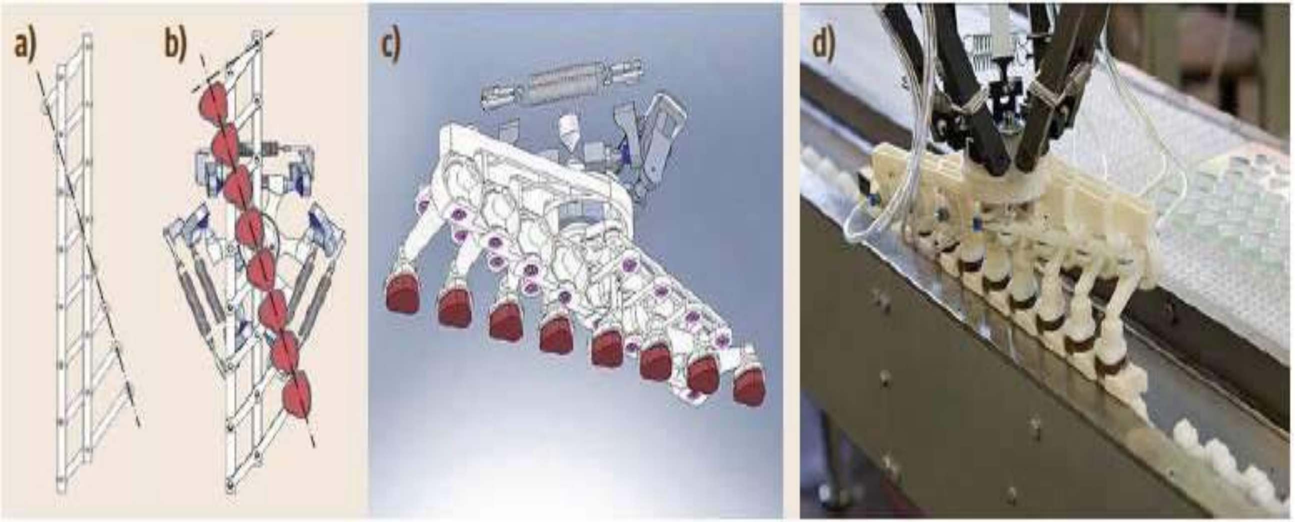


ABB
Sweden
KUKA
Germany
COMAU ROBOTICS
Italy
FANUC Robotics
Japan
OTC DAIHEN Inc.
Japan
YASKAWA MOTOMAN ROBOTICS
Japan
Kawasaki Robotics
Japan
STÄUBLI ROBOTICS
Swiss
Panasonic Robotics
Japan
adept iRobot
USA
igm
Austria
mechatronik
Major Industrial Robot Manufacturers

Typical Industrial Robot Applications

Out of the many possible uses of industrial robots, high-potential robot applications will be briefly described.

Handling : grasping, transporting, packaging, palletizing, and picking.



In food automation,
untouched by human hand entails critical requirements for robot automation such as the need for hygienic design, operational speed, ease of programming, and cost.

Bin-Picking

repeatable manner

grasping partly or randomly ordered parts

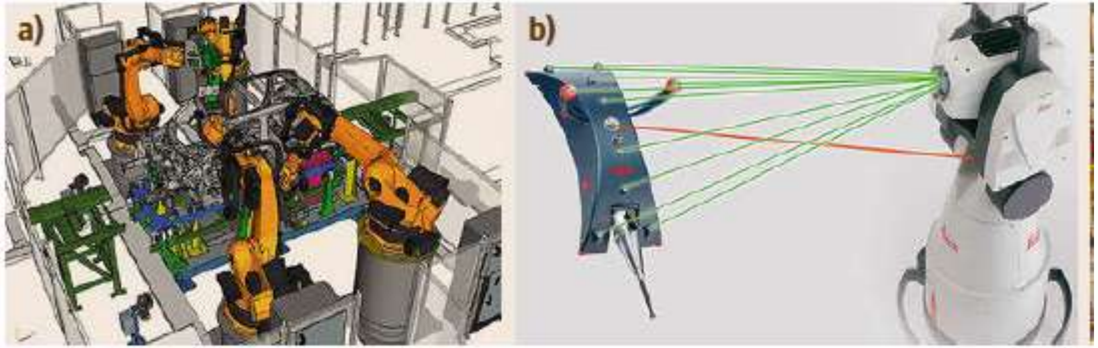
Welding

Typical robot-based welding processes are

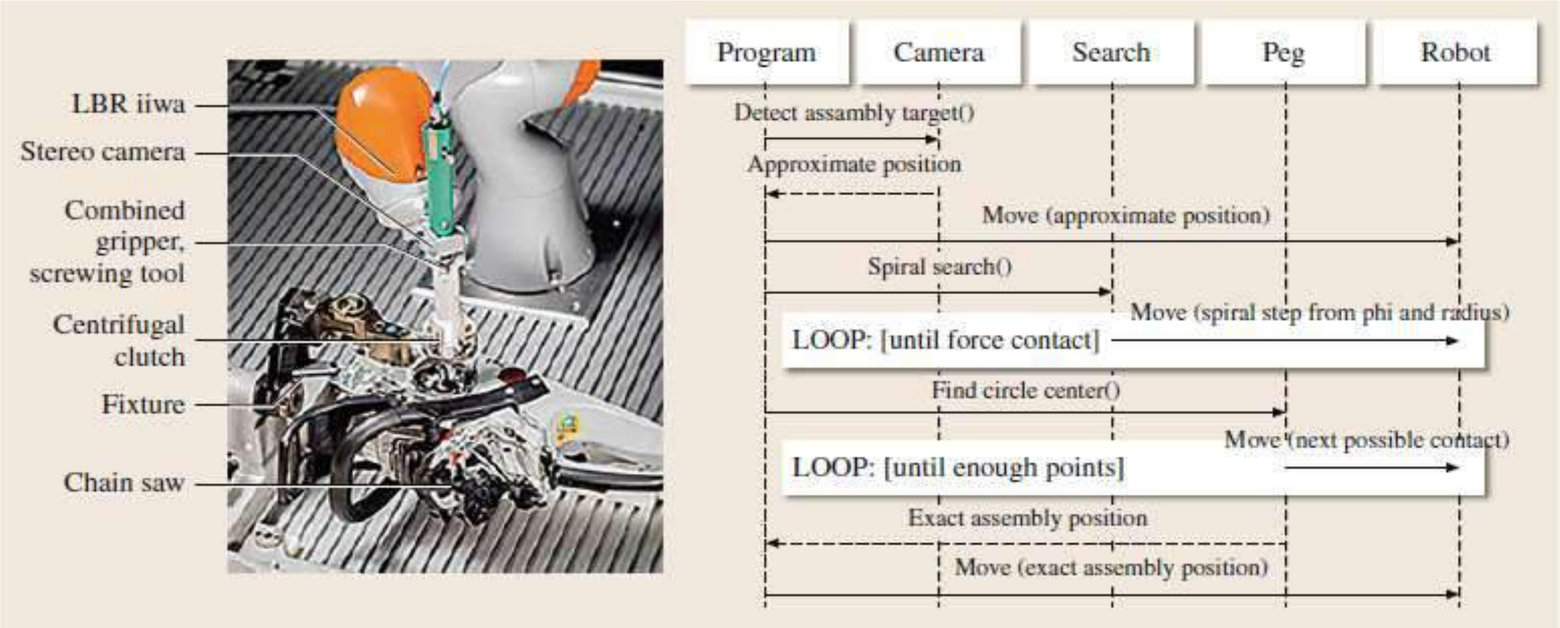
spot welding, particularly in car body assembly, and

gas-shielded metal arc welding (GMAW)

- increasing compactness of laser sources and robot motion accuracy laser welding is in the rise



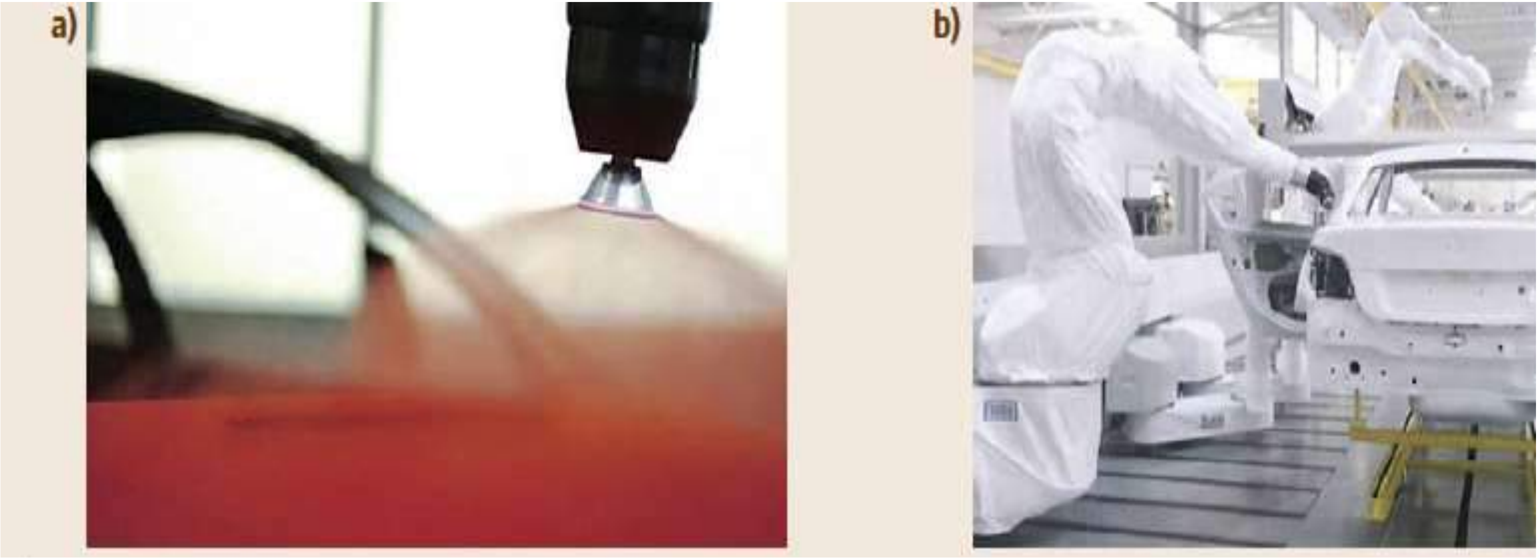
Assembly



Set up and implementation of a centrifugal clutch assembly for a chain saw

Painting

Hazardous working conditions for human operators

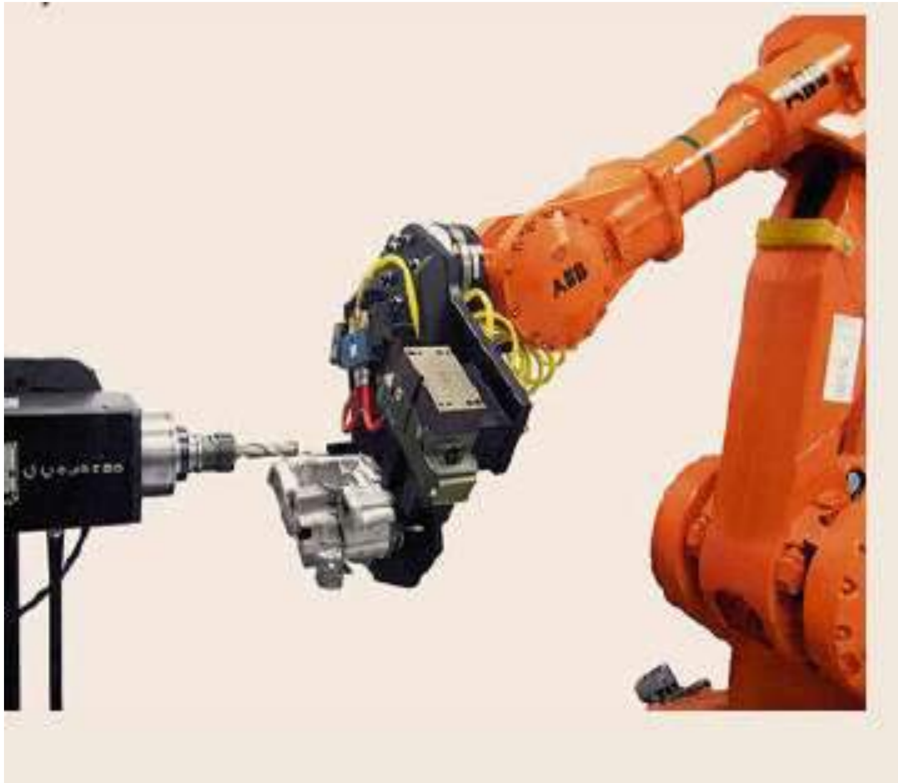


High-speed rotating atomizer and a multirobot workcell for car body painting

Processing

Material removal processes such as

- grinding,
- deburring,
- milling, and
- drilling



Space Robotics

- Space Shuttle Remote Manipulator System
- Teleoperated Rovers

http://handbookofrobotics.org/view-chapter/55/videodetails/330

- Autonomous Rovers

Rocky 4

Space Robotics Contd..

The Pathfinder rover, Sojourner : Returned 2.3 billion bits of information, including more than 16,500 images and 15 chemical analyses of rocks and soil
https://www.nasa.gov/mission_pages/mars-pathfinder

The Mars exploration rovers, Spirit and Opportunity, with a manipulator arm in front

Robotics in Agriculture and Forestry

Ex. Precision seeding system for broad acre farming

http://handbookofrobotics.org/view-chapter/56/videodetails/131
http://handbookofrobotics.org/view-chapter/56/videodetails/91

Robotics in Construction

Robotics in Hazardous Applications

Robotics in Mining

Disaster Robotics

Robot Surveillance and Security

Intelligent Vehicles

Medical Robotics and Computer-Integrated Surgery

Rehabilitation and Health Care Robotics

Domestic Robotics

Robotics Competitions and Challenges

Present and future applications cont..

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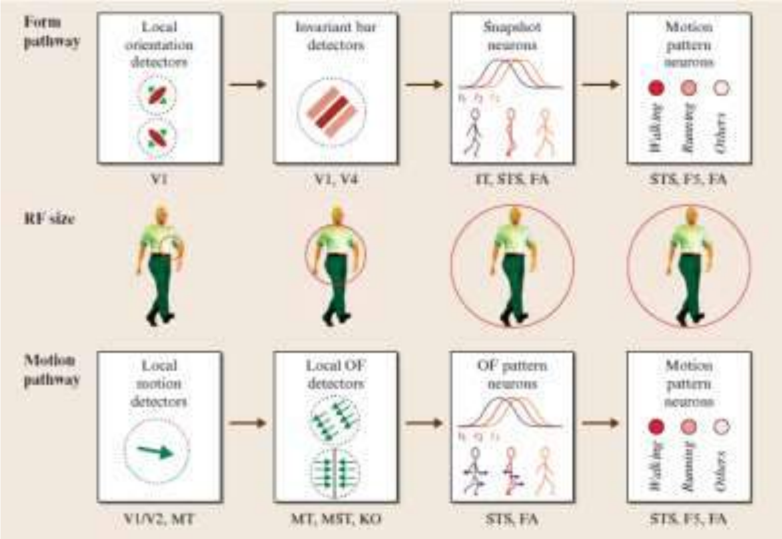
Robots and Humans – New upcoming vertical

Humanoids
Human Motion Reconstruction
Physical Human–Robot Interaction
Learning from Humans
Neurorobotics: From Vision to Action



http://handbookofrobotics.org/view-chapter/78/videodetails/569

New generation of robots may co-habitat with humans in homes, workplaces, and communities, providing support in services, entertainment, education, healthcare, manufacturing, and assistance.

References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York

Introduction to Robotics, Craig John J., Addison Wesley, New Delhi

“Robotics and Control” R K & Nagrath I J / Tata McGraw-Hill,india,edition, 2003

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https://nptel.ac.in/courses/112/101/112101098/

ROBOTICS: ADVANCED CONCEPTS & ANALYSIS

Ashitava Ghosal

NPTEL 2010

ROBOTICS FOR ENGINEERS

by Yoram Koren

McGraw-Hill Book Company

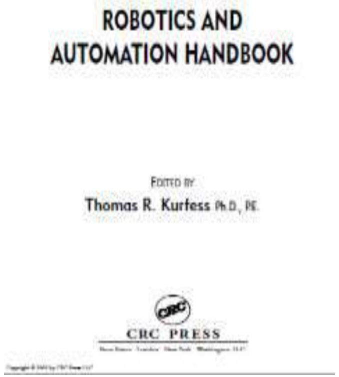
Introduction to Robotics

- 2.12 Lecture Notes -

H. Harry Asada

Ford Professor of Mechanical Engineering

Fall 2005



ROBOTICS AND AUTOMATION HANDBOOK

EDITED BY

Thomas R. Kurfess Ph.D., P.E.

CRC PRESS

Springer Handbook of Robotics

Siciliano

Khatib

Editors

2nd Edition

In this lecture you have been briefly introduced to:

- Developmental milestones of robots
- Present and future applications of robots

Congratulations, you have finished Lecture 3

Review Questions

First Unimation robots installed by KUKA for __________ process in a production line at Daimler-Benz AG, Stuttgart.

In which year KUKA entered into robotic business with their own FAMULUS robot.

List any five robot applications in space science.

Explain the scope of robots in agriculture.

ROBOTICS (17130705)

Presented By:
Name of the Faculty
Designation
Department
College

Lecture Details:
Topic Name
Subject/Branch, Semester etc.

ROBOTICS (17130705)

Unit-I Classification by coordinate system and control system

IV B.Tech. (Mechanical Engg.) I Sem.

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UNIT – I

Syllabus

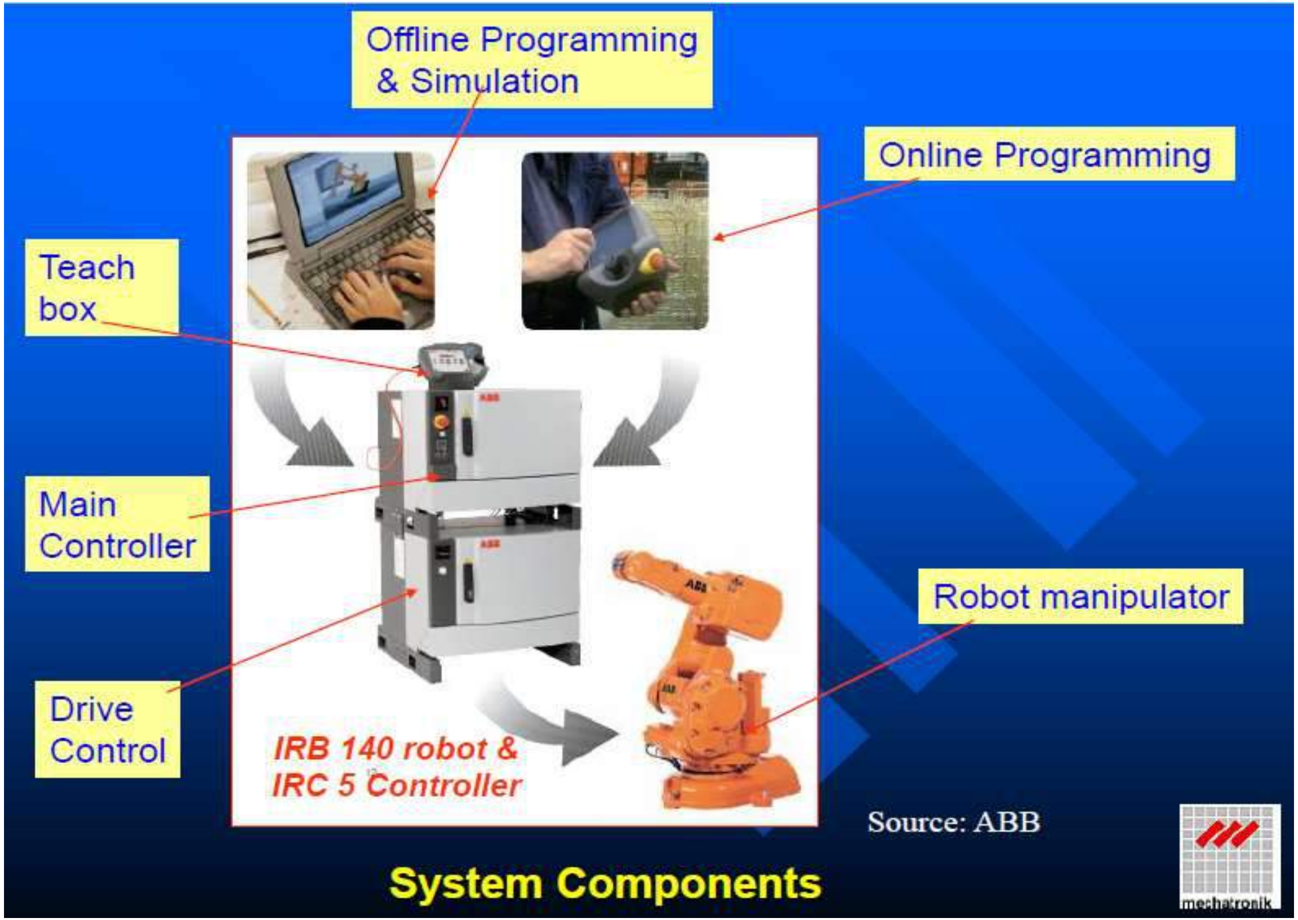
INTRODUCTION:

Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications – **Classification by coordinate system and control system** - Robot applications in manufacturing

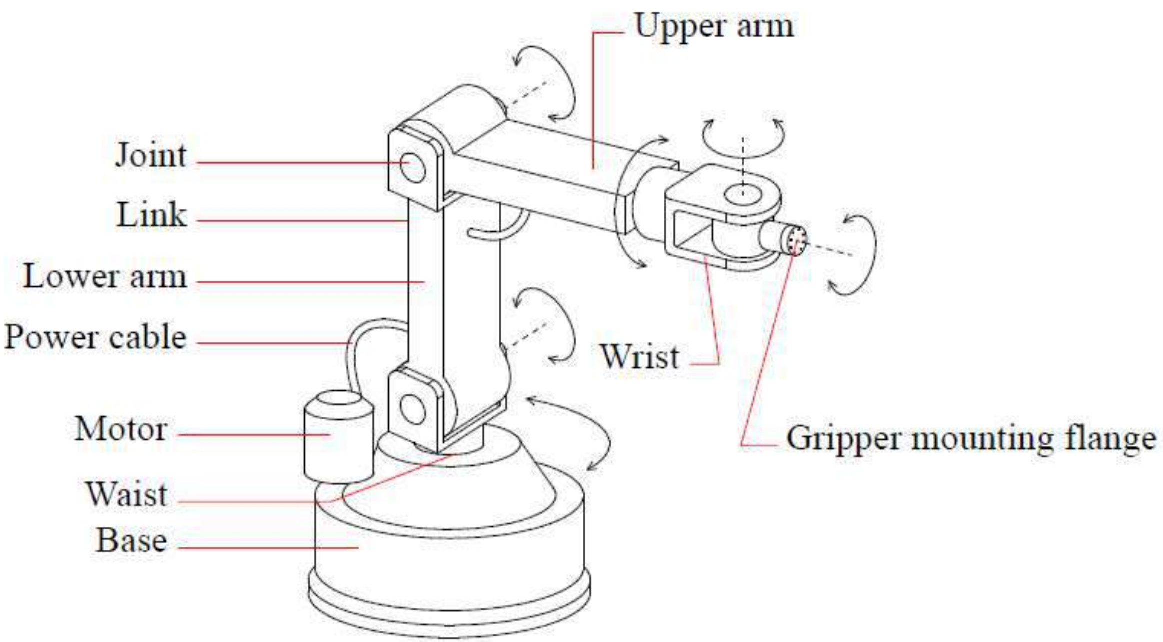
- By the definition of a robot: It is a machine which can perform a given task automatically using artificial intelligent and without human intervention.

Robot is made up of :

- Machine With Links and Joints
- Actuator (Motors) Attached At Each Joints
- The End-Effector
- Sensors Viz., Position Sensor Velocity Sensor or the Vision Sensor, Cameras Etc.,
- Controller Which Uses a Computer


Offline Programming & Simulation
Online Programming
Teach box
Main Controller
Drive Control
Robot manipulator
IRB 140 robot & IRC 5 Controller
Source: ABB
System Components
mechatronik

Robotic Arm

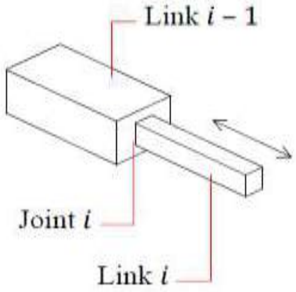


Upper arm
Joint
Link
Lower arm
Power cable
Motor
Waist
Base
Wrist
Gripper mounting flange

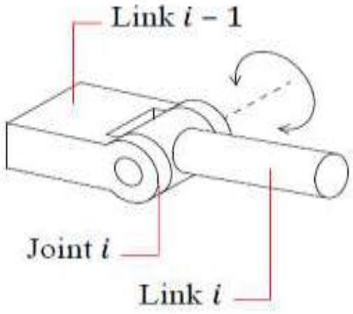
Types of Joints

Joints are of two types (movement)

1. Linear joint – links move in linear fashion with respect to its joint when actuated



2. Rotary joint – links move in rotary fashion with respect to its joint when actuated



Linear Joint

Rotary Joint

Moving Link executes linear motion about its joint axis.

P: Prismatic

Moving link executes rotary motion about its joint axis

R: Revolute

Degrees of Freedom

- Degrees of freedom (DOF) is defined as the ability of a joint to produce linear or rotary movement when actuated.

- Number of DOF for a robot is equal to the number of joint axes in the robotic arm.

Lower Pair Joints

A lower pair joint is the joint in which two contacting surfaces can slide over with one another in rotary or linear manner.

They are of six types

a) Revolute joint – 1 DOF

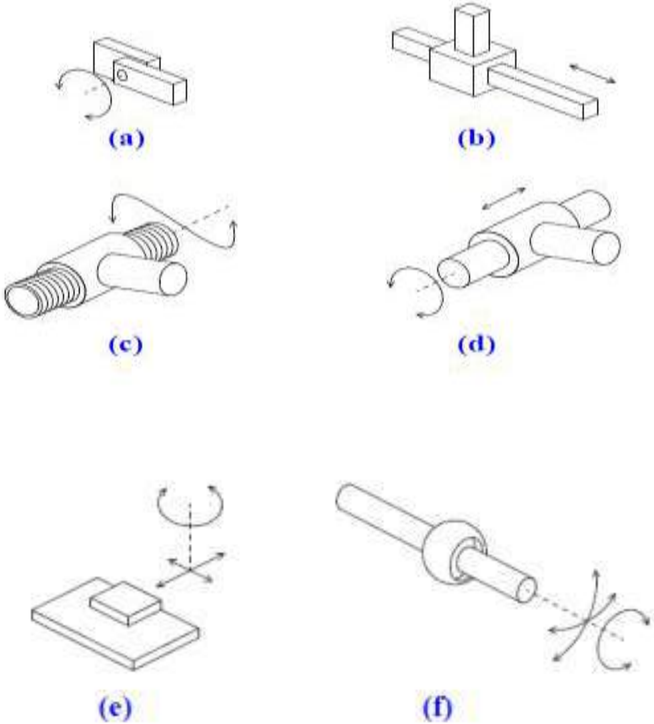
b) Prismatic joint – 1 DOF

c) Screw joint – 1 DOF

d) Cylindrical joint – 2 DOF

e) Planar joint – 3 DOF

f) Spherical joint – 3 DOF



(a) Revolute joint
(b) Prismatic joint
(c) Screw joint
(d) Cylindrical joint

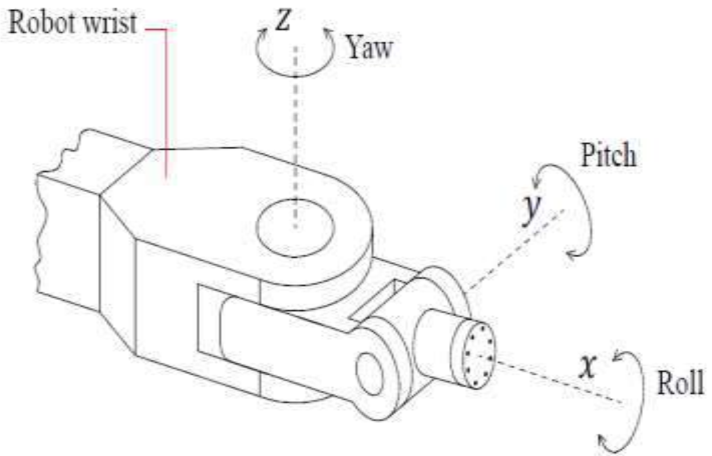
(e) Planar joint
(f) Spherical joint

Wrist Motion

1. Yaw – Rotary motion executed about z axis. Causes movement in left and right directions.

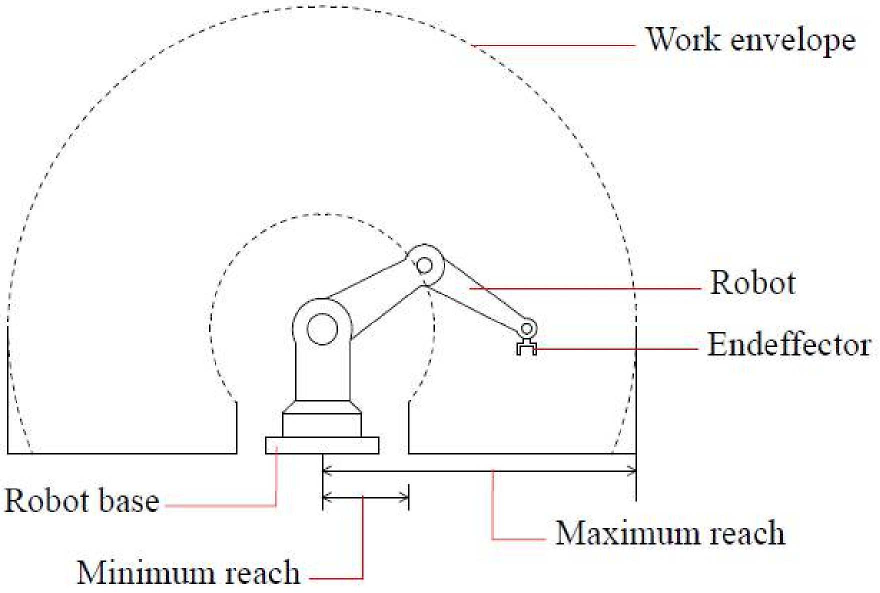
2. Pitch – Rotary motion executed about y axis. Causes movement in up and down directions.

3. Roll – Rotary motion executed about x axis.



Robot’s Work Volume

The three dimensional space around the robot



Classification of Manipulator

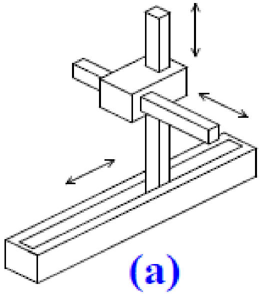
1. Cartesian coordinate robot system
2. Cylindrical robot system
3. Polar robot system
4. Pendulum robot system
5. Articulated or Jointed arm robot system

a) Horizontal axis jointed arm

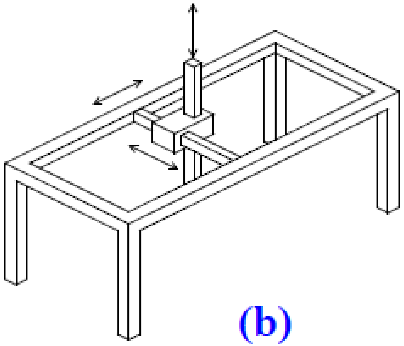
b) Vertical axis jointed arm

6. Multiple joint robot system

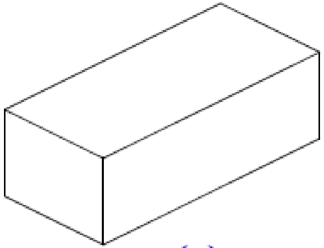
Cartesian Coordinate Robot System



(a)



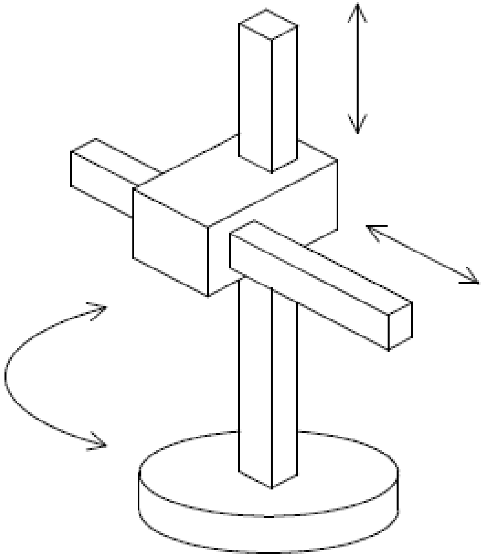
(b)



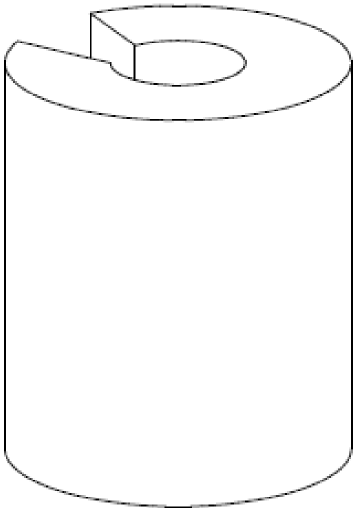
(c)

(a) Cartesian coordinate robot system
(b) Gantry style (area gantry)
(c) Rectangular work envelope

Cylindrical Robot System

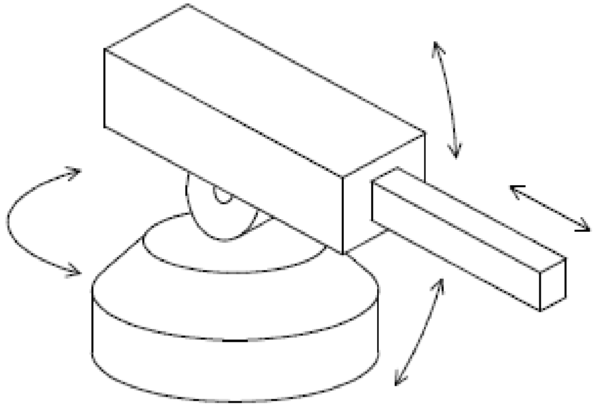


(a) Cylindrical robot system

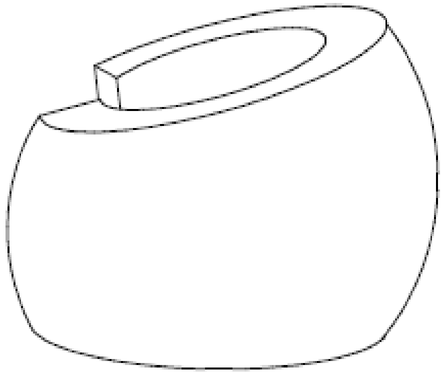


(b) Cylindrical work envelope

Polar Robot System

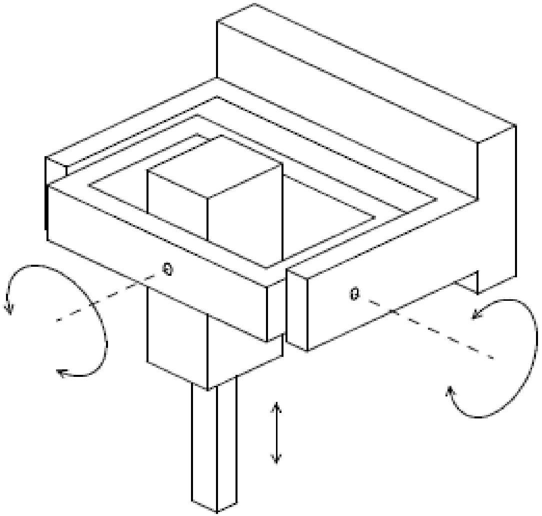


(a) Polar robot system

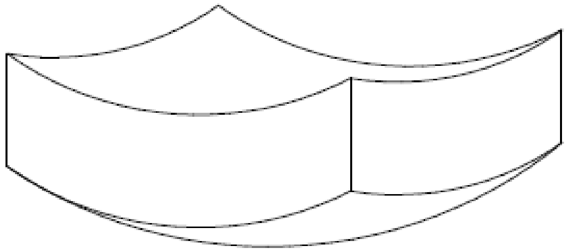


(b) Spherical work envelope

Pendulum Robot System

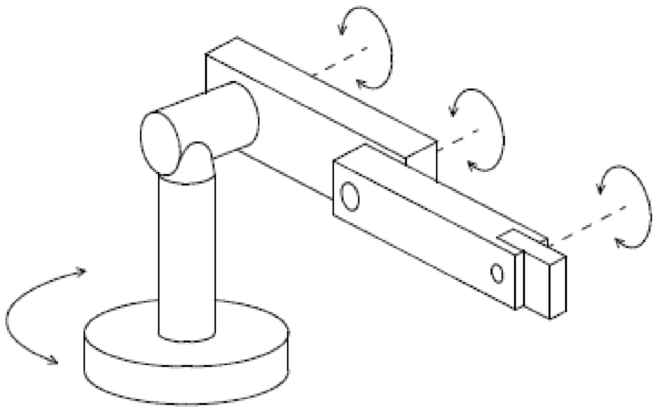


(a) Pendulum robot system

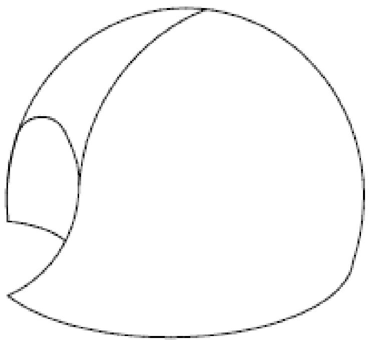


(b) Partially spherical work envelope

Horizontal Axis Jointed Arm

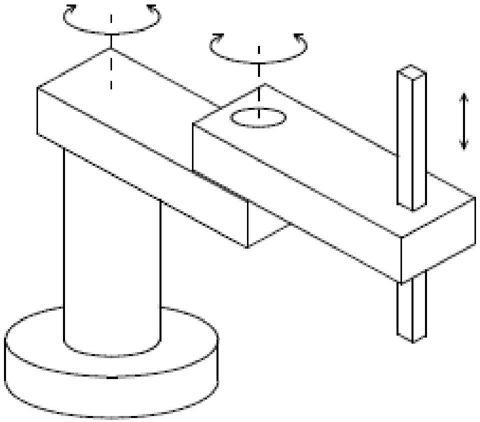


(a) Horizontal axis robot system

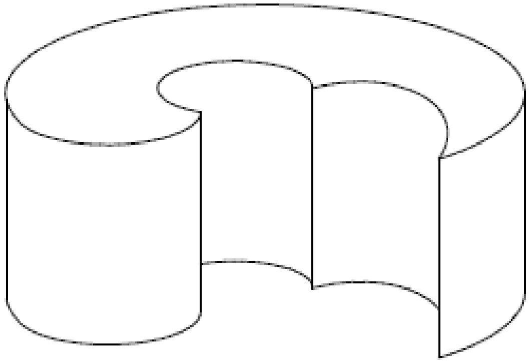


(b) Spherical work envelope

Vertical Axis Jointed Arm

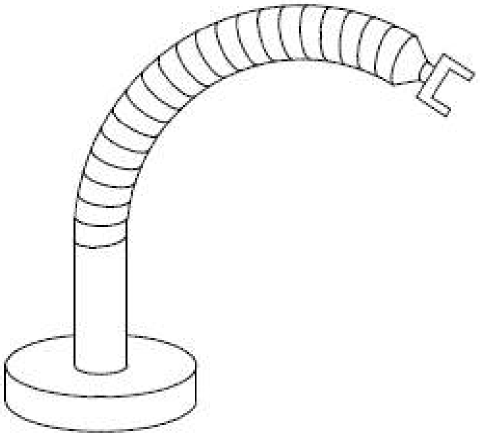


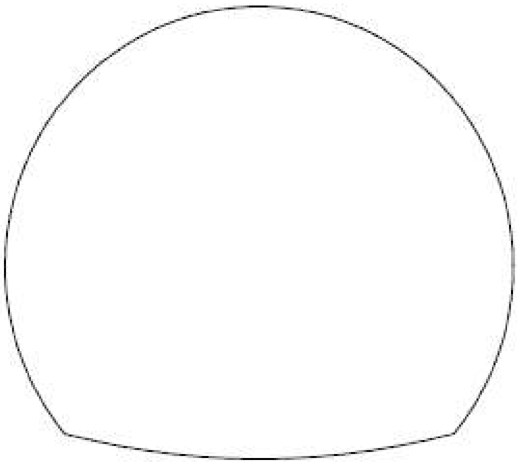
(a) Vertical axis robot system



(b) Cylindrical work envelope

Multiple Joint Robot System


(a) Spine robot system


(b) Spherical work envelope

Classification of Robot Manipulators based on types of joints

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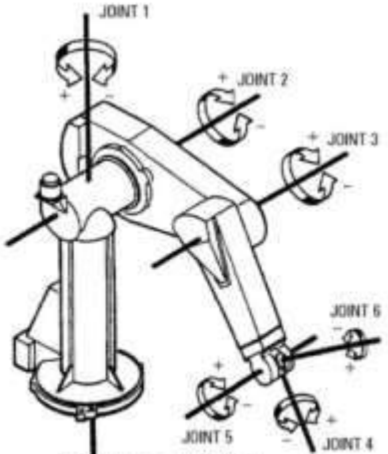
Arm Geometry (Joints)

- Serial link robots
  - Articulated (RRR)
  - Spherical (RRP)
  - SCARA (RRP)
  - Cylindrical (RPP)
  - Cartesian (PPP)
- Parallel robot
  - Closed chain

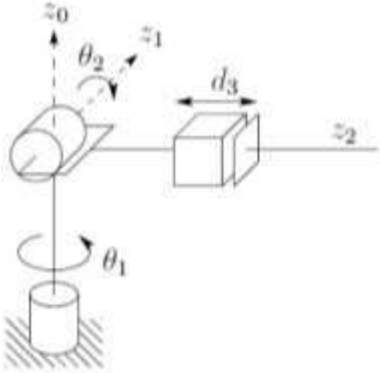
Articulated Manipulator (RRR)

- Number of joints determines the number of DOFs.
- 6 joints = 6 DOFs
  - J1: waist
  - J2: shoulder
  - J3: elbow
  - J4: wrist rotation
  - J5: wrist bend
  - J6: Flange rotation



Puma 560

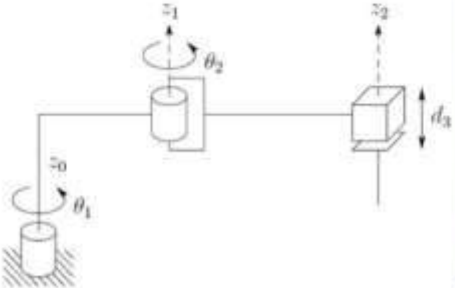
Spherical Manipulator (RRP)



Stanford arm

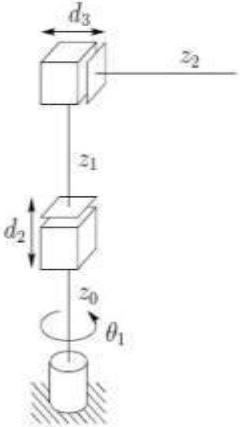
SCARA (RRP)

- SCARA: Selective Compliant Articulated Robot for Assembly



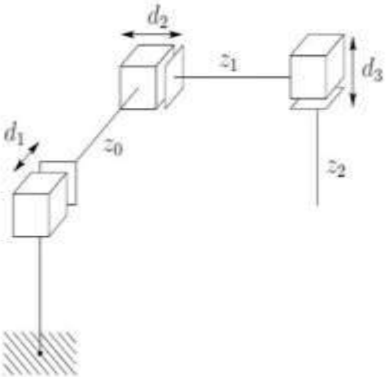
Epson E2L653S

Cylindrical Manipulator (RPP)



Seiko RT3300

Cartesian Manipulator (PPP)



Epson Cartesian robot

Parallel Manipulators

- Closed chains
- Prismatic actuators with spherical joints
- 6DOF Stewart platform: 6 linear actuators
- Precise positioning
- Large payload, small workspace
- Forward kinematics is hard to solve due to constraints and has multiple solutions.

Robot Control

- Actuators
- Transmission systems
- Power supplies
- Sensors and other electronics
- Electronics
- Software

- Actuators are required to move joints, provide power and do work.
- Serial robot actuators - low weight –actuators near the base.
- Parallel robots – Often actuators are at the base.
- Actuators drive a joint through a transmission device

Three commonly used types of actuators:

- Hydraulic
- Pneumatic
- Electric motors

References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York

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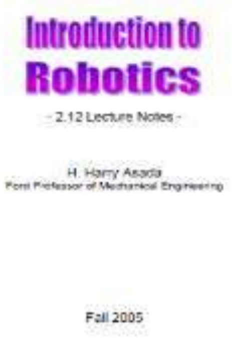

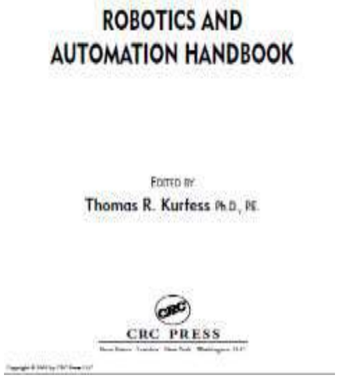

In this lecture you have been briefly introduced to:

- Robot Structure
- Robot Links and Joints
- Robot Configurations
- Classification of robots

Congratulations, you have finished Lecture 4

Review Questions

Explain DOF in robotics.

Classify robots based on joints.

List various joints.

What is work volume.

In robotics joints connects ______

What is RRR configuration.

***

ROBOTICS (17130705)

Unit-I Robot applications in manufacturing
IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:
Dr T Jayananda Kumar
Professor
Mechanical Engineering
GIET(A) , Rajahmundry.

UNIT – I

Syllabus

INTRODUCTION:

Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system. **Robot applications in manufacturing**

Industrial Robotics: The Main Driver for Robotics Research and Application

- CAD/CAM and CIM
- CNC machines for workerless shifts
- FMS
- Higher flexibility in manufacturing automation

Today’s industrial robots are mainly rooted in

- Capital-intensive large-volume manufacturing
- Automotive, electronics, and electrical industries
- In 1973, the company ASEA (now ABB) introduced

the first microcomputer-controlled all-electric industrial robot

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A robot workcell consists of one or more robots with controllers and so-called robot peripherals,

e.g., grippers or tools,

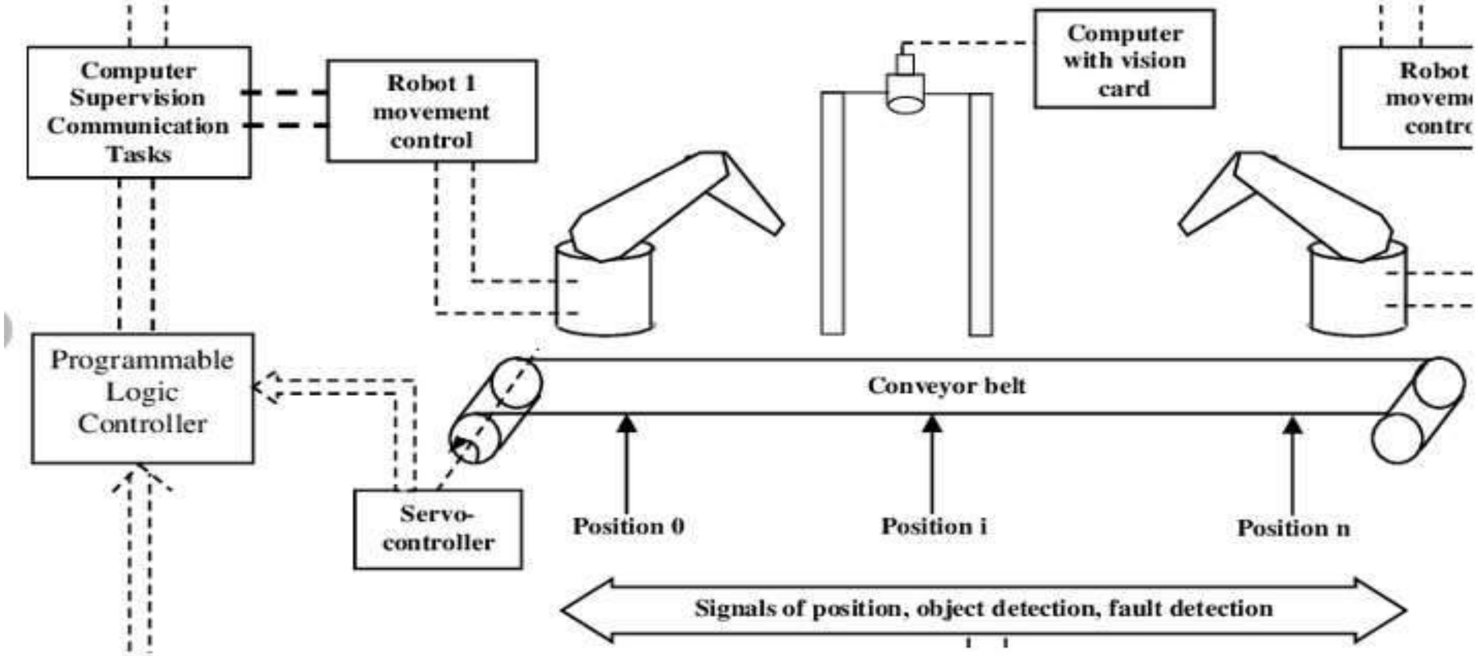
safety devices,

sensors, and

Material transfer components for moving

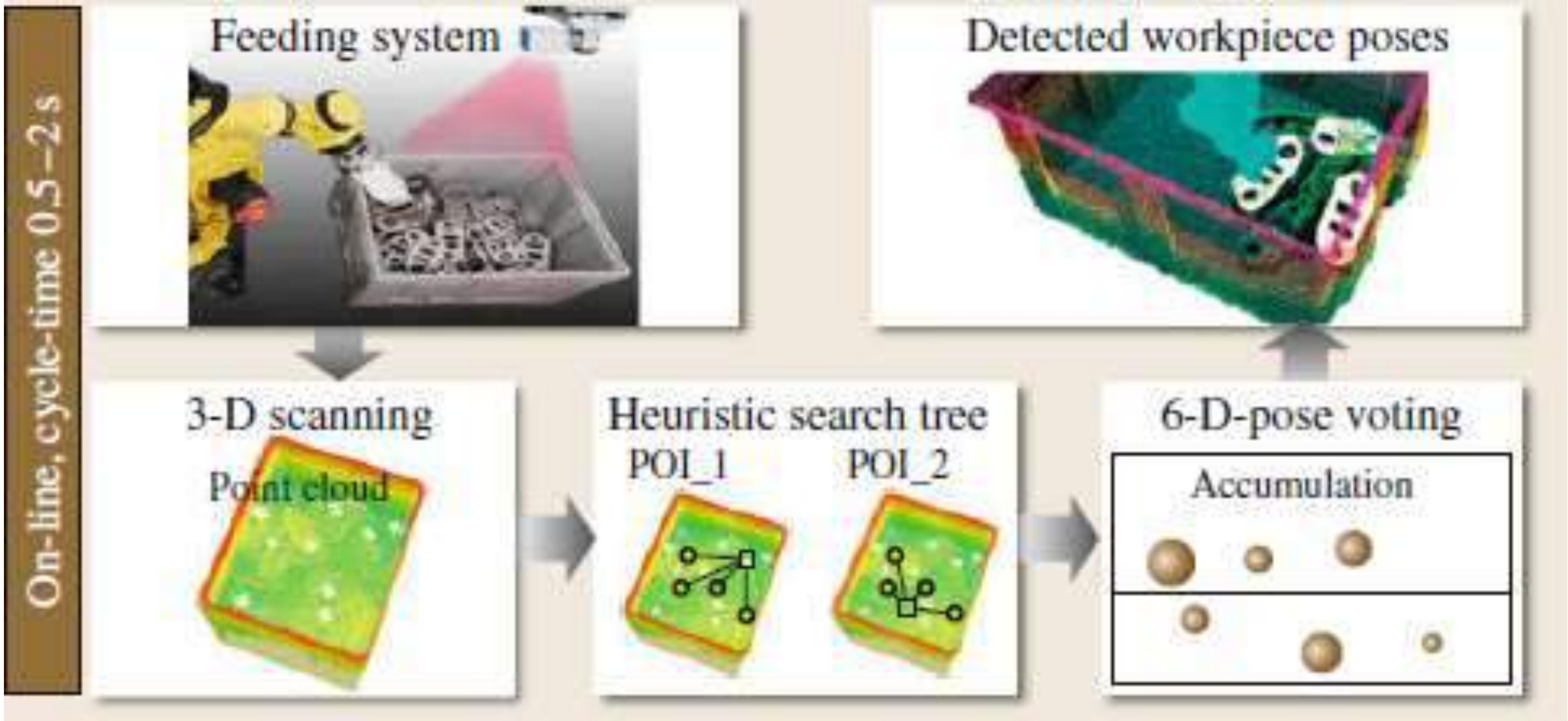
- https://www.nist.gov/video/coordinated-assembly-heterogeneous-robotic-work-cell

Robot workcell

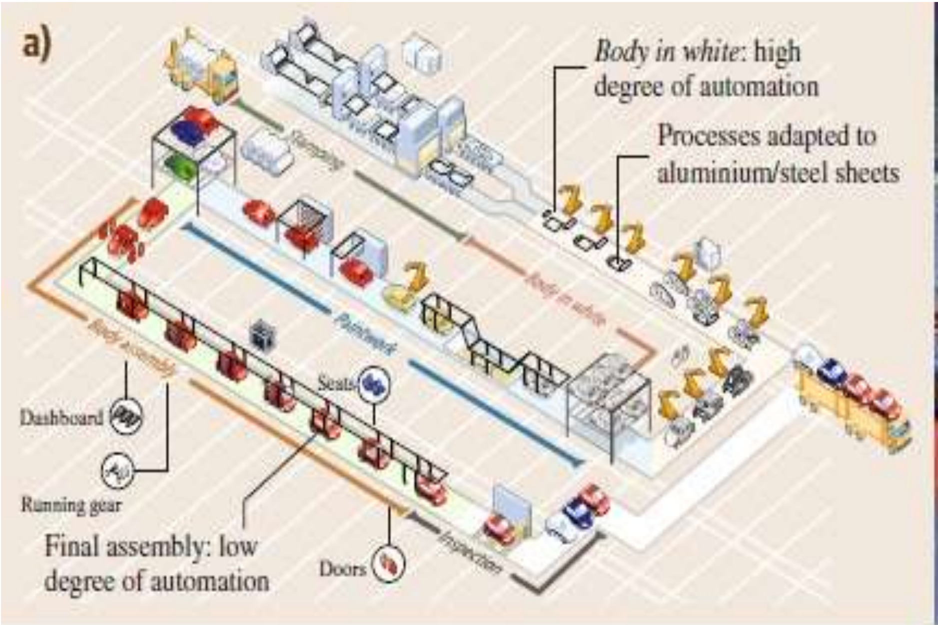


Classical elements at robotic workcell

Typical working cycle of a Robot workcell

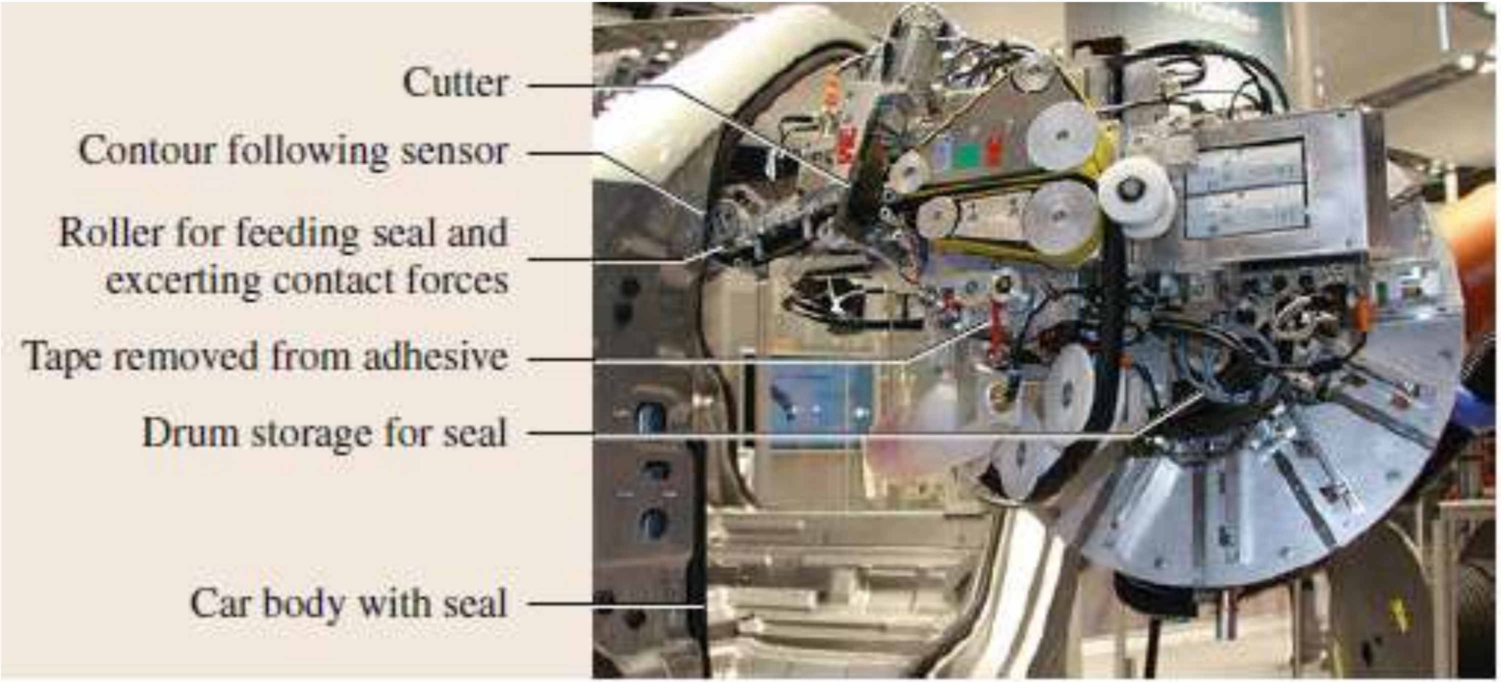


Car production



a. assembly line

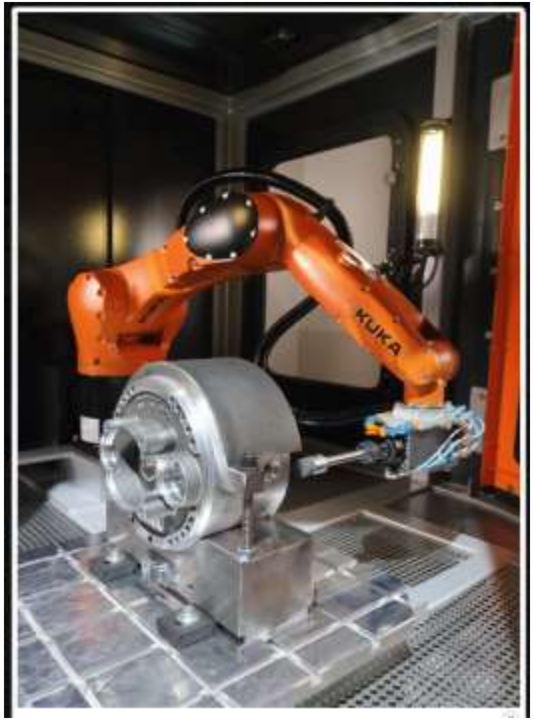
b. highly automated *robot garden*



A robot-guided tool for handling and processing limb material, in this case a self-adhesive seal for car bodies

CIM and FMS


CNC Milling Machine
CNC Lathe
6 axis robot
Load/Unload
Arm
Automated
Storage/
Retrieval System
Automated Guided Vehicle
(AGV)


KUKA

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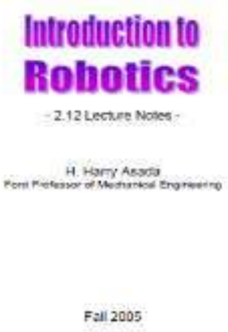
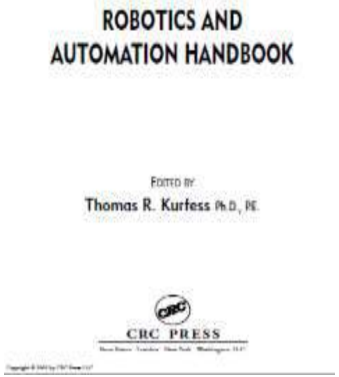




In this lecture you have been briefly introduced to:

- Application of robots
- Integration of CAM and FMS
- CIM

Congratulations, you have finished Lecture 5

Review Questions

State the relation between CAM and Robotics.

What do you understand by CIM.

Explain FMS.

Design a Robot garden for any one manufacturing unit of your choice.

***

ROBOTICS (17130705)

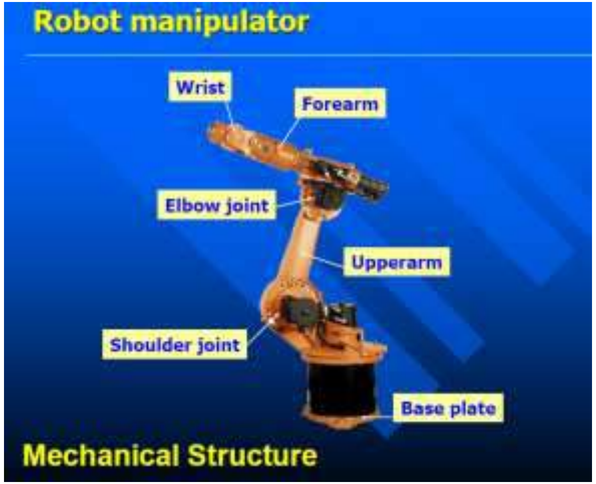
Unit – II : Components of the Industrial Robots
IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:
Dr T Jayananda Kumar
Professor
Mechanical Engineering
GIET(A) , Rajahmundry.

UNIT – II

Syllabus

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.

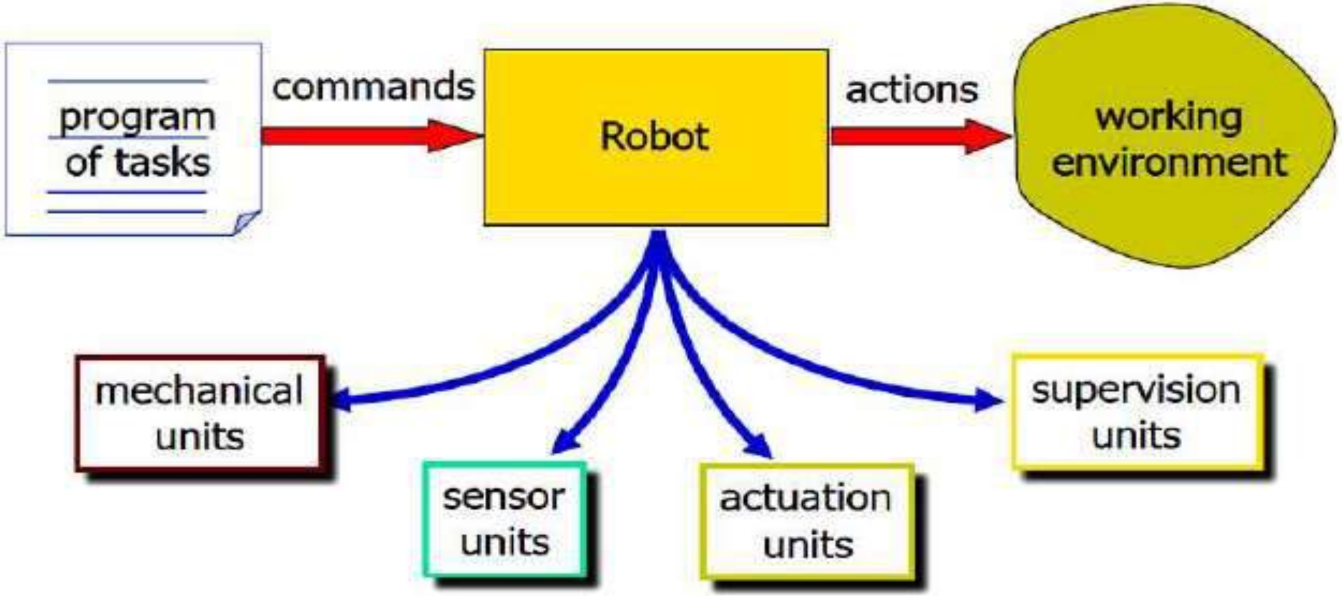


Course Outcomes

After completion of this course, a successful student will be able to:

- CO-1. Identify various robot configuration and components. (PO4)
- CO-2. Select appropriate actuators and sensors for a robot based on specific application. (PO6)
- CO-3. Solve kinematic and dynamic problems for simple serial kinematic chains. (PO7)
- CO-4. Plan trajectory for a manipulator for avoiding obstacles. (PO5)

ROBOT AS A SYSTEM:



Functional Units of a Robot:

- Mechanical Structure
- Sensor Units
- Actuator Units
- Supervision Units

Mechanical structure or mechanism of the robot:

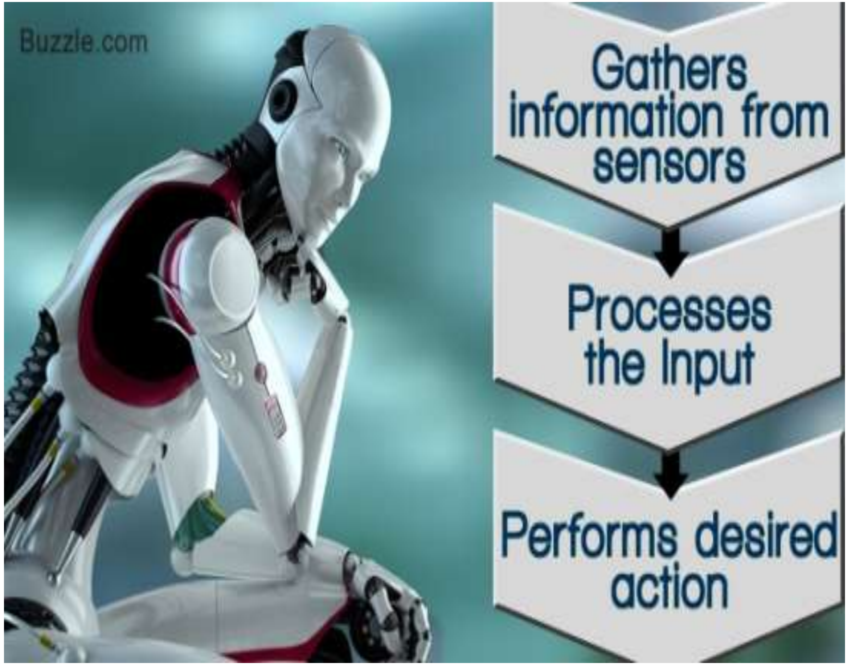
The physical structure that create its movable skeleton of the robot

- Beams,
- Links,
- Castings,
- Shafts,
- Slides,
- and Bearings

https://www.fanuc.eu/es/en/robots/robot-filter-page/m-2000-series/m-2000ia-2300

Sensors used in Robots

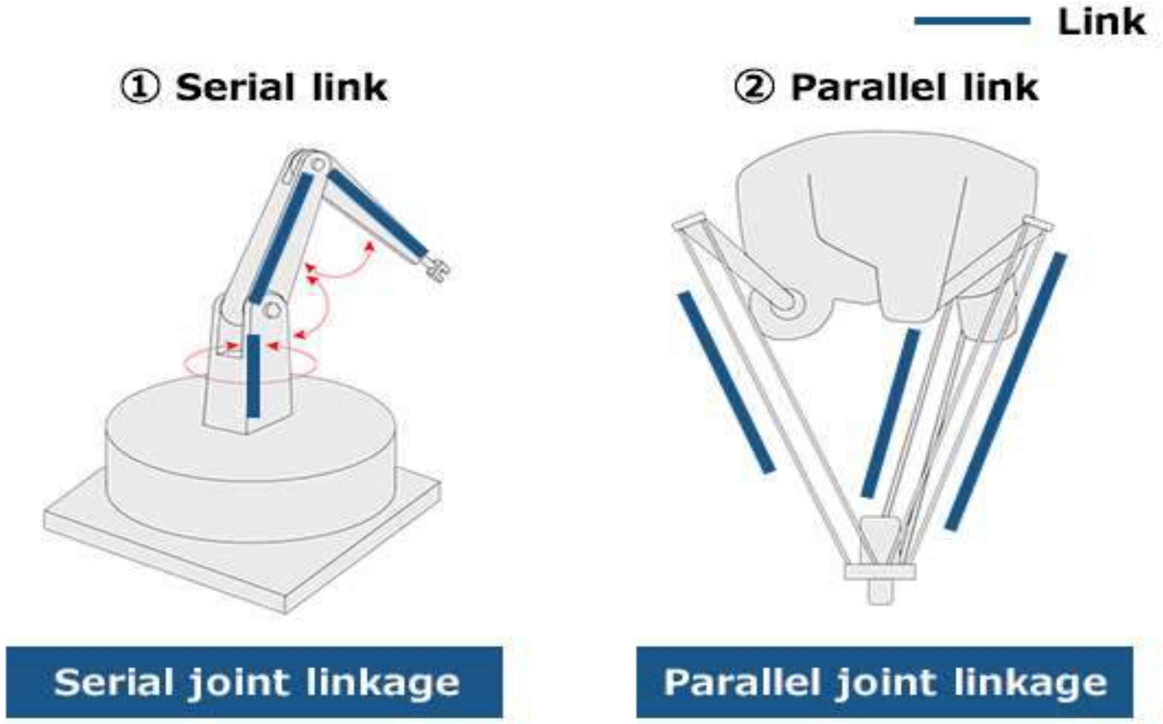
- Light Sensor
- Sound Sensor
- Proximity Sensor
- Tactile Sensors
- Temperature Sensor
- Navigation and Positioning Sensors
- Acceleration Sensor



Desirable characters of Robot control

- Save floor space
- User-friendly control
- Maximum energy savings
- Out-of-the-box Intelligence
- Easy set-up
- Safer Software to control

Common types of arms



https://vimeo.com/122758385

- Robot design focuses on the number of joints
- Physical size
- Payload capacity
- The movement requirements of the end-effector
- Robot ARMs discussed in UNIT I

- The configuration of the movable skeleton and the overall size of the robot are determined by
- Task requirements for reach
- Workspace

and reorientation ability

References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York

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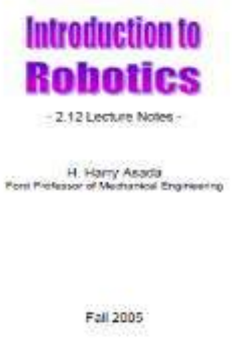
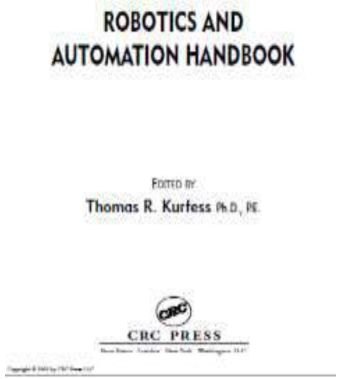




In this lecture you have been briefly introduced to:

Function line diagram representation of robot arms
Common types of arms

Congratulations, you have finished Lecture 1 of Unit-II

Review Questions

List functional units of a Robot.

Describe various sensors used in Robots.

Design a Robot control unit.

***

ROBOTICS (17130705)

Unit – II : Components, Architecture, number of degrees of freedom

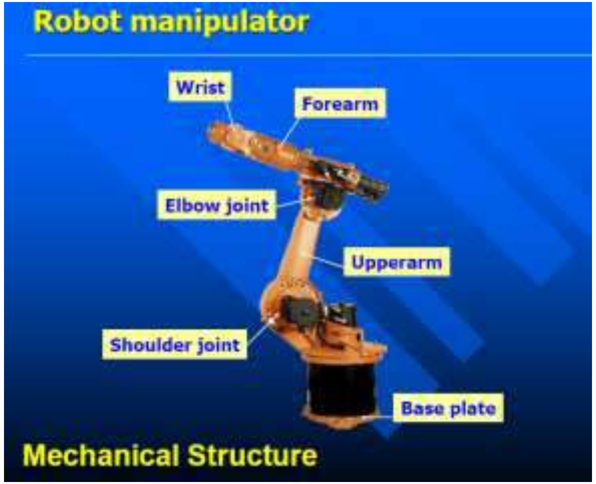
IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:
Dr T Jayananda Kumar
Professor
Mechanical Engineering
GIET(A) , Rajahmundry.

UNIT – II

Syllabus

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. **Components, Architecture, number of degrees of freedom** – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.



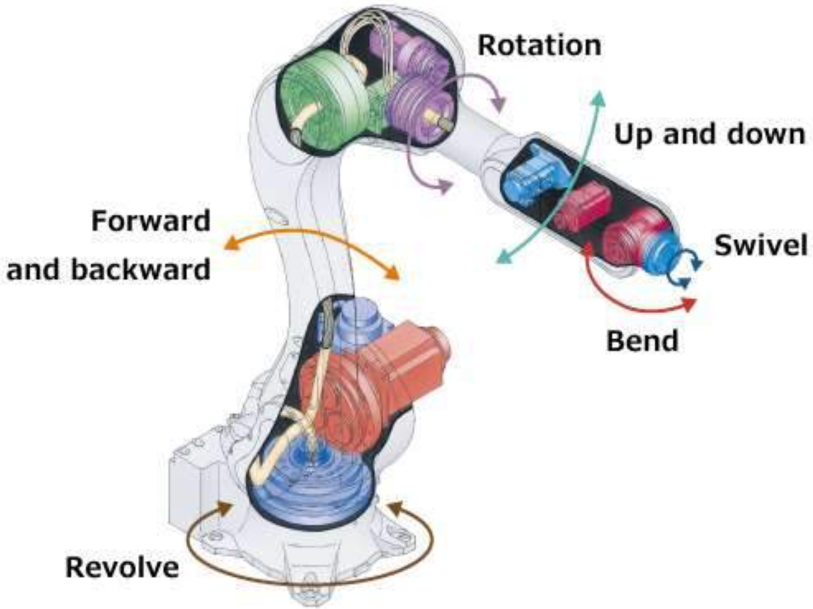
Course Outcomes

After completion of this course, a successful student will be able to:

- CO-1. Identify various robot configuration and components. (PO4)
- CO-2. Select appropriate actuators and sensors for a robot based on specific application. (PO6)
- CO-3. Solve kinematic and dynamic problems for simple serial kinematic chains. (PO7)
- CO-4. Plan trajectory for a manipulator for avoiding obstacles. (PO5)

A robot joint mechanism consists of at least four major components :

The joint axis structure,
An actuator,
Transmission,
and state sensor

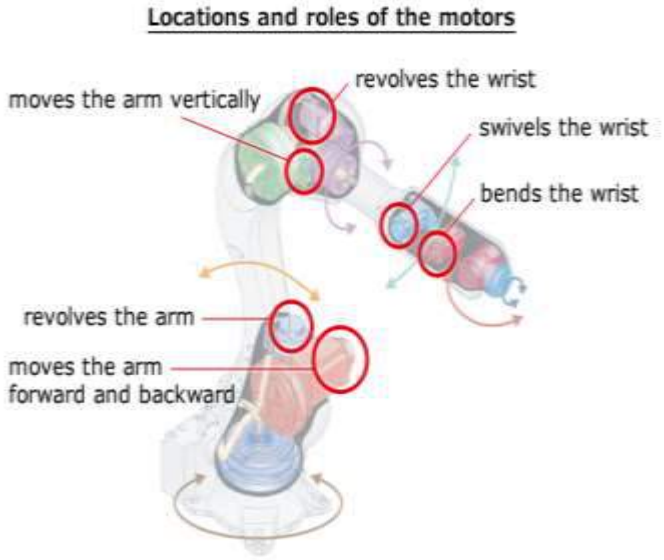


Functional Units of a Robot:

- Mechanical Structure
- Sensor Units
- Actuator Units
- Supervision Units

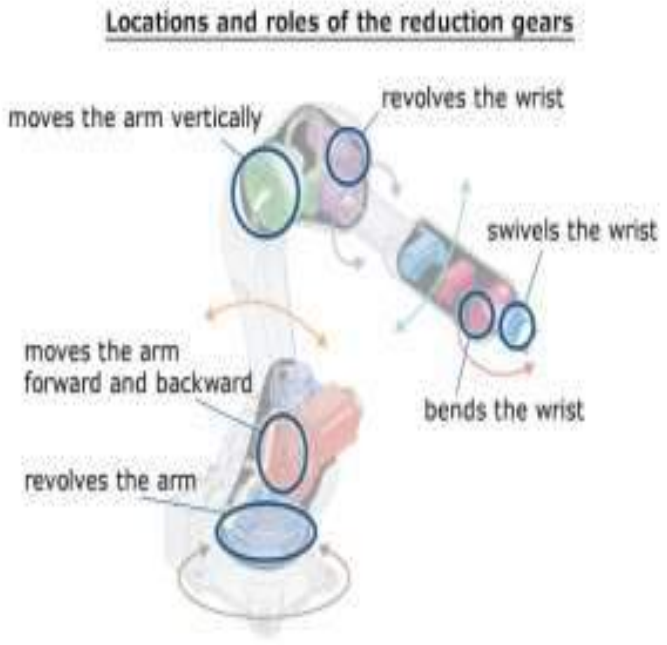
- The actuator is a component that functions as the joint of the robot

- Allows a robot to move the arm up and down or rotate, and it converts energy into mechanical motions.



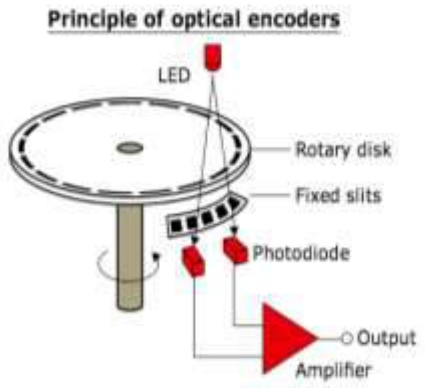
A reduction gear

- A reduction gear is a device for increasing the power of a motor.
- If you combine gear wheels with the different number of gears and reduce the motor's rotation by a factor of 10, the power of the motor will be multiplied by 10.
- This is the same principle as a bicycle transmission.



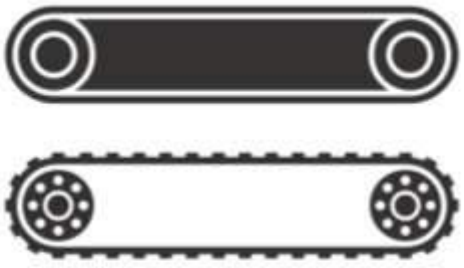
Encoder

- An encoder is a device that indicates the position (angle) of a motor's rotational shaft.
- Having an encoder, it can provide tangible data about in what direction and how much the robot moves.
- General optical encoders have a disk attached to the rotating shaft of the motor. The disk has slits at regular intervals to let light passes and on both sides of the disk are light-emitting-diode (LED) and light receiving elements (photodiodes) to discriminate the light intensity (light and dark).



Transmission

- The transmission is a component that transmits the power generated by the actuators and reduction gears.
- The transmission is also capable of changing the direction and magnitude of power.
- A motor used in robots is usually placed near the joints, but it can also be placed away from the joints by using transmission mechanisms such as belts and gears.



- Since the motor can be installed on the elbow part of the arm by the conduction mechanism, a compact wrist is feasible.

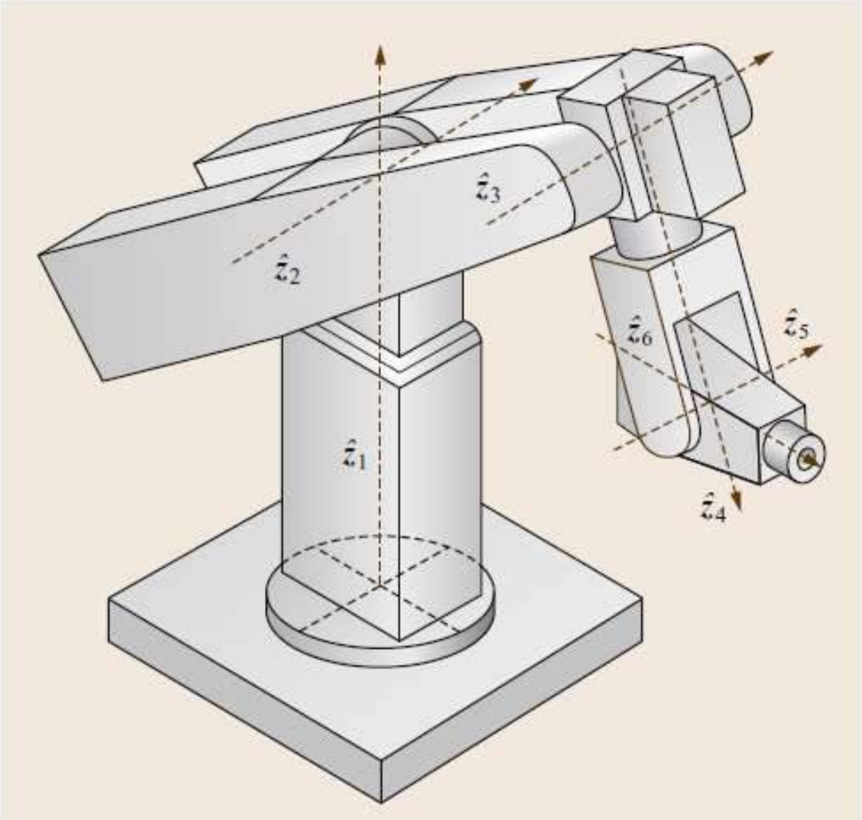
FANUC - M-900iB/280

https://www.fanuc.eu/es/en/robots/robot-filter-page/m-2000-series/m-2000ia-2300
https://www.youtube.com/watch?time_continue=65&v=r9ZmGgiBtaU&feature=emb_logo

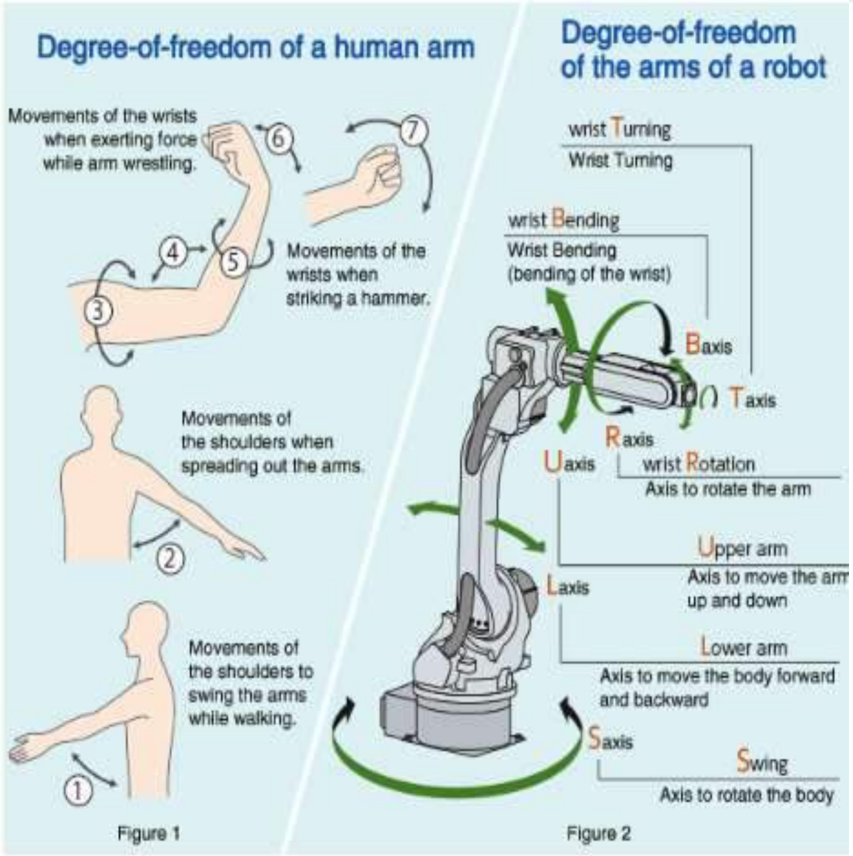
Degrees of Freedom:

The minimum number of coordinates required to prescribe the motion is called the number of degrees of freedom.

- Degree of freedom is the number of variables which is required to identify the parts of a robot manipulator
- A rigid body will have 6 degrees of freedom: 3 position variables and 3 rotation variables
- An object moving in a plane has 3 degrees of freedom: two position variables and one rotation variables
- More than 6 degrees of freedom for a robot manipulator is called a redundant robot manipulator
- We can perform or reach a particular object in an infinite way.



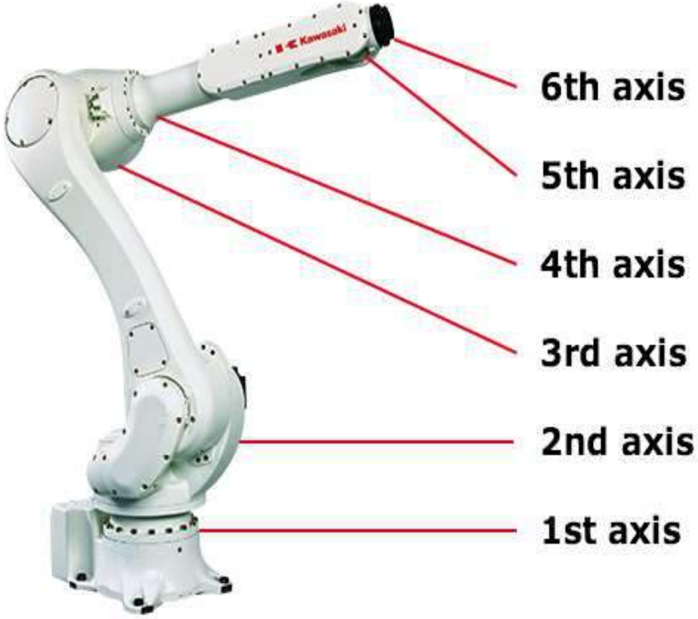
Six-degree-of-freedom serial chain manipulator composed of an articulated arm with a spherical wrist

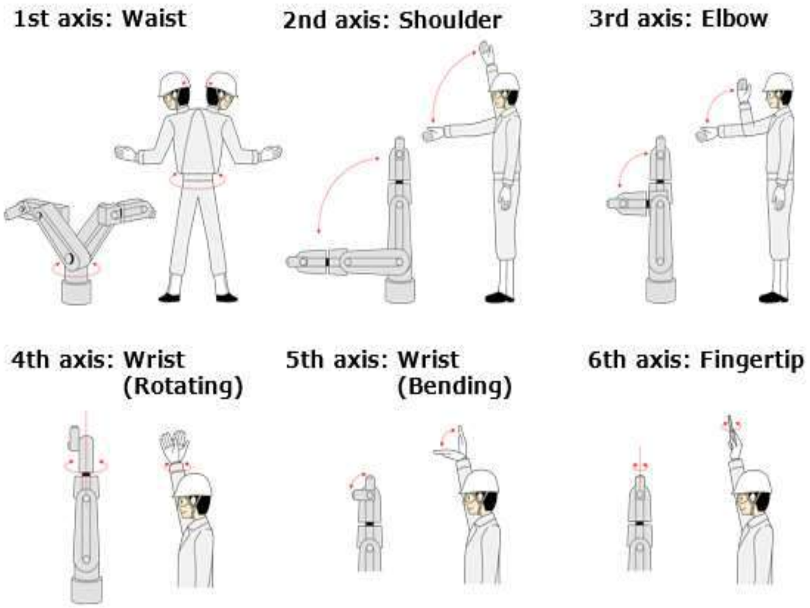


Let's begin taking count starting at the shoulders (Figure 1).

- 1) Degree-of-freedom at the front and back of the shoulders
  2) Degree-of-freedom for moving the shoulders left and right
  3) Degree-of-freedom for twisting the upper arms
  4) Degree-of-freedom for bending and stretching at the elbows
  5) Degree-of-freedom for twisting the forearm
  6) Degree-of-freedom for bending at the wrists toward the palm of the hand
  7) Degree-of-freedom for moving the wrists sideways
  And that's a total of seven points to check for degrees of freedom.
- How many degrees of freedom a human hand have.

Are the structures of robots and humans the same?





https://www.youtube.com/watch?time_continue=46&v=Gu74rGY426g&feature=emb_logo

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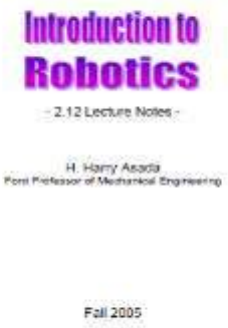
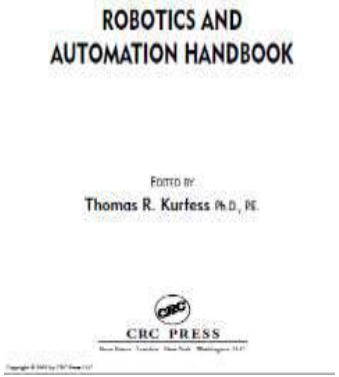




In this lecture you have been briefly introduced to:

Components,
Architecture,
Number of degrees of freedom

Congratulations, you have finished Lecture 2 of Unit-II

Review Questions

List four major components of a Robot.

Describe reduction gears used in Robots.

Explain the function of an Encoder.

How many degrees of freedom a human hand have?

Design a Robot control unit with 7 DoF.

Explain it’s advantages , if any.

***

ROBOTICS (17130705)

Unit – II : Requirements and challenges of end effectors

IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:

Dr T Jayananda Kumar

Professor

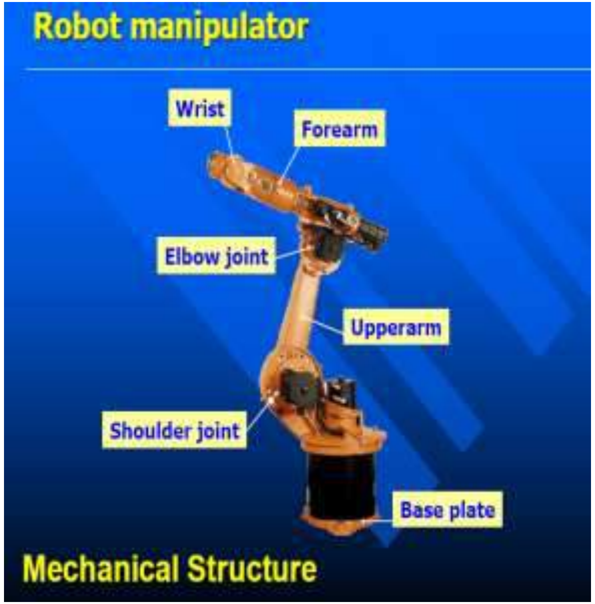
Mechanical Engineering

GIET(A) , Rajahmundry.

UNIT – II

Syllabus

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – **Requirements and challenges of end effectors, determination of the end effectors,** comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.



Course Outcomes

After completion of this course, a successful student will be able to:

- CO-1. Identify various robot configuration and components. (PO4)
- CO-2. Select appropriate actuators and sensors for a robot based on specific application. (PO6)
- CO-3. Solve kinematic and dynamic problems for simple serial kinematic chains. (PO7)
- CO-4. Plan trajectory for a manipulator for avoiding obstacles. (PO5)

In robotics, an **end effector is the** device at the **end** of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot

It is mounted on the wrist, enables the robot to perform specified tasks.

End-effectors are categorised into two major types:

1. Grippers
2. Tools

Types of end effectors

- Grippers. Grippers are the most common type of end effector
- Force-Torque Sensors. Force-torque sensors (FT sensors) are pucks installed between the robot flange and the tool that interacts with the part
- Material Removal Tools
- Welding Torches
- Collision Sensors
- Tool Changers.

In order to select the right end effector, different aspects should be considered such as:

- Stroke.
- Grip force.
- Speed.
- Form factor.
- Weight.
- Material.
- Repeatability.
- Sensing.

A gripper is a device which enables the holding of an object to be manipulated.

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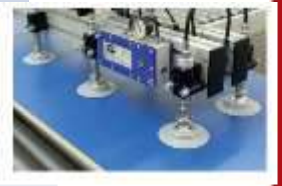
Selecting the best gripper for your automation project will be much easier once you learn about the most common gripper types available.

- Parallel Motion Two-Jaw Gripper
- Three-Jaw Gripper
- Bellows Gripper
- Collet and Expanding Mandrel Grippers
- O-Ring Grippers
- Needle Grippers
- Multi-Finger and Adaptive Grippers

END EFFECTORS – GRIPPERS

Type	Comment
Mechanical gripper	Two or more fingers that can be actuated by robot controller to open and close on a work part.
Vacuum gripper	Suction cups are used to hold flat objects. https://www.youtube.com/watch?time_continue=67&v=vKD20BTkXhk&feature=emb_logo
Magnetised devices	Making use of the principles of magnetism, these are used for holding ferrous work parts.


END EFFECTORS – GRIPPERS

Type	Comment
Adhesive devices	Deploying adhesive substances these hold flexible materials, such as fabric
Simple mechanical devices	For example, hooks and scoops.
Dual grippers	Mechanical gripper with two gripping devices in one end effector for machine loading and unloading. Reduces cycle time per part by gripping two work parts at the same time.
Interchangeable fingers	Mechanical gripper whereby, to accommodate different work part sizes, different fingers may be attached.

END EFFECTORS – GRIPPERS

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Type	Comment
Sensory feedback fingers	Mechanical gripper with sensory feedback capabilities in the fingers to aid locating the work part and to determine correct grip force to apply (for fragile work parts).
Multiple fingered grippers 	Mechanical gripper with the general anatomy of the human hand. https://www.youtube.com/watch?time_continue=2&v=21DtmkUSAnU&feature=emb_logo

An industrial robot is used to lift an 80 Kg load vertically using a constraint gripper. The gripper weighs 20 Kg. If it moves with an acceleration of g/2, what minimum payload must be specified for the robot?

References

Industrial Robotics Technology, Programming and Applications, Groover Mikell P., McGraw-Hill, New York
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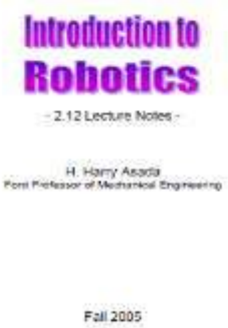

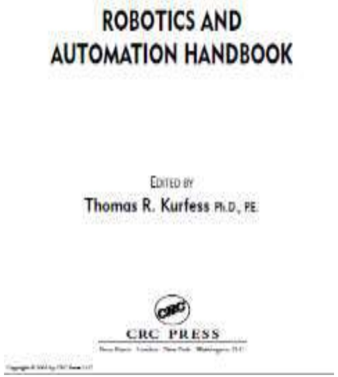

In this lecture you have been briefly introduced to:

1. End effectors
2. Types and Design parameters

Congratulations, you have finished Lecture 3 of Unit-II

Review Questions

List functional aspects of End effectors.

Describe various types of end effectors.

An industrial robot is used to lift an 80 Kg load vertically using a constraint gripper. The gripper weighs 20 Kg. If it moves with an acceleration of g/2, what minimum payload must be specified for the robot?

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ROBOTICS (17130705)

Unit – II : Actuators used in robots.

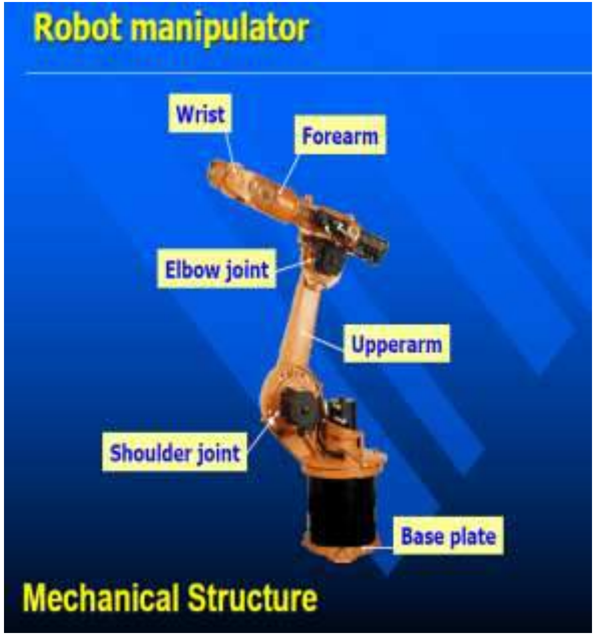
IV B.Tech. (Mechanical Engg.) I Sem.

Presented By:
Dr T Jayananda Kumar
Professor
Mechanical Engineering
GIET(A) , Rajahmundry.

UNIT – II

Syllabus

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, **comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.**



Course Outcomes

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After completion of this course, a successful student will be able to:

- CO-1. Identify various robot configuration and components. (PO4)
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Actuators are used in order to produce locomotion in robots.

Actuators supply the motive power for robots.

Actuators are the muscles of robots. There are many types of actuators available depending on the load involved.

The term load is associated with many factors including force, torque, and speed of operation, accuracy, precision and power consumption.

TYPES OF ACTUATORS

1. Direct Drive Motor
2. Hydraulic Actuators
3. Pneumatic Actuators
4. Magnetostrictive Actuators
5. Shape Memory Metal Actuators

Desirable characteristics of Actuators:

Weight

- Stepper motors are generally heavier than servomotors for the same power.

Power-to-weight Ratio

- The high the voltage of electric motors, the better power-to weight ratio.
- Pneumatic systems deliver the lowest power-to-weight ratio.
- Hydraulic systems have the highest power-to-weight ratio.

Actuators ....

- Stepper motors have capability of achieving precision angular rotation in both directions and are commonly employed to accommodate digital control technology.
- Hydraulic and pneumatic actuators are under fluid power actuators. Fluid power refers to energy that is transmitted via a fluid under pressure. When a pressure is applied to a confined chamber containing a piston, the piston will exert a force causing a motion.
- Materials which undergo some sort of transformations through physical interaction are referred to as active materials. Piezoelectric (voltage-load), shape-memory alloys (react to heat), magnetostrictive are examples of these materials.

Electric Servomotors

- Most robot manipulators use servomotors as a power source.
- Servomotors are designed to accurately follow the desired position, velocity and torque which change frequently.
- They have structures similar to ordinary electric motors, but with low inertia and large torque capably for high accelerations.
- Typical servomotors used for robotic applications are permanent magnet (PM) DC motors and brushless DC (BLDC) motors.

Working ..

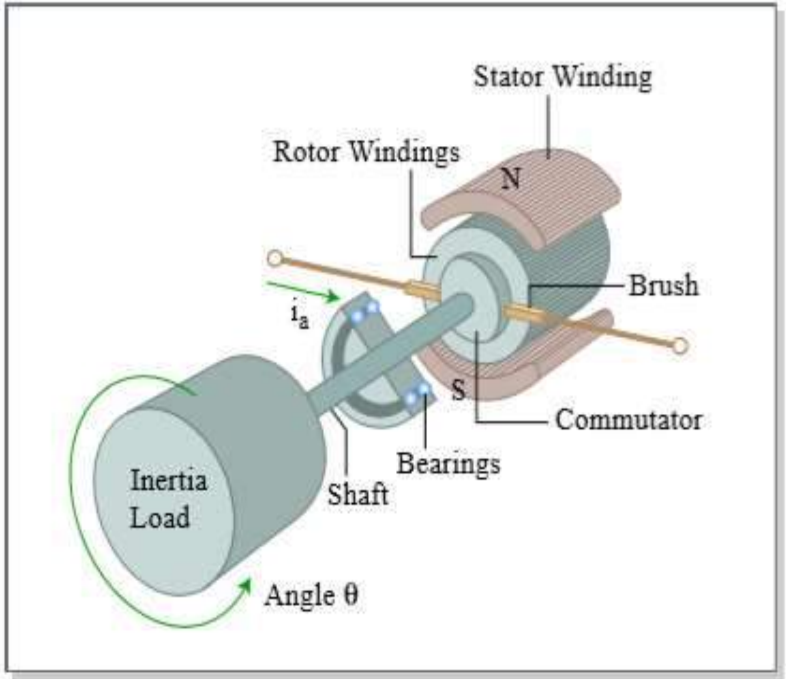
The stator consists of permanent magnets, creating a magnetic field in the air gap between the rotor and the stator.

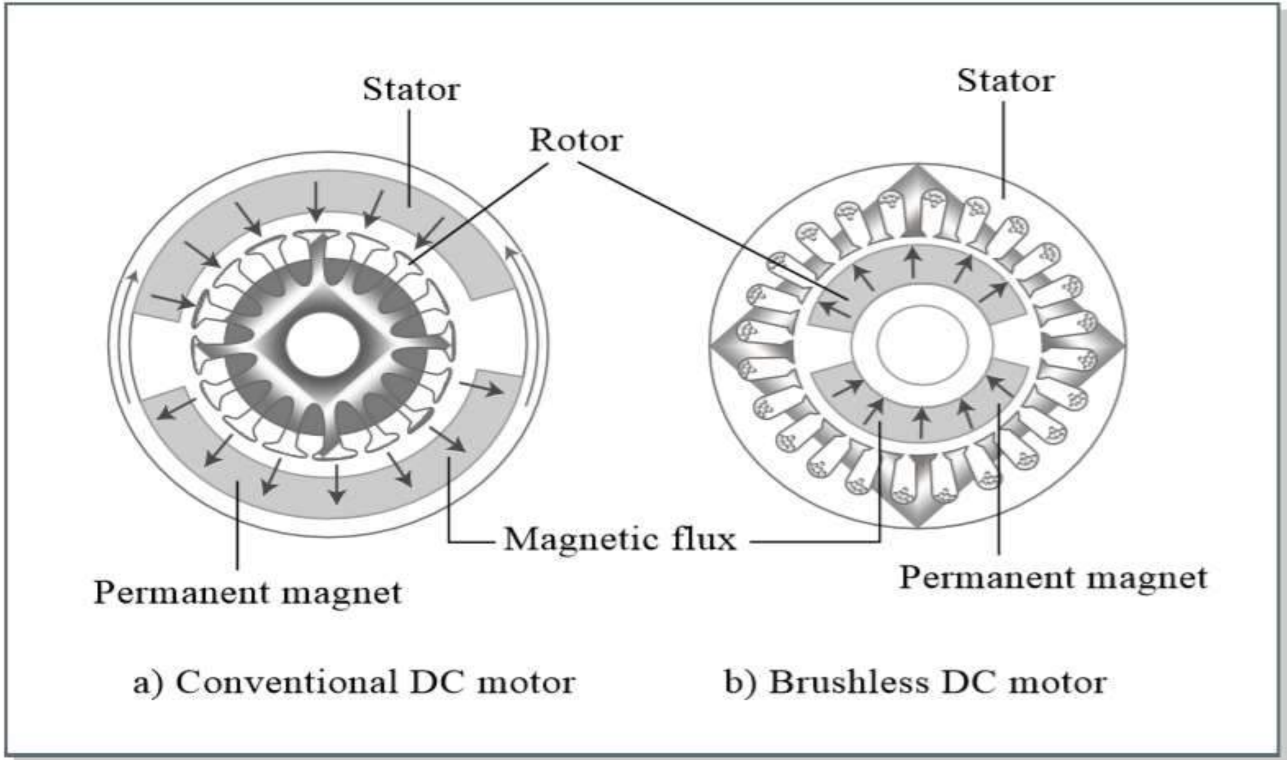
The rotor has several windings arranged symmetrically around the motor shaft.

An electric current applied to the motor is delivered to individual windings through the brush-commutation mechanism, as shown in the figure.

As the rotor rotates the polarity of the current flowing to the individual windings is altered. This allows the rotor to rotate continually.

- The DC motor converts electrical energy into rotational or linear mechanical energy.
- The lowest-cost PM motors use ceramic (ferrite) magnets and robot toys and hobby robots often use this type of motor.
- Brushless motors, also called AC servomotors or brushless DC motors, are widely used in industrial robots
- Brushless motors eliminate the friction, sparking, and wear of commutating parts.
- Brushless motors generally have good performance at low cost because of the decreased complexity of the motor.
- The controllers for these motors are more complex and expensive than brush-type motor.





Construction of brushless DC motor and conventional DC motor

Stepper Motors

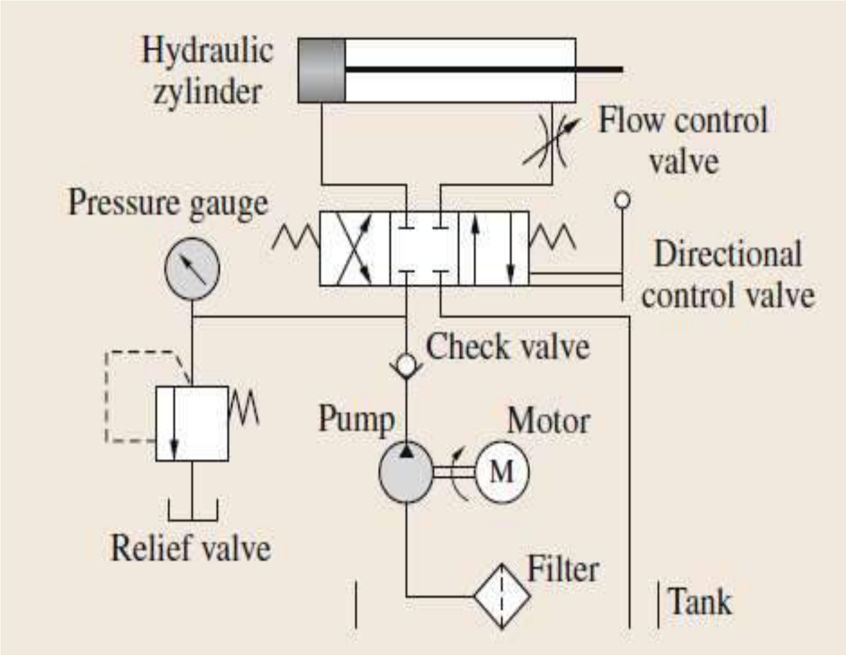
- Small, simple robots, such as bench top adhesive dispensing robots, frequently use stepper or pulse motors of the permanent magnet (PM) hybrid type.
- They are relatively low in cost and interface easily to electronic drive circuits. Microstep control can produce 10 000 or more discrete robot joint positions.
- Power-to-weight ratios are lower for stepper motors than for other types of electric motors.

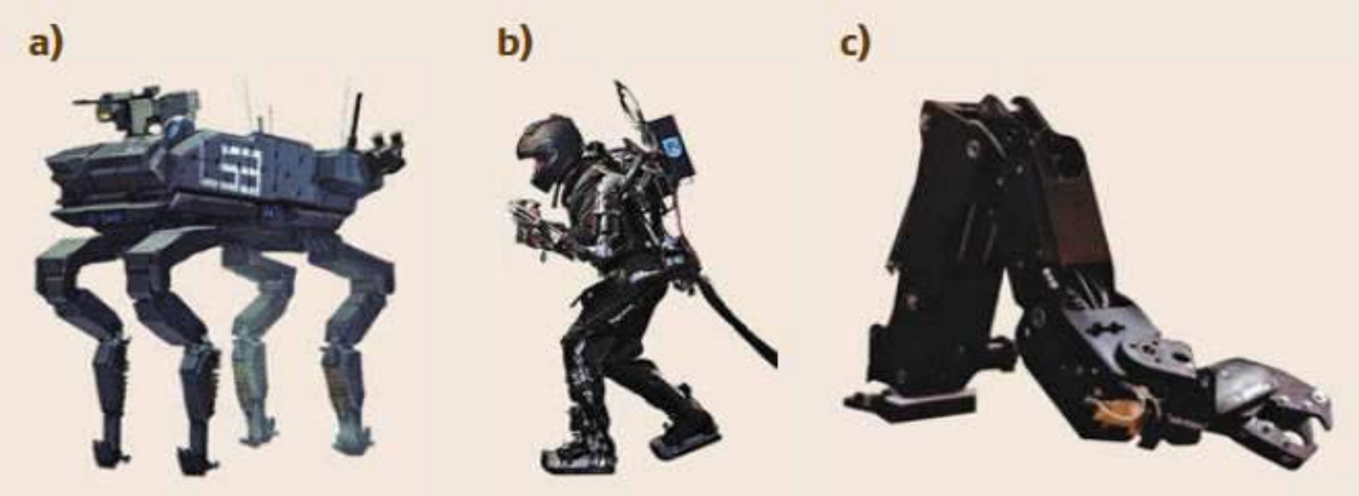
https://www.youtube.com/watch?v=vKD20BTkXhk&feature=emb_logo

Hydraulic Actuators

Hydraulic actuators, chosen as power sources for the earliest industrial robots, offer very large force capability and high power-to-weight ratios.

- Hydraulic actuators have several advantages and disadvantages due to the use of high pressure fluid.
- They can offer very large force or torque and high power-to-weight ratios.
- Both linear and rotary motions are readily available with small inertia of the moving part.
- However, the hydraulic power supply is bulky and the cost of the proportional, fast-response servovalves are high. Leaks and maintenance issues have limited the use and application of hydraulically powered robots.





Applications of hydraulic actuators to robot:

(a) Big Dog (Boston dynamics)

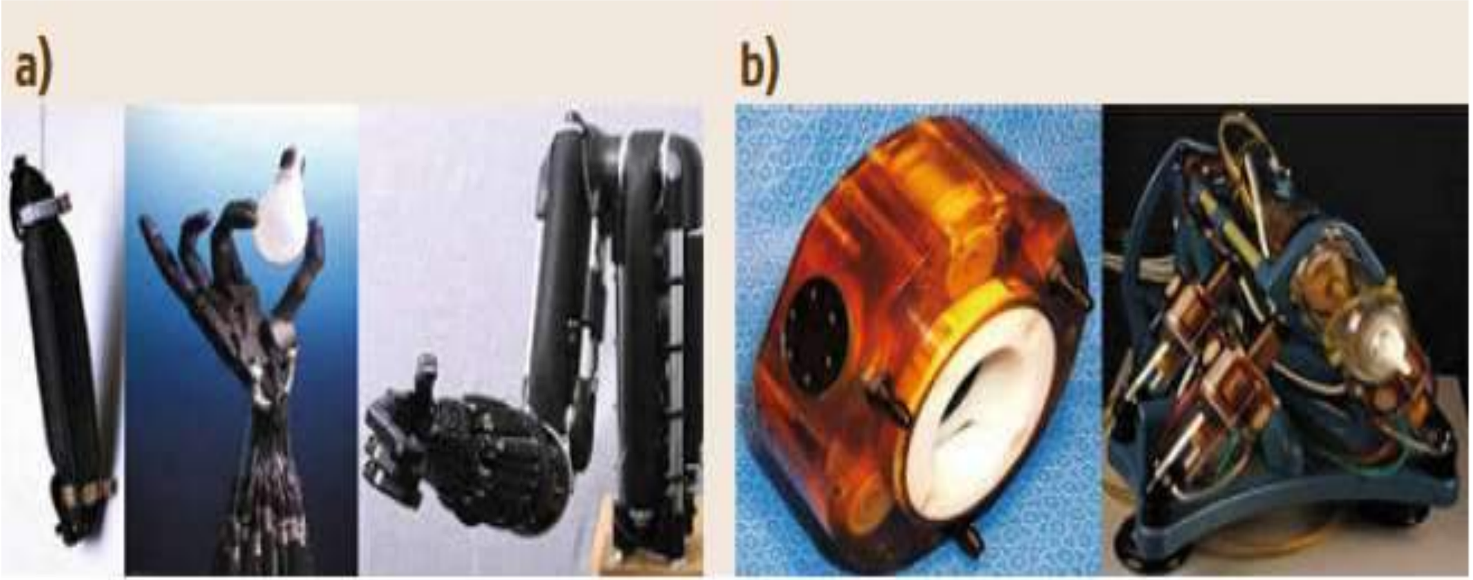
(b) Sarcos exosceleton (Raytheon)

(c) Magnum

- https://www.youtube.com/watch?v=M8YjvHYbZ9w&feature=emb_logo
- https://www.youtube.com/watch?time_continue=28&v=Nhj3Z9o6t0g&feature=emb_logo

Pneumatic Actuators

- Pneumatic actuators are similar to hydraulic actuators.
- Pneumatic actuators are primarily found in simple manipulators.
- Typically they provide uncontrolled motion between mechanical limit stops.
- These actuators provide good performance in point to point motion.
- They are simple to control and are low in cost.
- Pneumatic motors have several advantages over electric motors.
- They are relatively safe in the explosive environment.
- Pneumatic actuators are not used for applications requiring large forces or torques since they produce less power than hydraulic actuators or electric actuators.
- However, they are used in robot hands or artificial muscles, which require high power-to-weight ratios.
- Pneumatic artificial muscles are contractile or extensional devices operated by pressurized air filling a pneumatic bladder.
- Pneumatic actuators can be used for medical robots since they are not affected by magnetic field.



Applications of pneumatic actuator:

(a) robot hand and arm with artificial muscle (Shadow robot) and

(b) pneumatic step motor and MrBot (Urobotics, Johns Hopkins)

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ROBOTICS: ADVANCED CONCEPTS
&
ANALYSIS
NPTEL 2010


ROBOTICS FOR ENGINEERS
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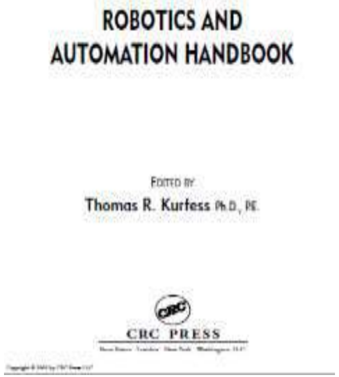
Introduction to Robotics
- 2.12 Lecture Notes -
H. Harry Asada
Ford Professor of Mechanical Engineering
Fall 2005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EDITED BY
Thomas R. Kurfess Ph.D., P.E.
CRC PRESS


Handbook of Robotics
Siciliano
Khatib
Editors
2nd Edition

In this lecture you have been briefly introduced to:

- Types of Actuators
- Working Principles
- Applications

Congratulations, you have finished Lecture 4 of Unit-II

Review Questions

Draw circuit diagram of Hydraulic actuators.

State constructional differences of brushless DC motor and conventional DC motor.

Where do you recommend stepper motors.

List applications and limitations of Pneumatic actuators.

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