BECE312L
Robotics and Automation

Dr. Velmathi G

Professor- Higher Academic Grade

School of Electronics Engineering

Course Objectives

1. To provide basic understanding of robotics and automation.
2. To demonstrate the need of various sensors and drives in robotic system.
3. To make students understand about the robotic kinematics, path planning
and different trajectories.
4. To deliver the programming languages to design robots in practice and
research for contemporary use.

Course Outcomes contd..

- At the end of the course, students will be able to
- 1. Classify robots and summaries their role in diverse applications
- 2. Infer the working of basic electric, electronic, and other types of drives required in robots.
- 3. Distinguish and interpret the sensors for various applications in robotics and automation.

Course Outcomes

- 4. Determine the mathematical model of robotic systems and analyze their kinematic behavior.
- 5. Design robots for varied working environments encompassing all types of motions across different paths and diverse trajectories.
- 6. Apply the ideas in performing various robotic tasks for contemporary industry standards using suitable programming skills.

Module:1 Robotics and Automation (5 hours)

- Robots: Basics, Types-Application, Mobility, DoF, Terrain, components classification, performance characteristics, Industrial Robots, HRI, Automatic
- assembly system

Module 2 -Drives for Robotics (5 hours)

- Drives:
- Electric,
- hydraulic and
- pneumatic drives

Module 3-**Sensors for Robots (7 hours)**

- Tactile sensors –
- Proximity and range sensors –
- Optical Sensor-
- limit switch sensor-
- surface array sensor
- Acoustic sensors –
- Vision sensor systems –Vision feedback system
- Image processing and analysis –
  - Image data reduction
  - Segmentation
  - Feature extraction
  - Object recognition.

Module 4 -Robot Kinematics and Dynamics (10 hours)

- Kinematics of manipulators, rotational, translation and transformation Homogeneous, Transformations,
- Denavat – Hartenberg Representation
- Inverse Kinematics.
- Linearization of Robot Dynamics –
- State variable continuous and discrete models.

Module 5-**Path Planning (5 hours)**

- Types of trajectories,
- trajectory planning and avoidance of obstacles,
- path planning,
- skew motion,
- joint integrated motion and straight line motion

Module 6- Programming of Robots (5 hours)

- Robot programming: ROS1 and ROS2,
- languages and software packages - MATLAB/Simulink, OpenRDK, Adams.

Module 7 - Application of Robots (4)

- Industrial robots used for welding, painting and assembly,
- remote controlledr obots,
- robots for nuclear, thermal and chemical plants,
- industrial automation,
- typical examples of automated Industries,
- Humanoid robots, medical robots, under water robots, drones

Typical Projects

1. Pick and place robot
2. Ball throwing machine for cricket practice
3. Variable height vehicle
4. Wall plastering robot
5. Soil sample collecting robot
6. Object sorting robot
7. Automatic packing robot
8. Robotic goalkeeper

Module 1-Introduction to Robotics (2)

- Robots:
- Basics, Types-Application,
- Mobility, Terrain,
- components classification,
- performance characteristics.
- https://www.intorobotics.com/18-extreme-all-terrain-robots/

- There are six main types of **industrial** robots: cartesian, SCARA, cylindrical, delta, polar and vertically articulated. However, there are several additional types of robot configurations. Each of these types offers a different joint configuration. The joints in the arm are refer.red to as axes

- **Some of the important components of Robots are as follows:**
- Manipulator: Just like the human arm, the robot consists of what is called a manipulator having several joints and links. ...
- End effector:
- The Locomotion Device: ...
- The Controller: ...
- The Sensors:

Most robots are composed of 3 main parts:

- The Controller - also known as the "brain" which is run by a computer program. ...
- Mechanical parts - motors, pistons, grippers, wheels, and gears that make the robot move, grab, turn, and lift. ...
- Sensors - to tell the robot about its surroundings.

- What metals are used to make robots?
- **Contents**
- 1 Wood.
- 2 Metal. 2.1 Aluminum. 2.2 Steel. 2.3 Bronze. 2.4 Brass. 2.5 Copper.
- 3 Synthetic Materials. 3.1 PVC. 3.2 Plexiglass.
- 4 Composite materials.
- 5 Other Materials. 5.1 Foamcore. 5.2 Cardboard.

What are the advantages of robot welding over manual welding?

Welding is a process where two materials are fused together through heating, intermixing, and then cooling the materials and/or a filler to form a strong join. From arc welding to spot welding, new and used welding robots are typically used in welding processes where the weld required is repetitive and quality and speed are crucial. Robotic welding is an automated process that increases efficiency, consistency, and your ROI.

There are several advantages to automating a factory with welding robots, including faster, consistent cycle times, no break in production, and better weld quality. Basically, by using welding robotic automation, the process takes less time, and manufacturers can cut the cost of direct labor and safety and conserve materials.

Robotic weld cells provide an even safer work environment, dramatically reducing arc glare, overspray, and direct contact with the robot and part. A robot welder is more consistent and can move from one weld to the next quickly, speeding up the entire process.

Common Types of Industrial Robots:

Articulated - This robot design features rotary joints and can range from simple two joint structures to 10 or more joints. The arm is connected to the base with a twisting joint. The links in the arm are connected by rotary joints. Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes.

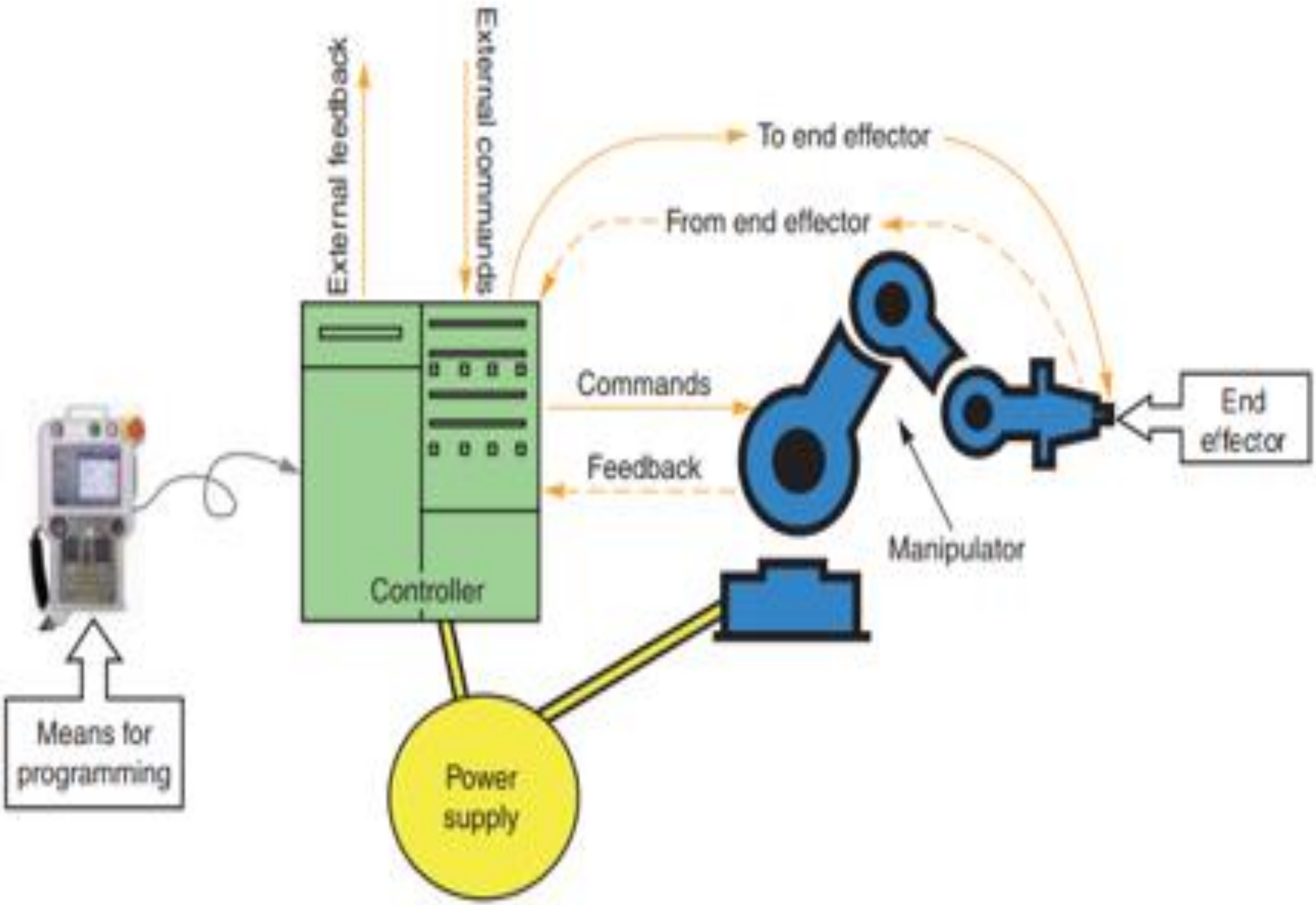
Cartesian - These are also called rectilinear or gantry robots. Cartesian robots have three linear joints that use the Cartesian coordinate system (X, Y, and Z). They also may have an attached wrist to allow for rotational movement. The three prismatic joints deliver a linear motion along the axis.

Cylindrical - The robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. The rotary joint uses a rotational motion along the joint axis, while the prismatic joint moves in a linear motion. Cylindrical robots operate within a cylindrical-shaped work envelope.

Polar - Also called spherical robots, in this configuration the arm is connected to the base with a twisting joint and a combination of two rotary joints and one linear joint. The axes form a polar coordinate system and create a spherical-shaped work envelope.

SCARA - Commonly used in assembly applications, this selectively compliant arm for robotic assembly is primarily cylindrical in design. It features two parallel joints that provide compliance in one selected plane.

Delta - These spider-like robots are built from jointed parallelograms connected to a common base. The parallelograms move a single EOAT in a dome-shaped work area. Heavily used in the food, pharmaceutical, and electronic industries, this robot configuration is capable of delicate, precise movement.


External feedback
External commands
To end effector
From end effector
Commands
Feedback
End effector
Manipulator
Controller
Means for programming
Power supply

Types Of Robots by Application

- **Industrial Robots** – Designed to move materials, parts and tools, performs variety of programmed tasks in manufacturing. Usually these are articulated arms specifically developed for such applications as welding, material handling, painting and others. If we judge purely by application this type could also include some automated guided vehicles and other robots.
- **Domestic or Household Robots** – Robots used at home. This type of robots includes many quite different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, gutter cleaners and other robots that can do different chores. Also, some surveillance and telepresence robots could be regarded as household robots if used in that environment.
- **Medical Robots** – Robots used in medicine and medical institutions. First and foremost – surgery robots. Also, some automated guided vehicles and maybe lifting aides.
- **Service Robots** – Robots that dont fall into other types by usage. These could be different data gathering robots, robots made to show off technologies, robots used for research, etc.

- **Military Robots** – Robots used in military. This type of robots includes bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields.
- **Entertainment Robots** – These are robots used for entertainment. This is a very broad category. It starts with toy robots such as robosapien or the running alarm clock and ends with real heavyweights such as articulated robot arms used as motion simulators.
- **Space Robots** – Id like to single out robots used in space as a separate type. This type would include robots used on the International Space Station, Canadarm that was used in Shuttles, as well as Mars rovers and other robots used in space.
- **Hobby and Competition Robots** – Robots that you create. Line followers, sumo-bots, robots made just for fun and robots made for competition.

Industries that used Robotics

- **The Health Care Industry** – Intuitive Surgical, Inc’s da Vinci robots, for example, are surgical robots that are used by doctors to perform minimally invasive surgery.
- **Military and Public Safety Industries** – Ex. Explosive Ordinance Disposal Robots
- **The Manufacturing Industry** – Ex. Automotive, etc.
- **The Mining Industry** – example, Stanley Innovation has an advanced custom robot that is placed on a Segway robotic mobility platform (RMP), allowing it to maneuver over hazardous terrain.

- **Controller**
  Every robot is connected to a computer controller, which regulates the components of the arm and keeps them working together. The controller also allows the robot to be networked to other systems, so that it may work together with other machines, processes, or robots. Almost all robots are pre-programmed using "teaching" devices or offline software programs. In the future, controllers with artificial intelligence (AI) could allow robots to think on their own, even program themselves. This could make robots more self-reliant and independent.

- **Arm**
  The arm is the part of the robot that positions the end-effector and sensors to do their pre-programmed business. Many are built to resemble human arms, and have shoulders, elbows, wrists, even fingers. Each joint is said to give the robot 1 degree of freedom. A simple robot arm with 3 degrees of freedom could move in 3 ways: up and down, left and right, forward and backward. Most working robots today have 6 degrees of freedom to allow them to reach any possible point in space within its work envelope. The human arm has 7.

- **Drive**
  The links (the sections between the joints) are moved into their desired position by the drive. Typically, a drive is powered by pneumatic or hydraulic pressure, or electricity.

- **End-Effector**
  The end-effector could be thought of as the “hand” on the end of the robotic arm. There are many possible end-effectors including a gripper, a vacuum pump, tweezers, scalpel, blowtorch, welder, spray gun, or just about anything that helps it do its job. Some robots can change end-effectors, and be reprogrammed for a different set of tasks.

- **Sensor**
  The sensor sends information, in the form of electronic signals back to the controller. Sensors also give the robot controller information about its surroundings and lets it know the exact position of the arm, or the state of the world around it. One of the more exciting areas of sensor development is occurring in the field of computer vision and object recognition. Robot sensors can detect infrared radiation to “see” in the dark.

-

Industrial Robot Applications (Basic Jobs)

- – Welding
  – Machine Tending
  – Removal
  – Painting
  – Handling
  – Packaging
  – Palletizing
  – Clinical Lab

Types of Industrial Robots

- **Articulated/Jointed arm** – This robot design features rotary joints and can range from simple two joint structures to 10 or more joints. The arm is connected to the base with a twisting joint. The links in the arm are connected by rotary joints. Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes.
- <u>Application:</u> Food,Bakery, Manufacturing (Palletizing)
  Heavy Duty robot with 500 Kg payload

- **Cartesian/Rectilinear/Gantry** – Cartesian robots have three linear joints that use the Cartesian coordinate system (X, Y, and Z). They also may have an attached wrist to allow for rotational movement. The three prismatic joints deliver a linear motion along the axis.
- <u>Application:</u> Electronics (ICs mounted on PCBs)

- **Cylindrical** – The robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. The rotary joint uses a rotational motion along the joint axis, while the prismatic joint moves in a linear motion. Cylindrical robots operate within a cylindrical-shaped work envelope.
- Application: Palletising, Grinding process, assembly, handling machine Tools. This type is one of the rarely used now a days because most of Its function, movement is now part of the SCARA robot, this type was Heavily used during the 80's.

- **Polar/Spherical** – in this configuration the arm is connected to the base with a twisting joint and a combination of two rotary joints and one linear joint. The axes form a polar coordinate system and create a spherical-shaped work envelope.
- Applications:Welding etc., extensively used in the car Industry

- **SCARA Selective Compliance Assembly Robot Arm or Selective Compliance Articulated Robot Arm** – Commonly used in assembly applications, this selectively compliant arm for robotic assembly is primarily cylindrical in design. It features two parallel joints that provide compliance in one selected plane.
- <u>Applications:</u> Pick and place (usually in assembly operations) Sealant application, machine tool handling

- **Delta** – These spider-like robots are built from jointed parallelograms connected to a common base. The parallelograms move a single EOAT (End Of Arm Tooling) in a dome-shaped work area. Heavily used in the food, pharmaceutical, and electronic industries, this robot configuration is capable of delicate, precise movement.
- <u>Applications:</u> Pick and Place (mostly in assembly)

History

-- Robot comes from the Czech word "*robota*", that means tireless work.

When did robots, as we know them today, come into existence?

- The first modern industrial robots, called Unimates, were developed by George Devol and Joe Engelberger in the late 50's and early 60's.
- The first robot patents were by Devol for parts-transfer machines.
- Engelberger formed Unimation and was the first to market robots. As a result, Engelberger has been called the 'father of robotics.'

Progressive Advancement in Robots

ϖ **First Generation** (repeating, nonservo, pick and place, or point to point kind) , in present 80% robots are of this kind. 1960

ϖ **Second Generation** (addition of sensing devices , path control capabilities). 1980

ϖ **Third Generation** (On-line computations and control, artificial vision, and active force/torque interaction with the environment). 1992

ϖ **Fourth Generation** (true android or an artificial biological robot or a super humanoid capable of its own clones). 2000

Industrial Robots Definition

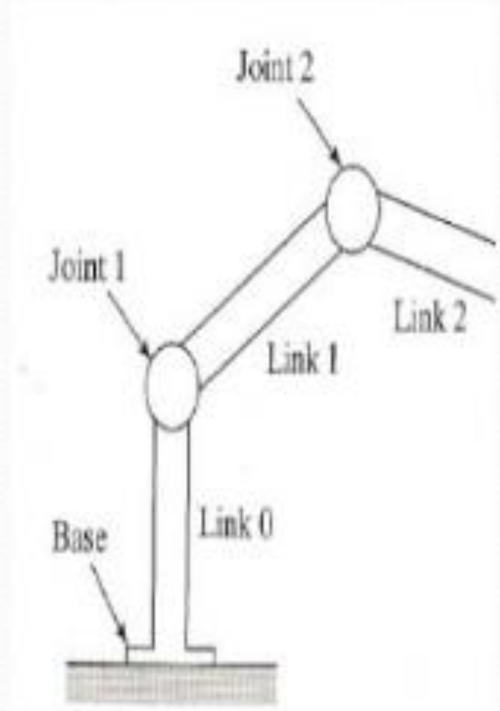
"A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks"

Robot Institute of America (RIA)

Main Components of Industrial Robots

- Arm or Manipulator.
- End effectors.
- Drive Mechanism.
- Controller.
- Custom features:

  e.g. sensors and transducers.

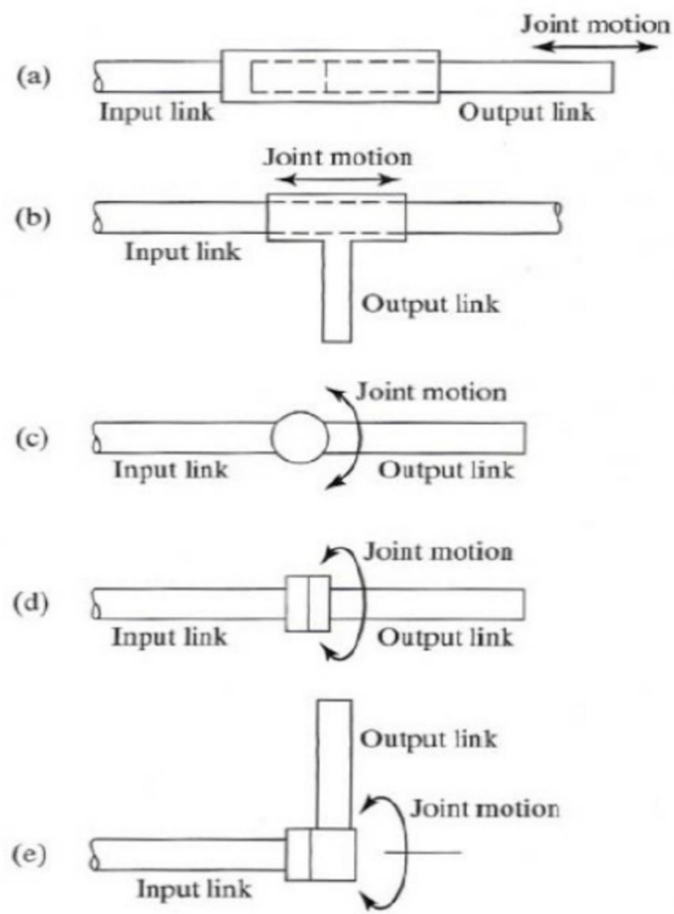


Types of Mechanical Joints for Industrial Robots

There are five types of mechanical joints

- Two provide translational motion
- Three provide rotary motion

1. **Linear joint (type L):** translational motion
   - Axes of input and output link are parallel
2. **Orthogonal joint (type O):** translational motion
   - Input and output links are perpendicular
3. **Rotational joint (type R):** rotary motion
   - Axis of rotation is perpendicular to input and output link axis
4. **Twisting joint (type T):** rotary motion
   - Axis of rotation parallel to axis of links
5. **Revolving joint (type V):** rotary motion
   - Axis of rotation parallel to input but perpendicular to output



Type of Drive System

- **Hydraulic**

– High strength and high speed
– Large robots, Takes floor space
– Mechanical Simplicity
– Used usually for heavy payloads

- **Electric Motor (Servo/Stepper)**

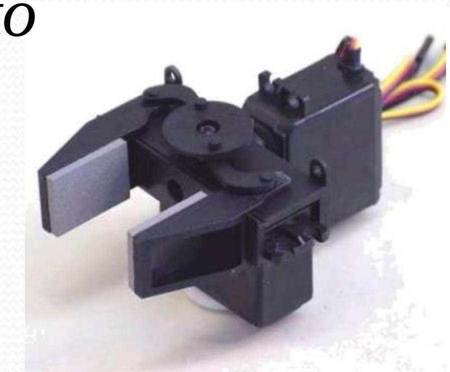
– High accuracy and repeatability
– Less floor space
– Low cost
– Easy maintenance

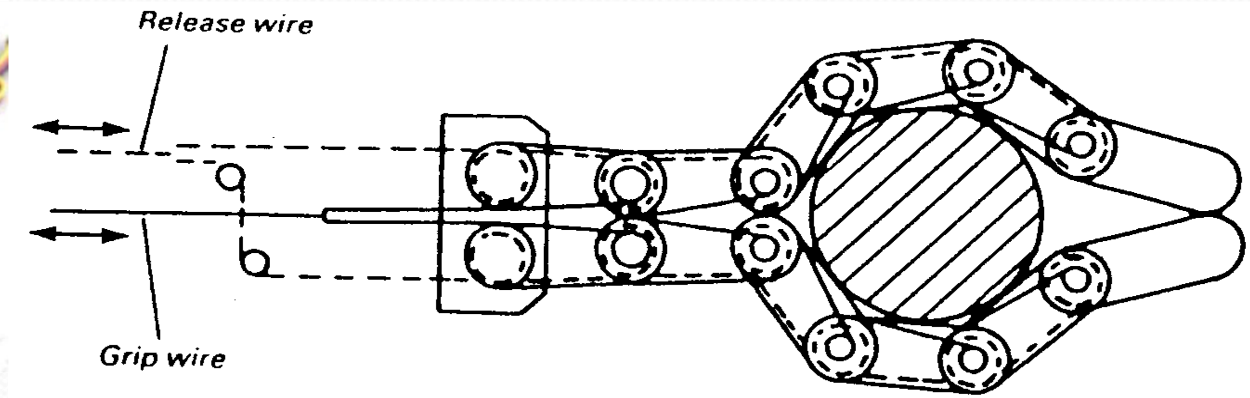
- **Pneumatic**

– Smaller units, quick assembly
– High cycle rate
– Easy maintenance

End Effectors

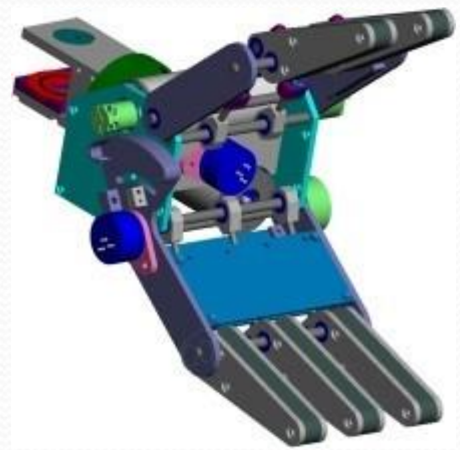
D the robot's wrist to perform a specific task
to





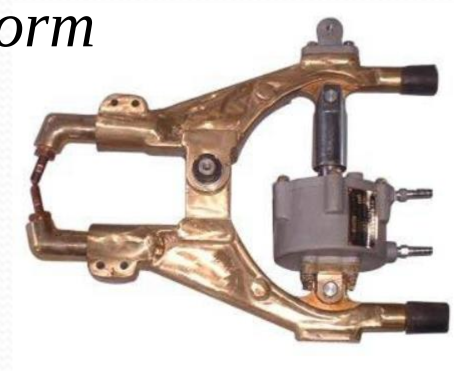
i

- – Mechanical Grippers
- – Suction cups or vacuum cups
- – Magnetized grippers
- – Hooks
- – Scoops (to carry fluids)



End Effectors

Device attached to the ro *a specific task*
form



Tools

– Spot Welding gun
– Arc Welding tools
– Spray painting gun
– Drilling Spindle
– Grinders, Wire brushes
– Heating torches

Motion Control Methods

- **Point to point control**
  - a sequence of discrete points
  - spot welding, pick-and-place, loading & unloading
- **Continuous path control**
  - follow a prescribed path, controlled-path motion
  - Spray painting, Arc welding, Gluing

Sensors in robotics

Types of sensors :

– Tactile sensors (touch sensors, force sensors)

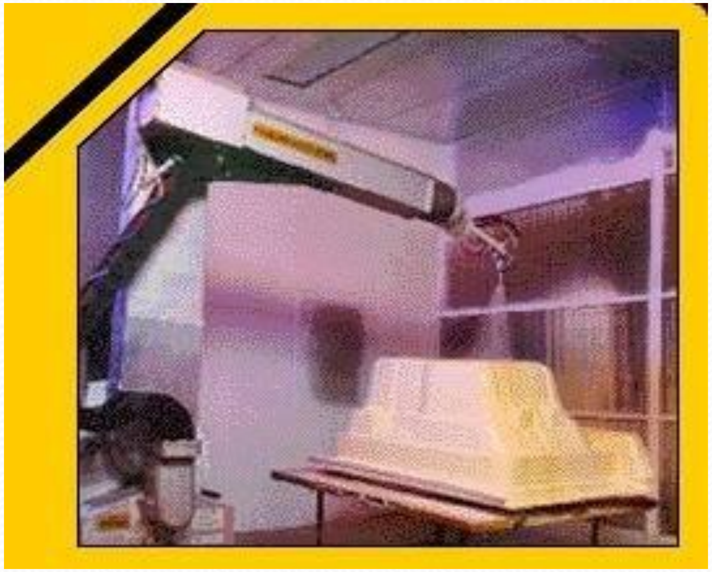
– Proximity and range sensors (optical sensors, acoustical sensors, electromagnetic sensors)

– Miscellaneous sensors (transducers and sensors which sense variables such temperature, pressure, fluid flow, thermocouples, voice sensors)

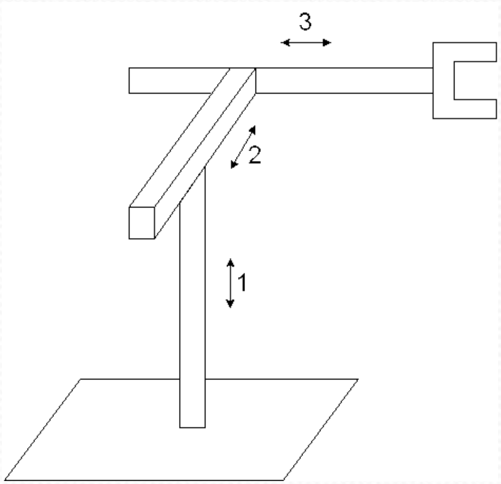
– Machine vision systems

Applications

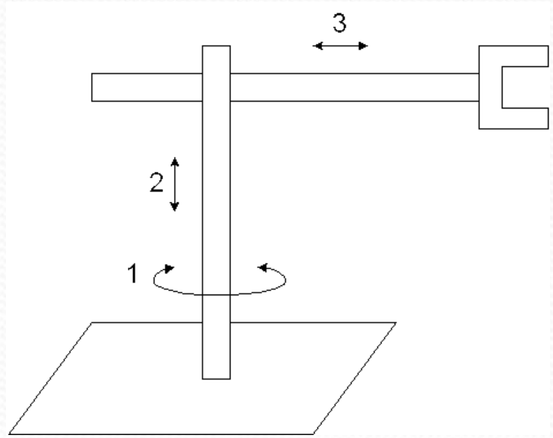
- Material Handling/Palletizing
- Machine Loading/Unloading
- Arc/Spot Welding
- Water jet/Laser cutting
- Spray Coating
- Gluing/Sealing
- Investment casting
- Assembly
- Inspection



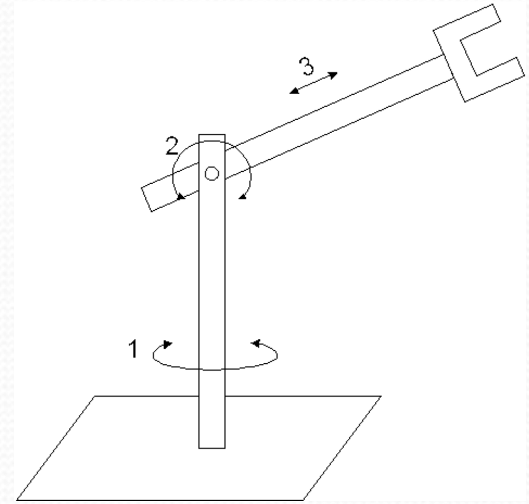
Robot Configuration (geometries)



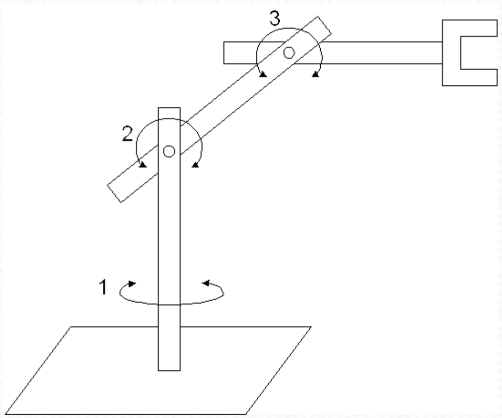
Cartesian: PPP



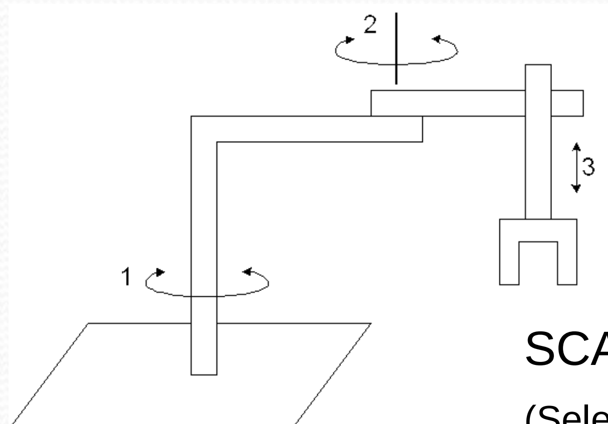
Cylindrical: RPP



Spherical: RRP



Articulated: RRR



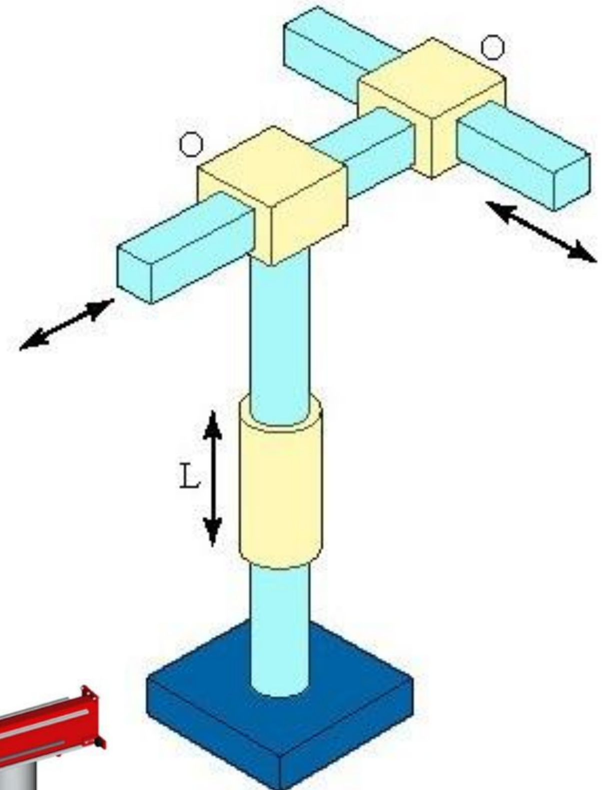
SCARA: RRP

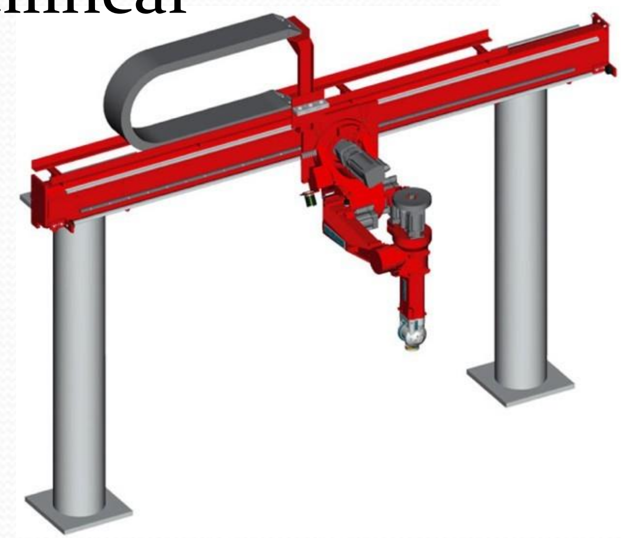
(Selective Compliance
Assembly Robot Arm)

Cartesian Coordinate

- Notation LOO:

- Consists of three sliding joints, two of which are orthogonal
- Other names include rectilinear robot and x-y-z robot

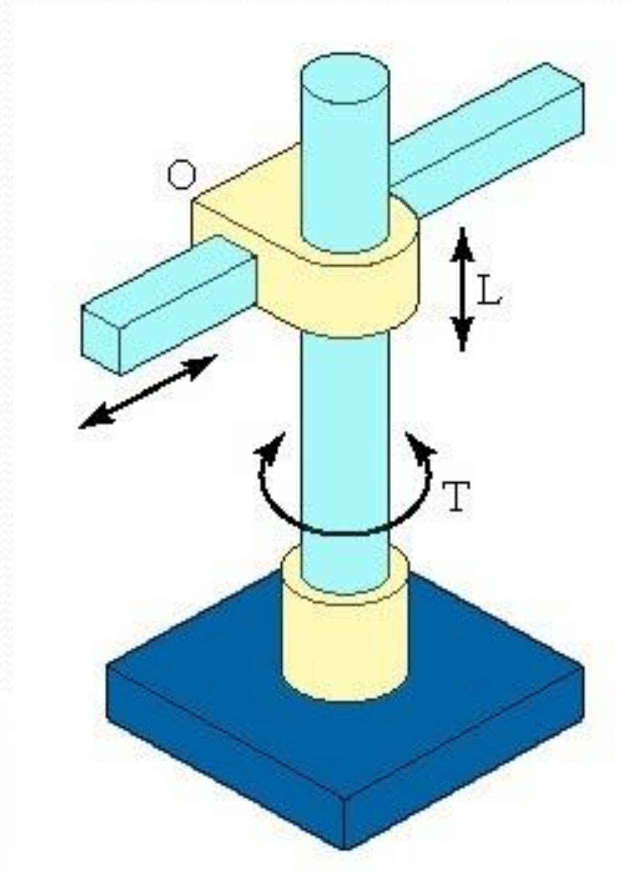




Cylindrical Coordinate

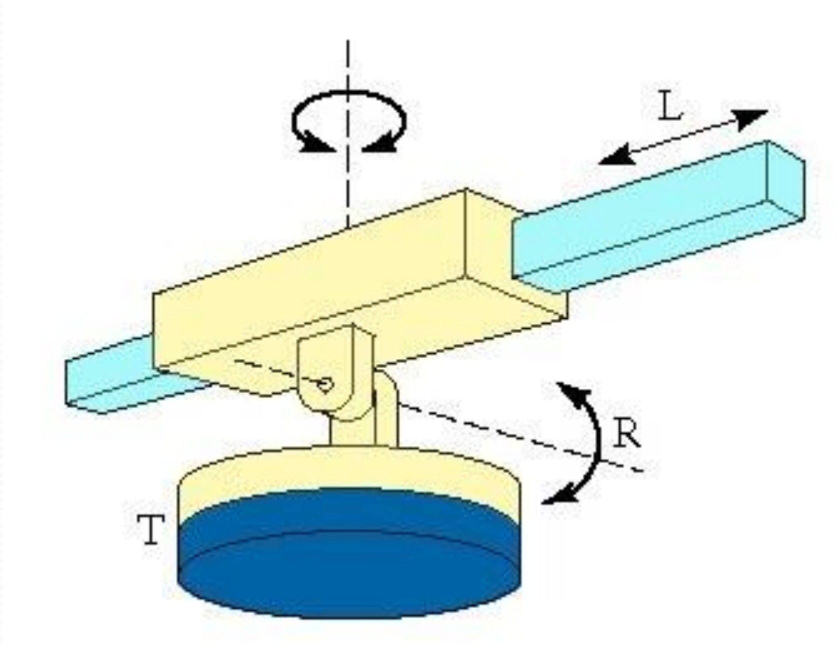
- Notation TLO:

- Consists of a vertical column, relative to which an arm assembly is moved up or down
- The arm can be moved in or out relative to the column



Spherical Coordinate

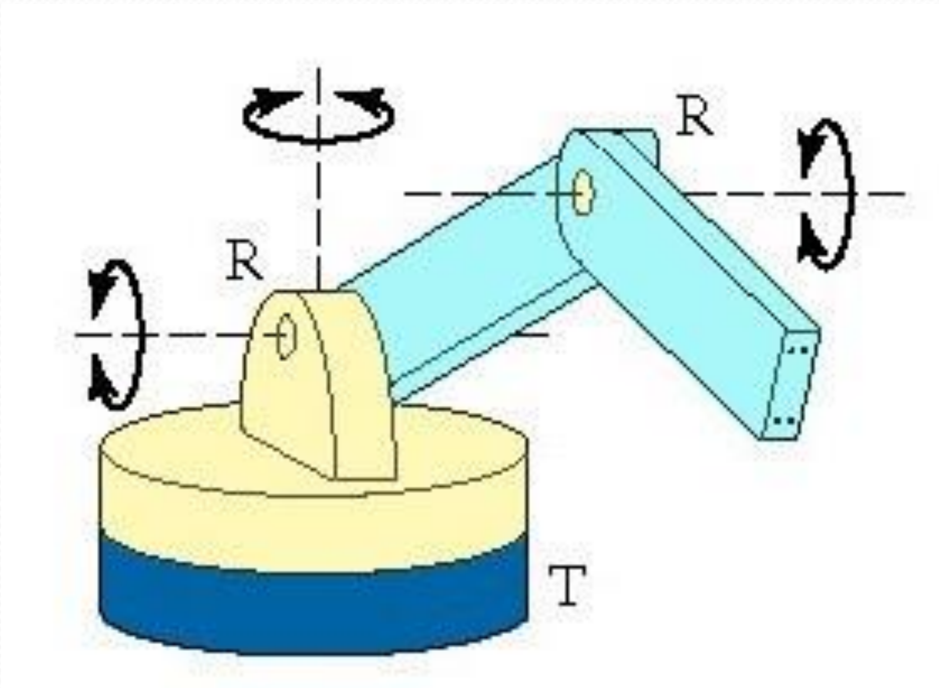
- Notation TRL:



- Consists of a sliding arm (L joint) actuated relative to the body, which can rotate about both a vertical axis (T joint) and horizontal axis (R joint)

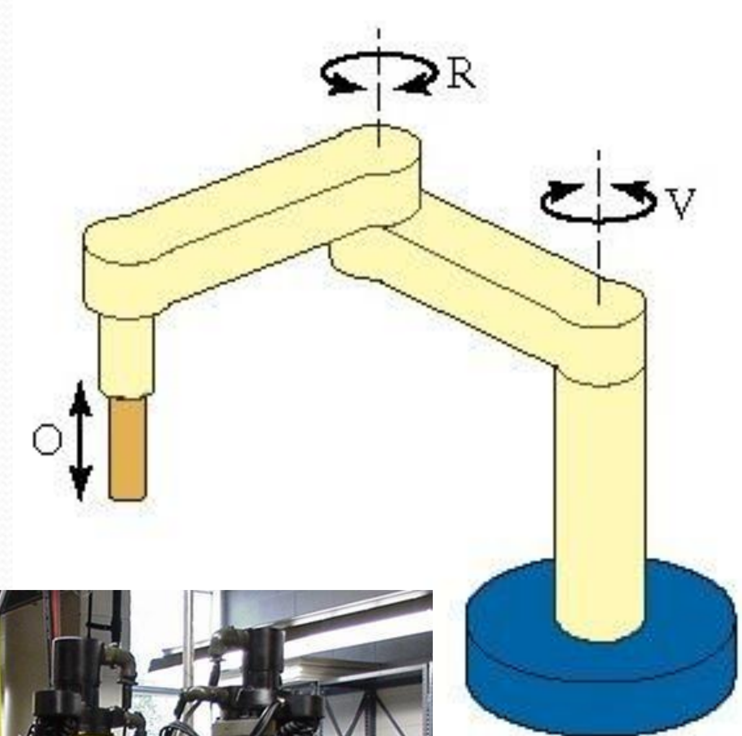
Articulated Coordinate

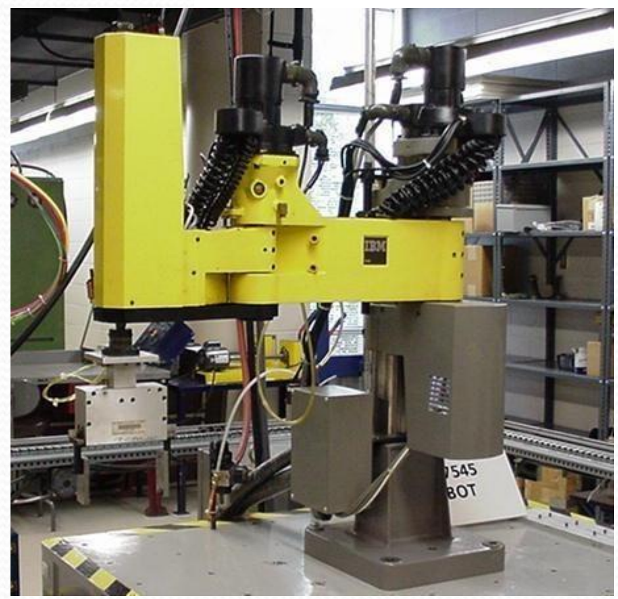
- Notation TRR:



SCARA Robot

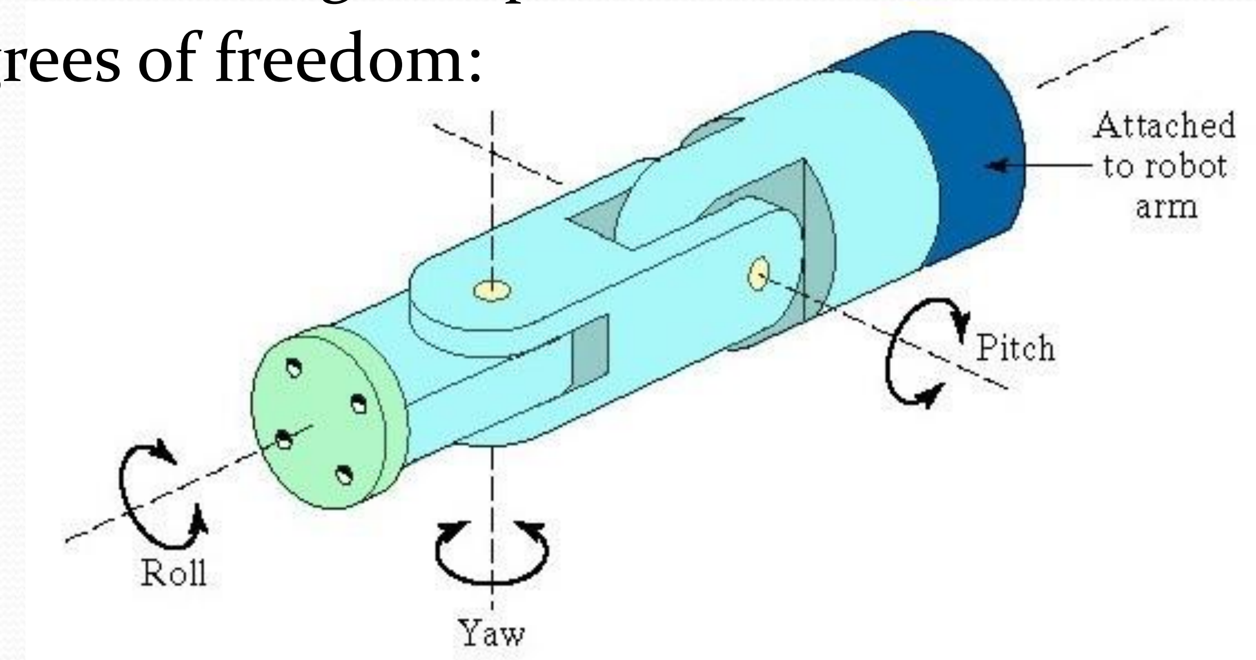
- Notation VRO
- SCARA stands for Selectively Compliant Assembly Robot Arm
- Similar to jointed-arm robot except that vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction for vertical insertion tasks





Wrist Configurations

- Wrist assembly is attached to end-of-arm
- End effector is attached to wrist assembly
- Function of wrist assembly is to orient end effector
  - Body-and-arm determines global position of end effector
- Two or three degrees of freedom:
  - Roll
  - Pitch
  - Yaw
- Notation :RRT



Performance Specifications of Industrial Robots

- Robot Specifications
  - Number of Axes
    - Major axes, (1-3) => Position the wrist
    - Minor axes, (4-6) => Orient the tool
    - Redundant, (7-n) => reaching around obstacles, avoiding undesirable configuration
  - Payload (load capacity).
  - Repeatability.
  - Precision and accuracy.
  - Maximum speed.

Capacity and speed

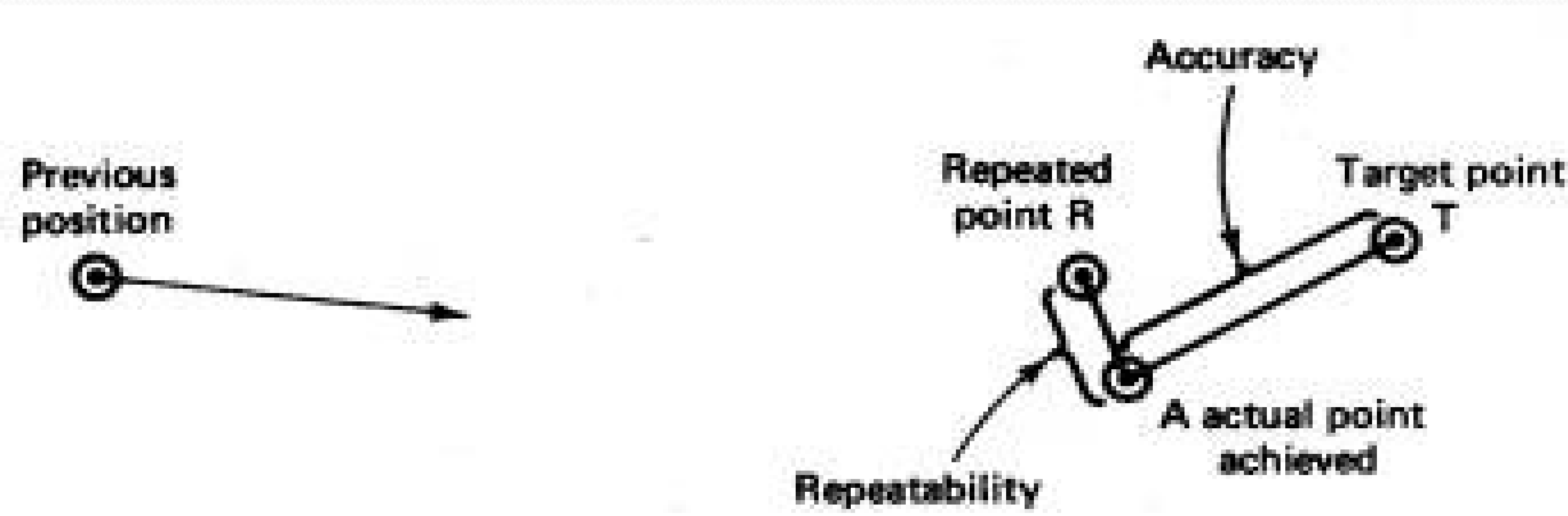
- Load-carrying capacity varies between robots
  - Minimover 5 Microbot educational table-top robot can handle 2.2 Kg load
  - but GCA-XR6 Extended Reach industrial robot is designed for loads of 4928 Kg

- Maximum tool-tip speed may vary between robots
  - Westinghouse Series 4000 => tool-tip speed= 92 mm/sec
  - Adept One SCARA => tool-tip speed= 9000 mm/sec

Repeatability

Ability to position back to a point that was previously taught

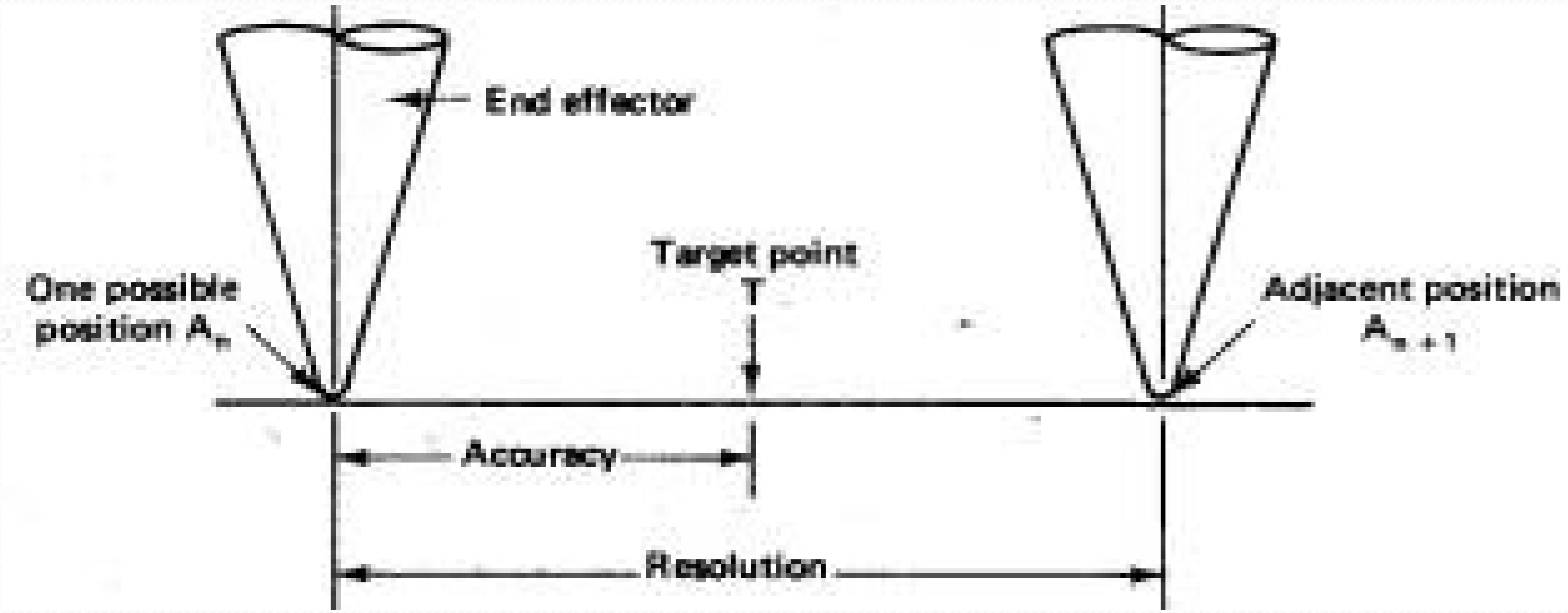
- Repeatability errors form a random variable.
- Mechanical inaccuracies in arm, wrist components
- Larger robots have less precise repeatability values



Spatial Resolution (Precision)

Smallest increment of motion of the tool that can be controlled by the robot

Depends on the position control system, feedback measurement, and mechanical accuracy



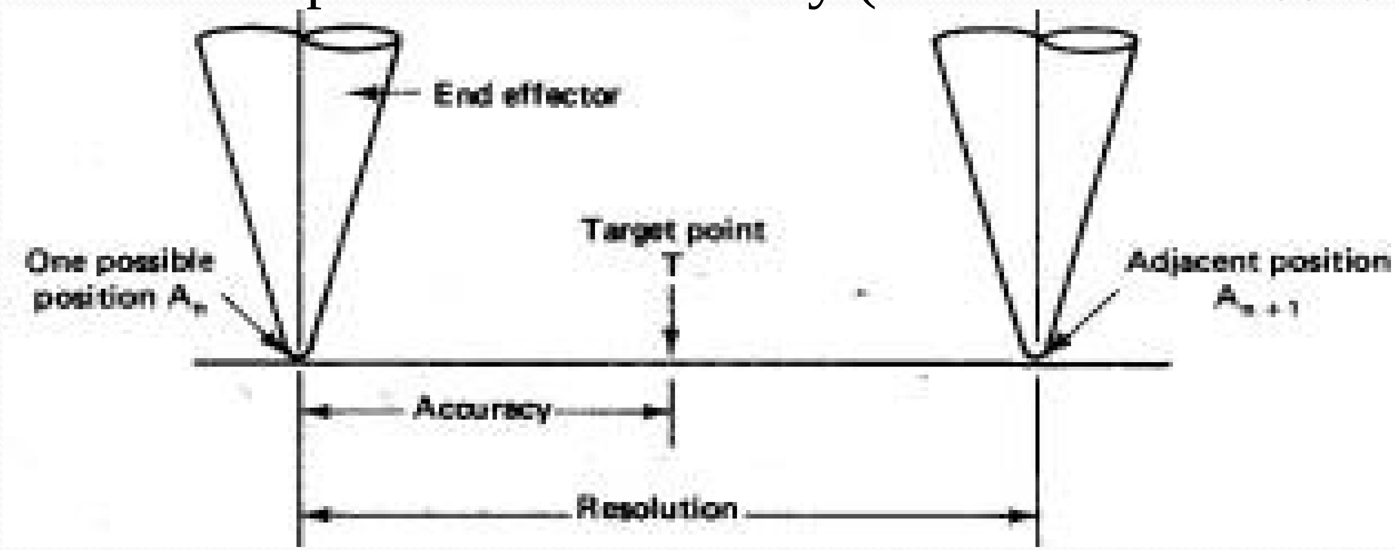
Accuracy

Capability to position the tool at a target point in the work volume

• One half of the distance between two adjacent resolution points

• Affected by mechanical Inaccuracies

• Manufacturers don't provide the accuracy (hard to control)



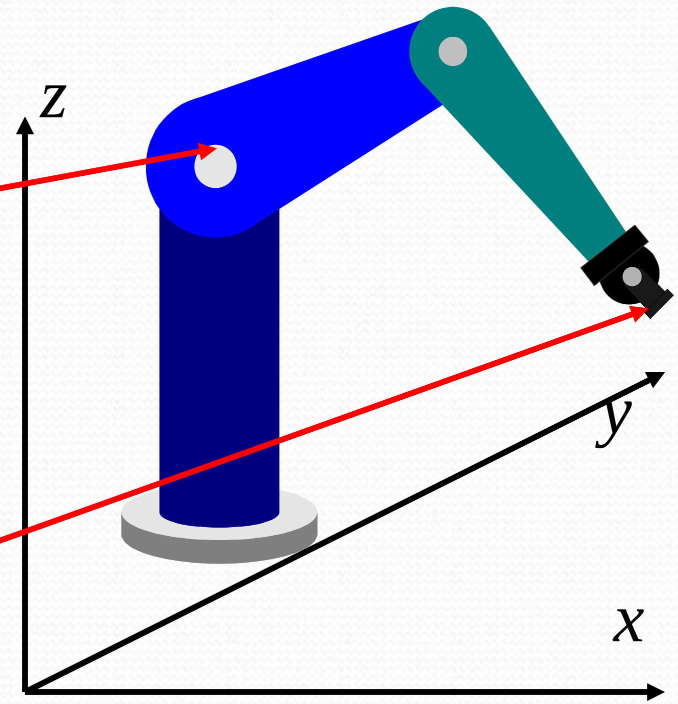
What is Kinematics

- Forward kinematics

Given joint variables

$$q \quad (q_1, q_2, q_3, q_4, q_5, q_6, \cdots q_n)$$

$$Y \quad (x, y, z, R_{13}, R_{23}, R_{33})$$



End-effector position and orientation, -Formula?

What is Kinematics

- Inverse kinematics

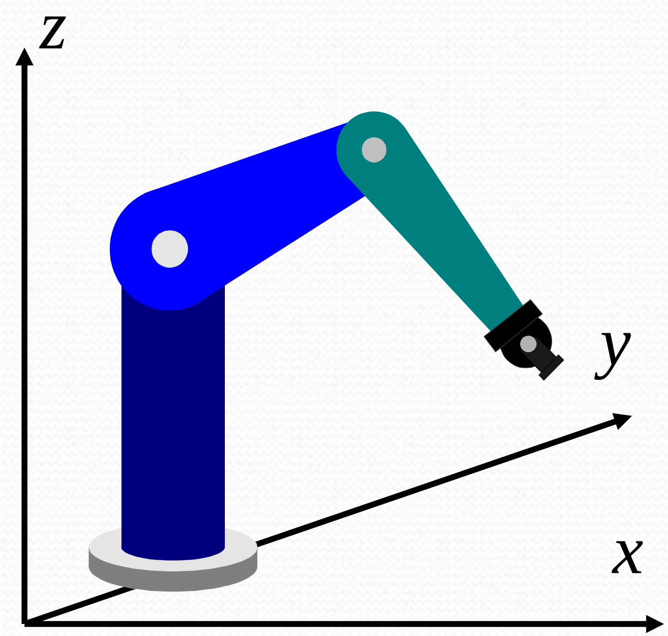
End effector position

and orientation

$$(x, y, z, R_{13}, R_{23}, R_{33})$$

$$q \quad (q_1, q_2, q_3, q_4, q_5, q_6, \cdots q_n)$$

Joint variables -Formula?



Example 1

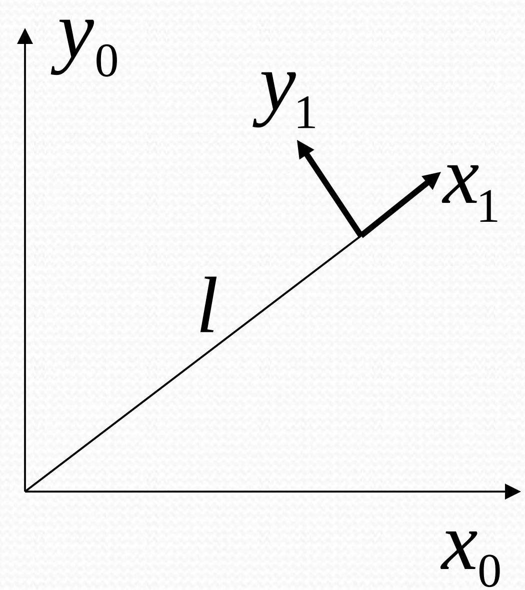
Forward kinematics

$x_0 \quad l\cos$

$y_0 \quad l\sin$

Inverse kinematics

$\cos^{1}(x_0 / l)$



Robot Applications (Configurations/Characteristics)

SCARA Robot

(Selective Compliance Assembly Robot Arm)

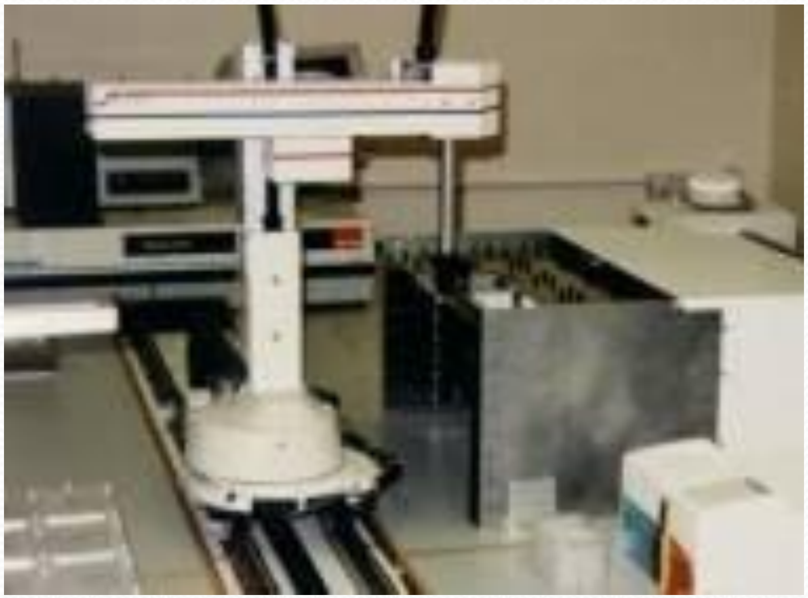
Characteristics:

•Repeatability: < 0.025mm (high)
•No. of axes: min 4 axes
• Vertical motions smoother, quicker, precise (due to dedicated vertical axis)
• Good vertical rigidity, high compliance in the horizontal plane.
•Working envelope: range < 1000mm
•Payload:10-100 kg
•Speed: fast 1000-5000mm/s

Applications:
•Precision, high-speed, light assembly

Robot Applications (Configurations/Characteristics)

Cylindrical Coordinate Robot



Characteristics:

•Wide range of sizes
•Repeatability: vary 0.1-0.5mm
•No. of axes: min 3 arm axes (2 linear)
•Working envelope: typically large (vertical stroke as long as radial stroke)
• The structure is not compact.
•Payload: 5 - 250kg
•Speed: 1000mm/s, average
•Cost: inexpensive for their size and payload

Applications:

•Small robots: precision small assembly tasks
•Large robots: material handling, machine loading/unloading.

Robot Applications (Configurations/Characteristics)

Vertical Articulated Arm Robot

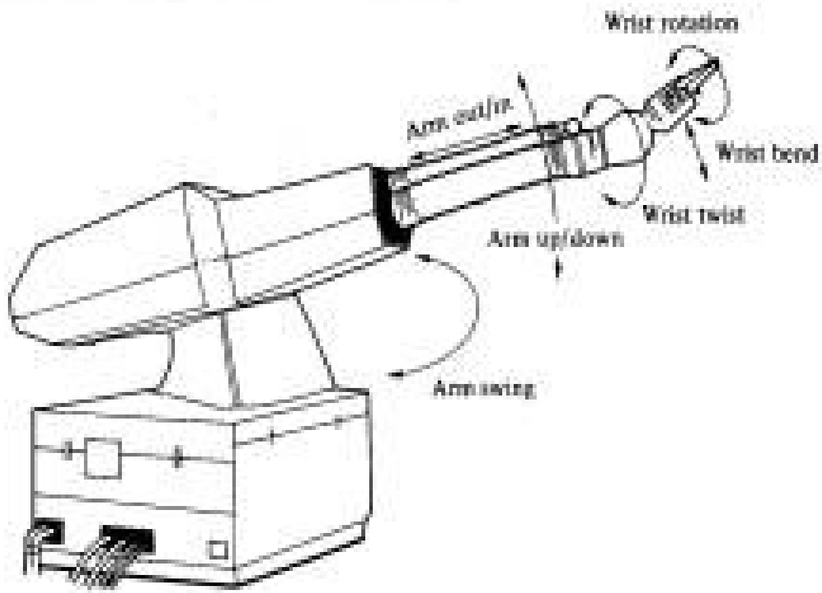
Characteristics:

- Repeatability: 0.1-0.5mm (large sizes not adequate for precision assembly)
- No. of axes: 3 rotary arm-axes, 2-3 additional wrist axis (excellent wrist articulation)
- Working envelope: large relative to the size, Structure compact, but not so rigid
- Payload: 5-130kg
- Tool tip speed: fast 2000mm/s

Applications: Welding, painting, sealing, deburring, and material handling

Robot Applications (Configurations/Characteristics)

Spherical Coordinate Robot



Characteristics:

- Repeatability: poor 0.5-1mm
- No. of axes: 3 arm-axes (1 linear radial), 1-2 additional wrist-axes.
- Working envelope: large vertical envelope relative to the unit size
- Payload: 5-100 kg
- Speed: low (linear motions are not smooth and accurate- require coordination of multiple axes)

Applications: Material handling, spot welding, machine loading

Robot Applications (Configurations/Characteristics)

Cartesian Coordinate Robot

Characteristics:

- Repeatability: high (0.015-0.1)
- No. of axes: 3 linear arm-axis,
- Working envelope:relative large
- Payload:5- 100kg
- Speed: fast

Applications: Precise assembly, arc welding, gluing, material handling

Robot Applications (Configurations/Characteristics)

Gantry Robot

Characteristics:

•Repeatability: 0.1-1mm

•No. of axes: 3 linear traverse-axes, 1-3 additional wrist axes

•Working envelope: very large

•Payload: vary function of size, support very heavy 10-1000kg

•Speed: low for large masses

Applications:

Handling very large parts, moving material on long distances, welding, gluing.

The Advantages of Industrial Robots

- Competitive Advantage
  - Robots can do some things more efficiently and quicker than humans.
- Mechanical
  - Robots never get sick or need to rest, so they can work 24 hours a day, 7 days a week.
  - Greater output per hour with consistent quality
  - Continuous precision in repetitive operation.

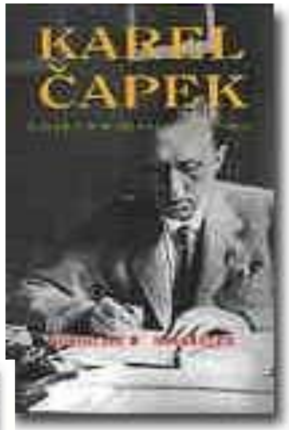
Limitations of Robotics

Today's robots:

- Are not creative or innovative
- Can not think independently
- Can not make complicated decisions
- Can not learn from mistakes
- Can not adapt quickly to changes in their surroundings

Every successful business must depend on real people for these abilities.

History



Isaac Asimov

The acclaimed Czech playwright Karel Capek made the first use of the word ‘robot’, from the Czech word for forced labor or serf.

The word 'robotics' was first used in ***Runaround***, a short story published in 1942, by Isaac Asimov.

But it was not until 1956 that a real robot came into existence.

History

The First Robot

Unimate Puma500 Manipulator

After the technology explosion during World War II, in 1956, George C. Devol, Norman Schafler and Joseph F. Engelberger and made a serious and commercial effort to produce a robot.

They started a firm named Unimation and succeeded in building the 1st robot named Unimate.

Joseph F. Engelberger is known as the ‘Father of Robotics’

History *The Unimate*

It was first used in General Motors.

It basically to extract die-castings from die casting machines and to perform spot welding on auto bodies, both tasks being particularly hateful jobs for people.

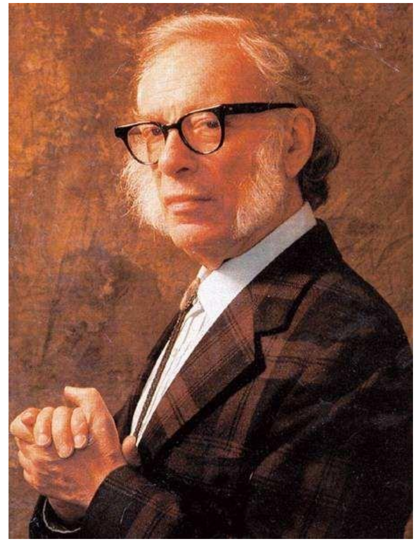
A variety of other tasks were also performed by robots, such as loading and unloading machine tools.

The Unimate started a revolution in the robotics industry and many robots of its Type were built for doing tiresome jobs for people.

Robots offer specific benefits to workers and industries. If introduced correctly, industrial robots can improve the quality of life by freeing workers from dirty, boring, dangerous and heavy labor.

History

Asimov's Laws



A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

A robot must obey the orders given it by human beings except where such orders would conflict with the First Law

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

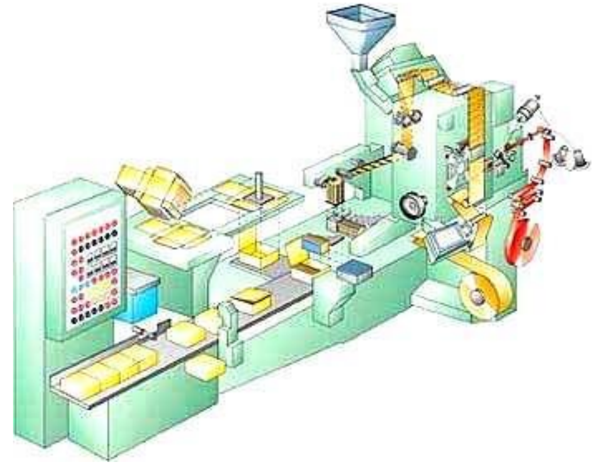
A robot can act as it wants, except if its actions are in conflict with the First three Laws.

fields

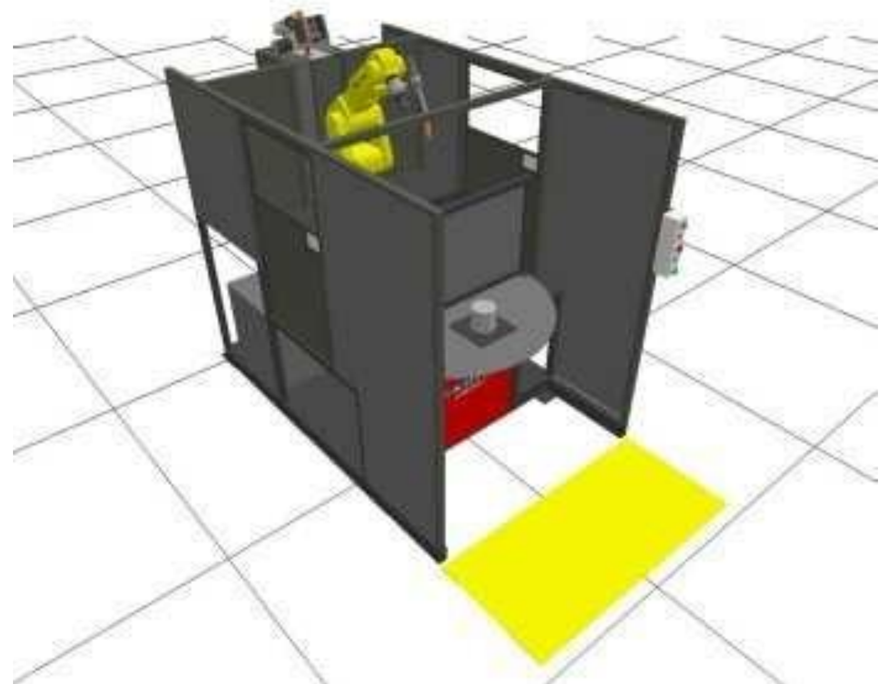
Not exhaustive!!!

- *Industrials robots*
- *Space Robots*
- *Aerial-robots*
- *Underwater Robots*
- *Internet Robots*
- *Services robots*
- *Surgery robots*
- *Biped robots*
- *Humanoid robots*
- *Intelligent Vehicles*
- *Entertainment robots*
- *Micro-robots*
- *…*

Robots **Full Automatization** ***(24 hours process)***



Industrial Robots **Unit Automatization :** ***robot unit***



Industrial Robots **Unit Automatization *: robot unit***

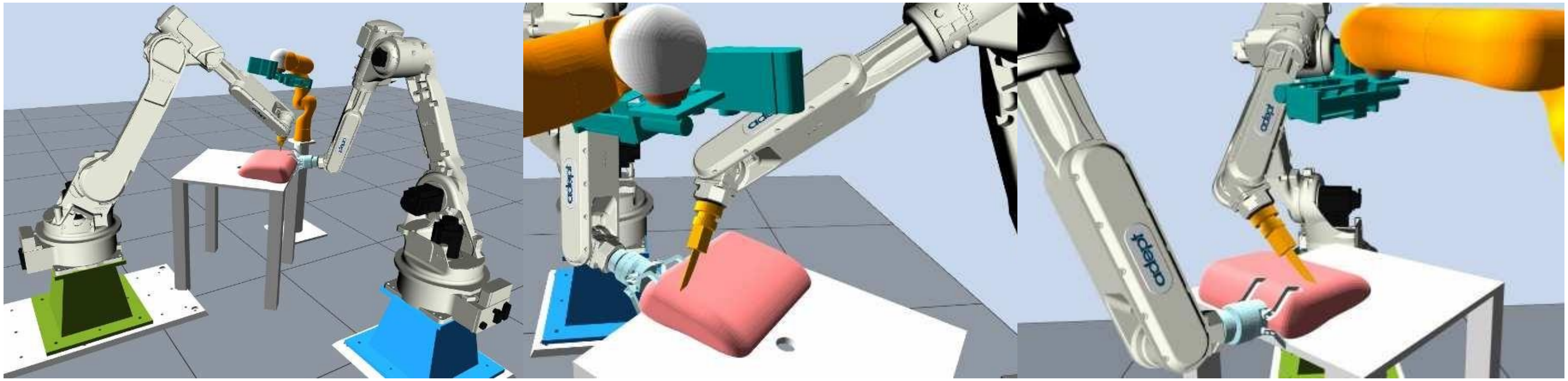




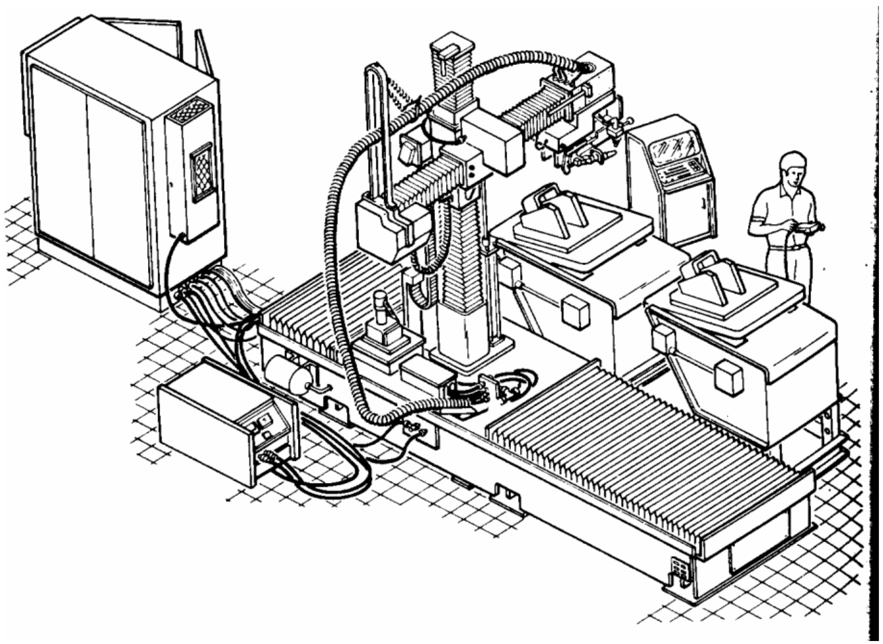


Industrial Robots **Unit Automatization : *Assembly lines***

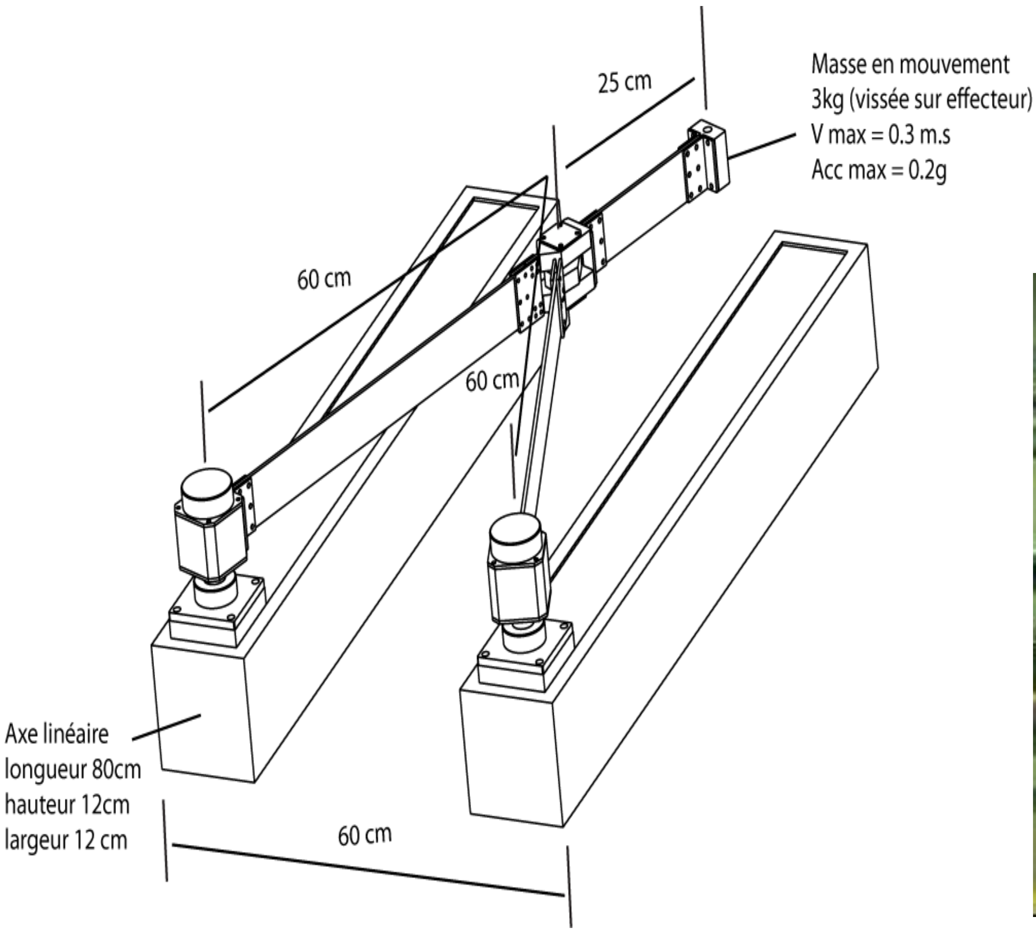
Industrial Robots **Unit Automatization : *deboning***

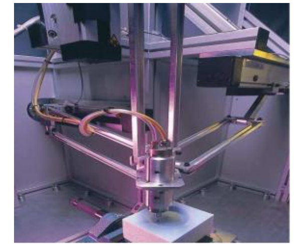


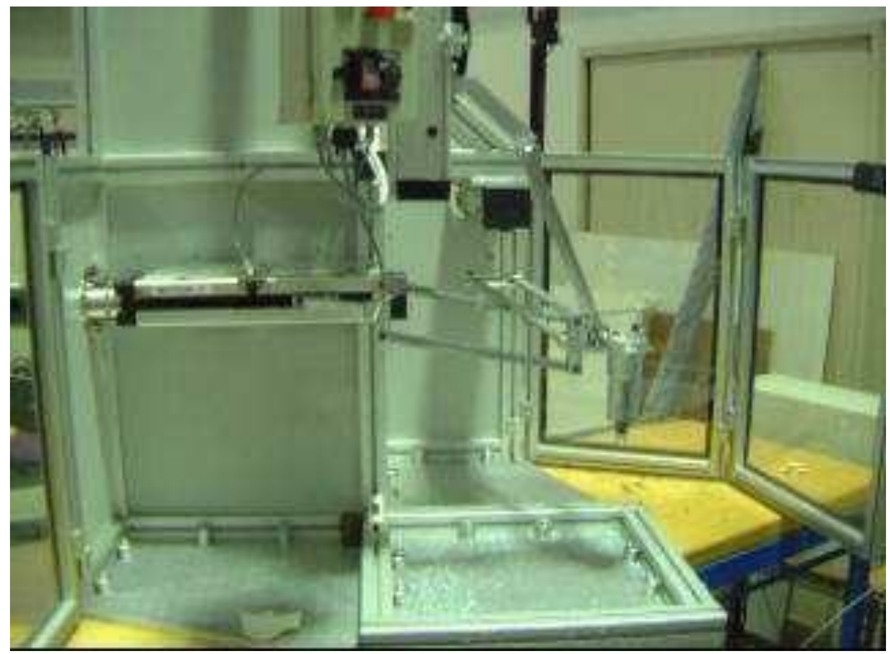
Industrial Robots *Manipulator robot with added mobility*

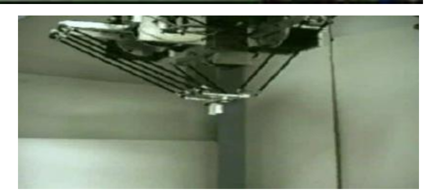


Industrial Robots **Parallel robot**



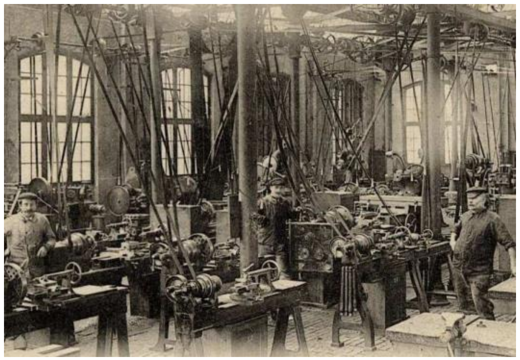






Industrial Robots **Evolution**

Machines tools



Introduction of:

-Electronic

-Computer sciences

-HMI

-Programming

-Calibration

-...

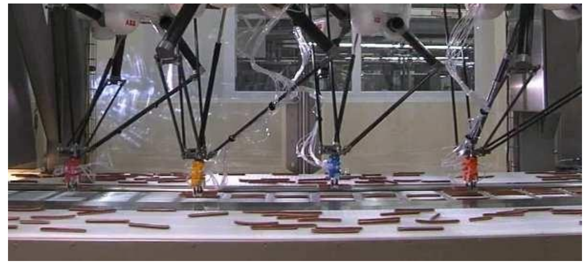
Industrial Robots Evolution

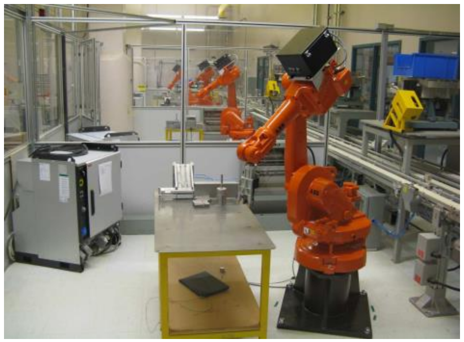
High Speed Machines

Quicker, more accurate, … robots

Evolution

Chemical, Food, packaging, …

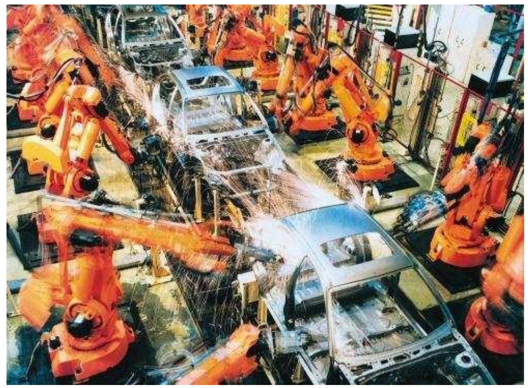




Automotive

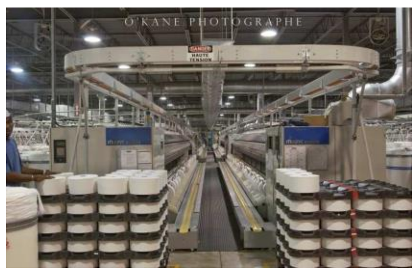
Robots working

in parallel



Robots working together

Automated/robotized Cell and Chains



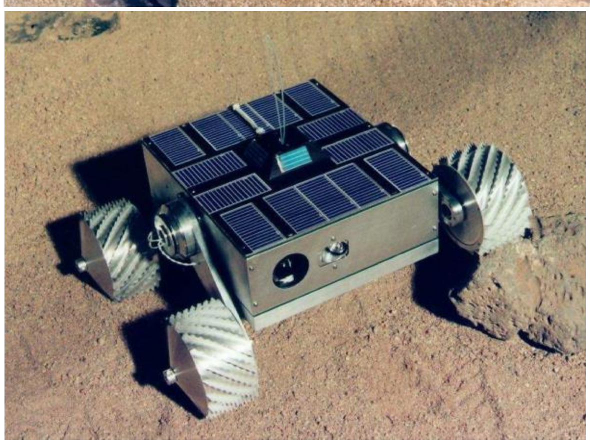
Space Robots

Blue rover

gofor

athena

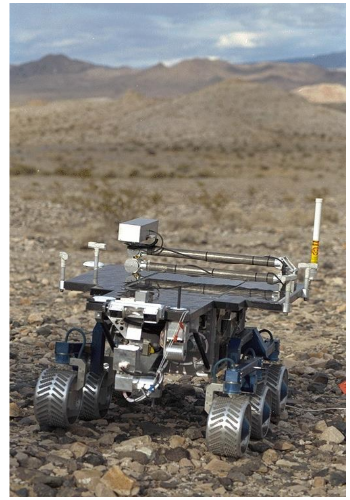
rocky3



Nrov3

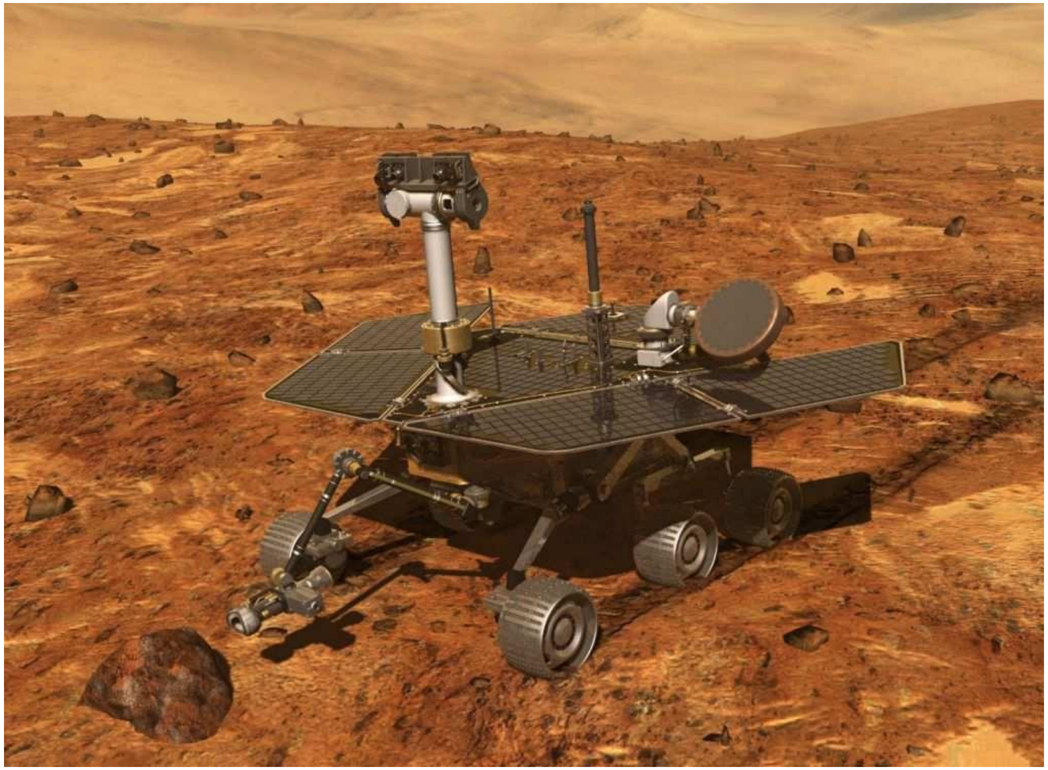
robby

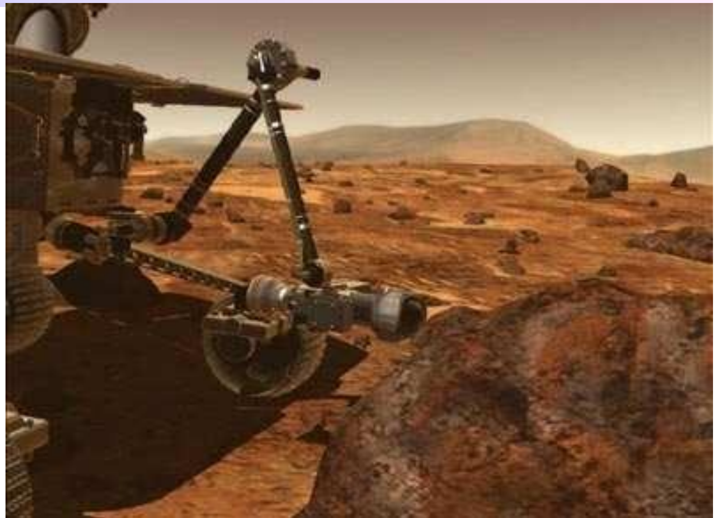
Space Robots



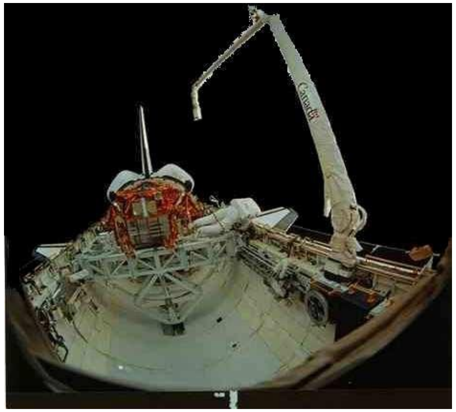
Space Robots

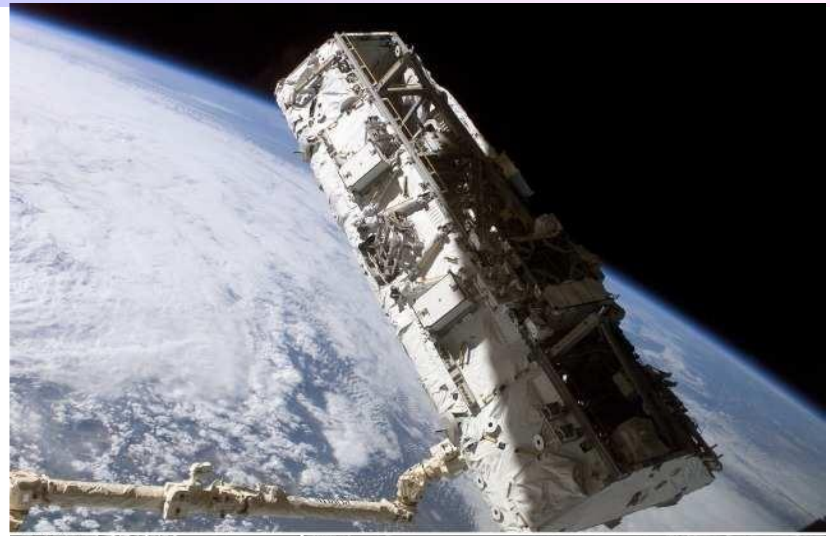
Mission on Mars

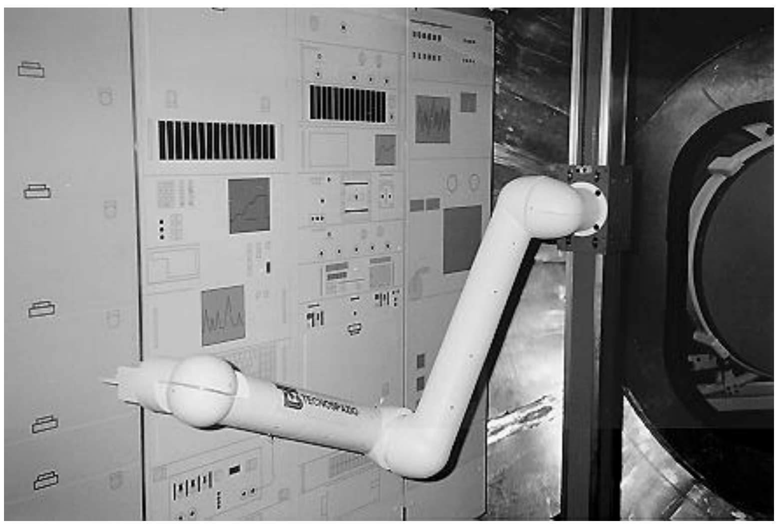




Space Robots

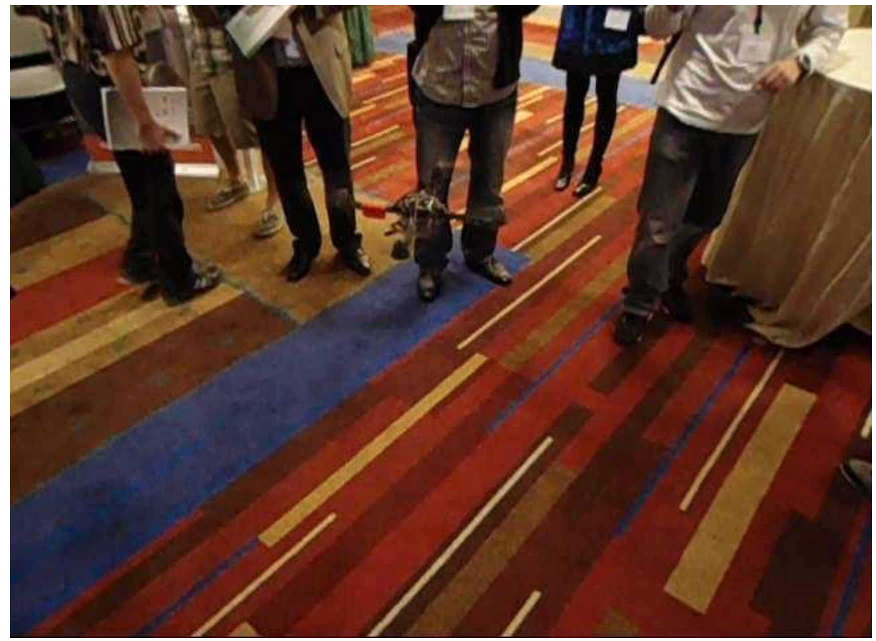




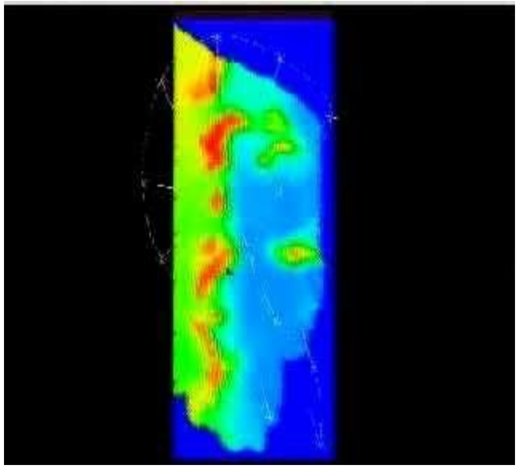


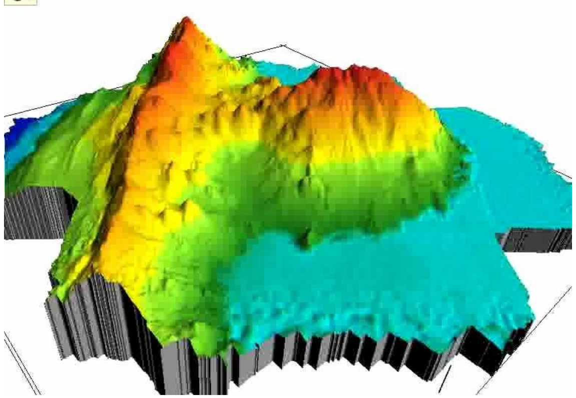
Aerial Robots

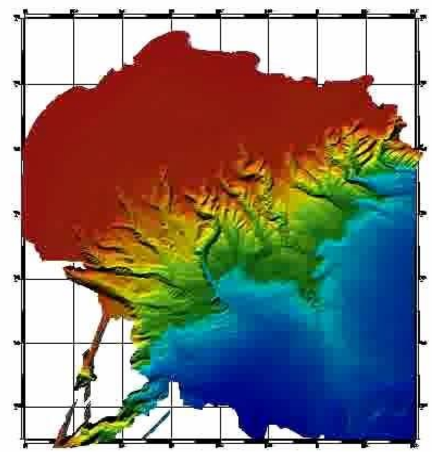
Drône



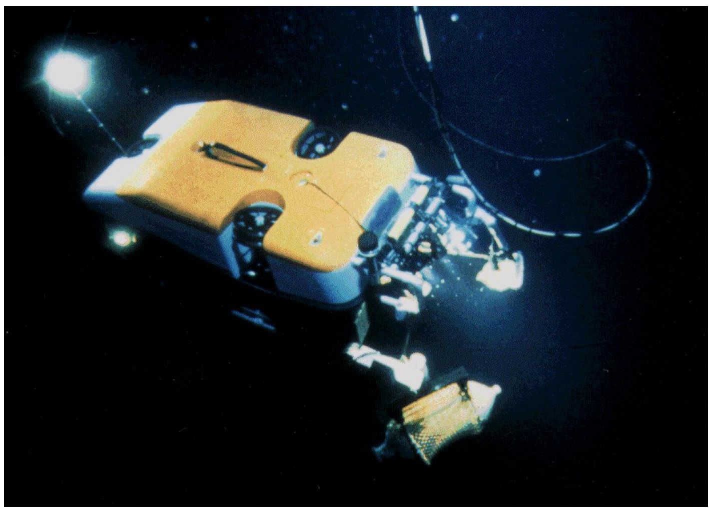
Underwater Robots

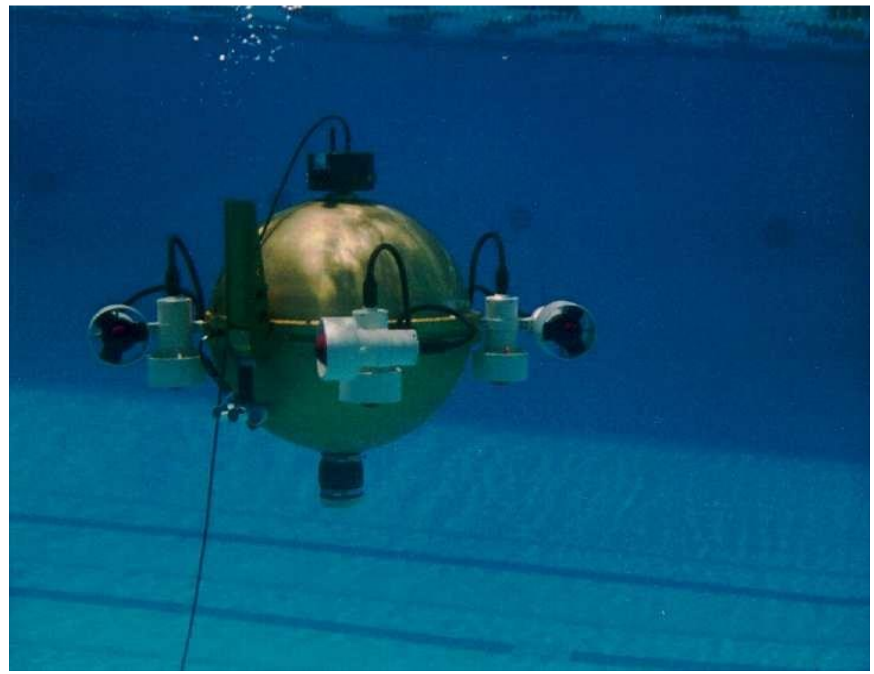






Underwater Robots



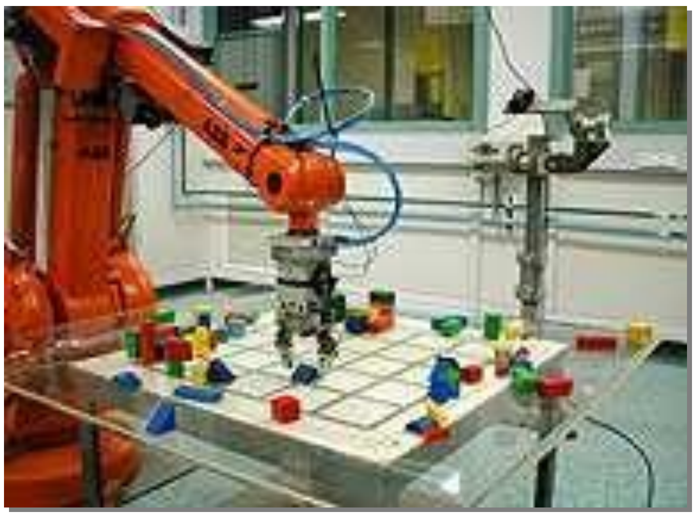


Internet Robots

http://cwis.usc.edu/dept/garden/

Interacting with a remote garden

Planting and watering



http://telerobot.mech.uwa.edu.au/

Manipulating objects on a board

[x,y,z] coordinates specification

Augmented reality (IFAC'2001)

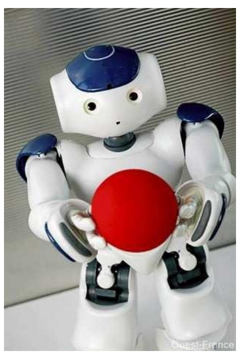
Internet Robots

Jaume I University : Education & Training

Off-line

On-line

Service Robots



Service Robots

**Dyson-
DC06
Vaccum
Cleaner**

Mower Robot
Husqvarna

**Robomow RL500
Mower**

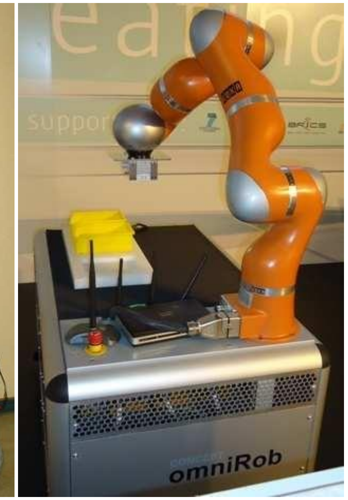
Vacuum Robot
Electrolux

Sweeper Robot
Kärcher

Inspection
robot

Service Robots

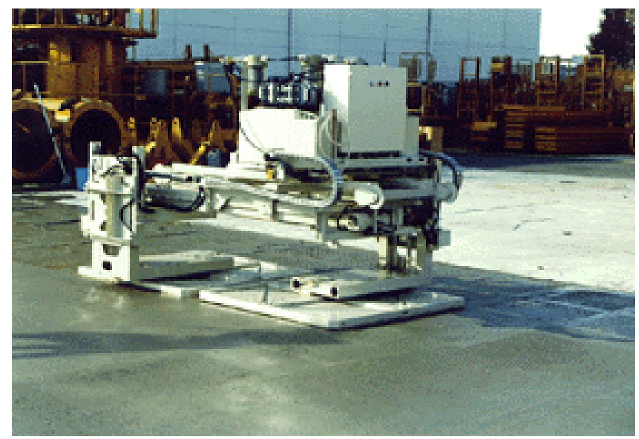
Transitic



Mobile Manipulators

Service Robots Construction robots

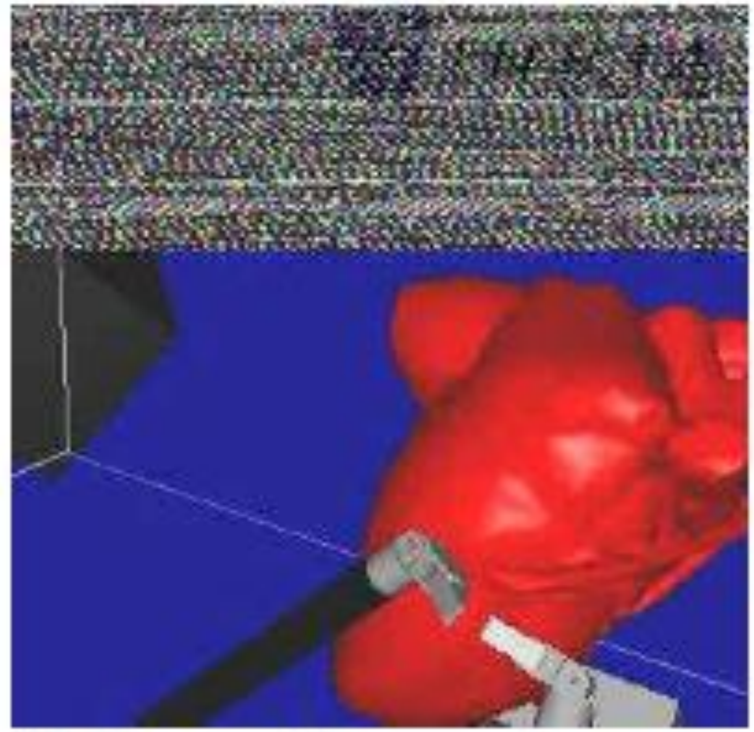

(c)1998-1999 The Japan Research Institute, Limited



Field Robots

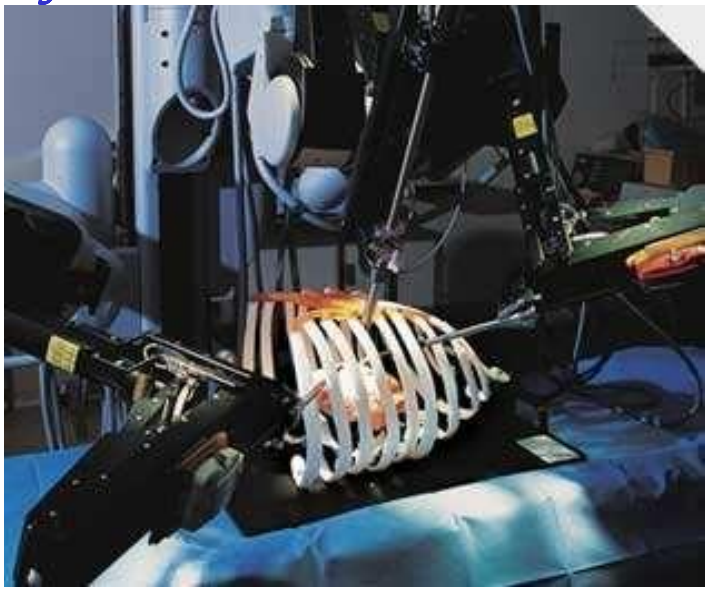
Demining

Surgery Robots



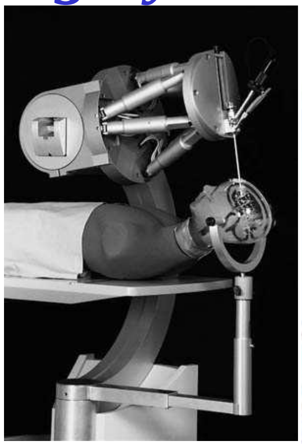
Teleoperation : endoscopy

Surgery Robots



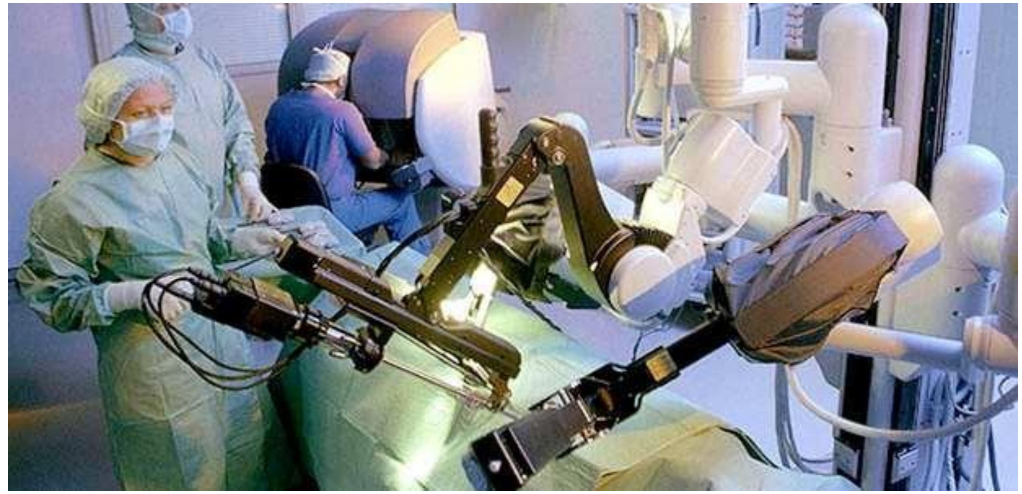
http://www.intuitivesurgical.com/

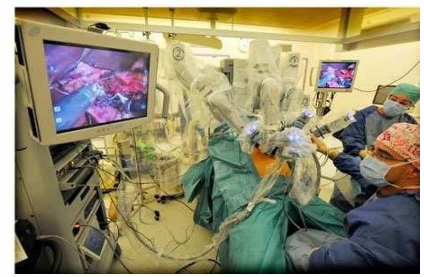
Surgery Robots



http://www.computermotion.com/

Surgery Robots



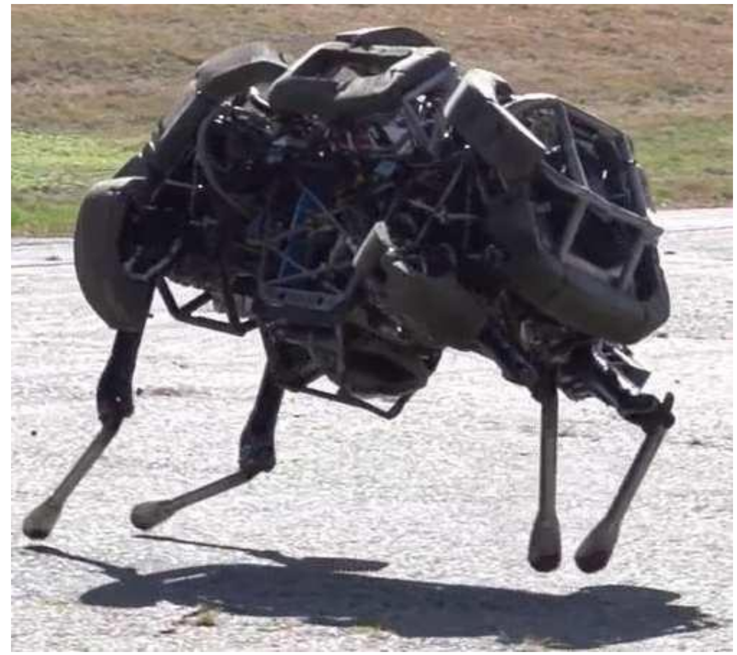


Surgery Robots

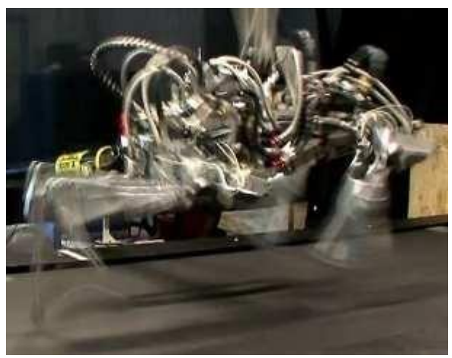
Multipod Robots

BigDog

Wildcat



7mph



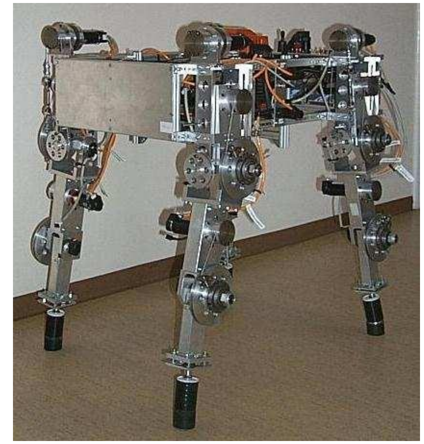
Cheetah

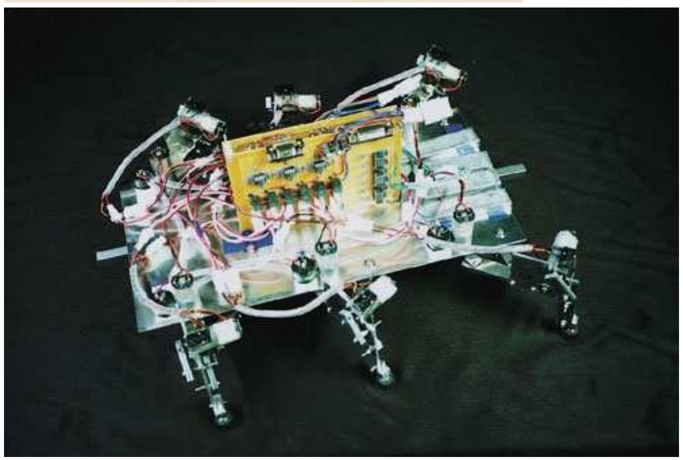
Run faster than Usain Bolt

Multipod Robots

Aïbo (Sony)

Warp (KTH)

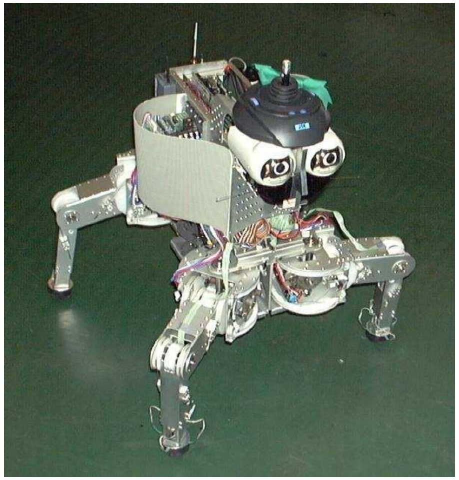


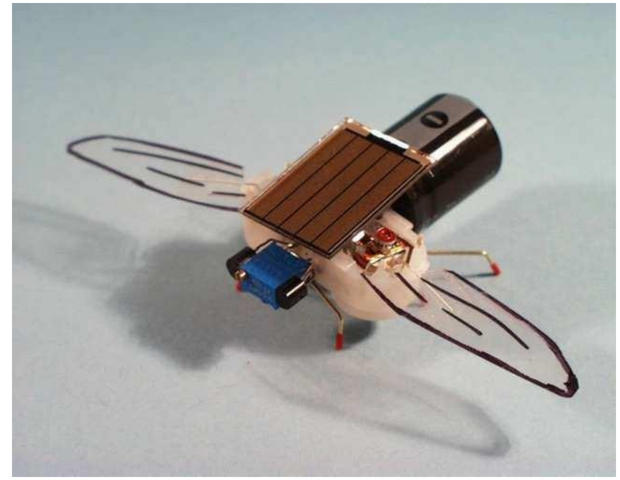


Hexapode

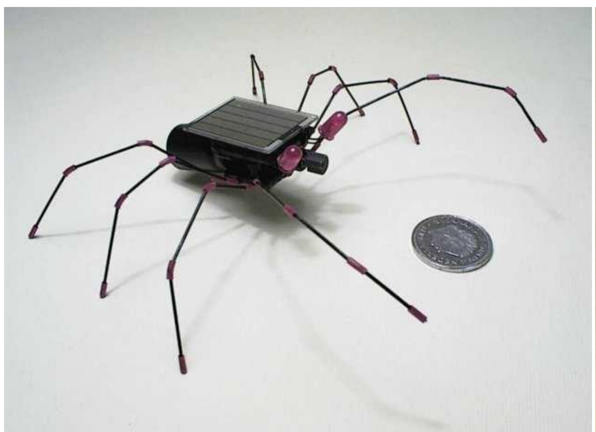
Big
Dog

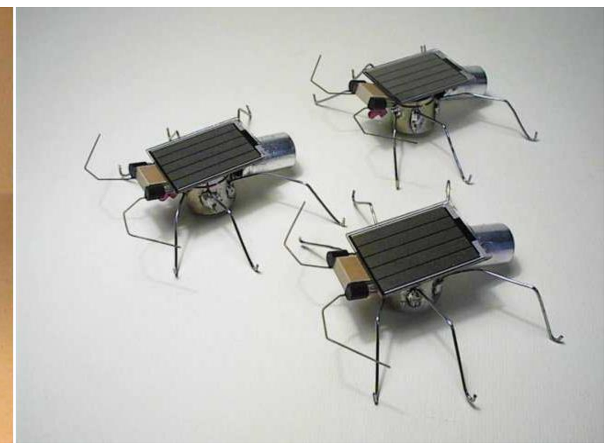
Micro Robots





Spider, mobile, cricket, solarfly





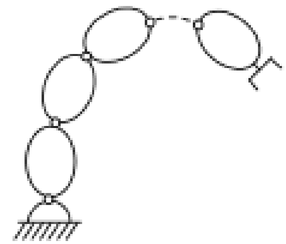
Miscellaneous Robots

Miscellaneous Robots

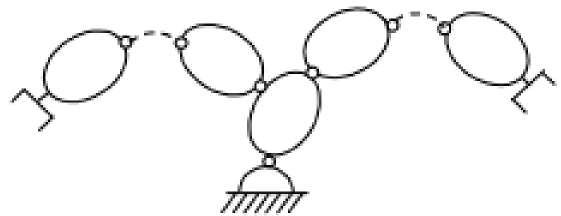
Bat-bot

Classification Chain structures

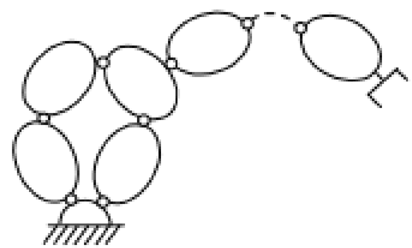
Serial chain



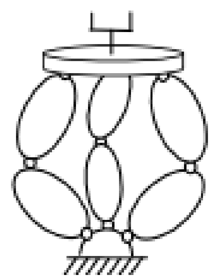
Tree structured chain



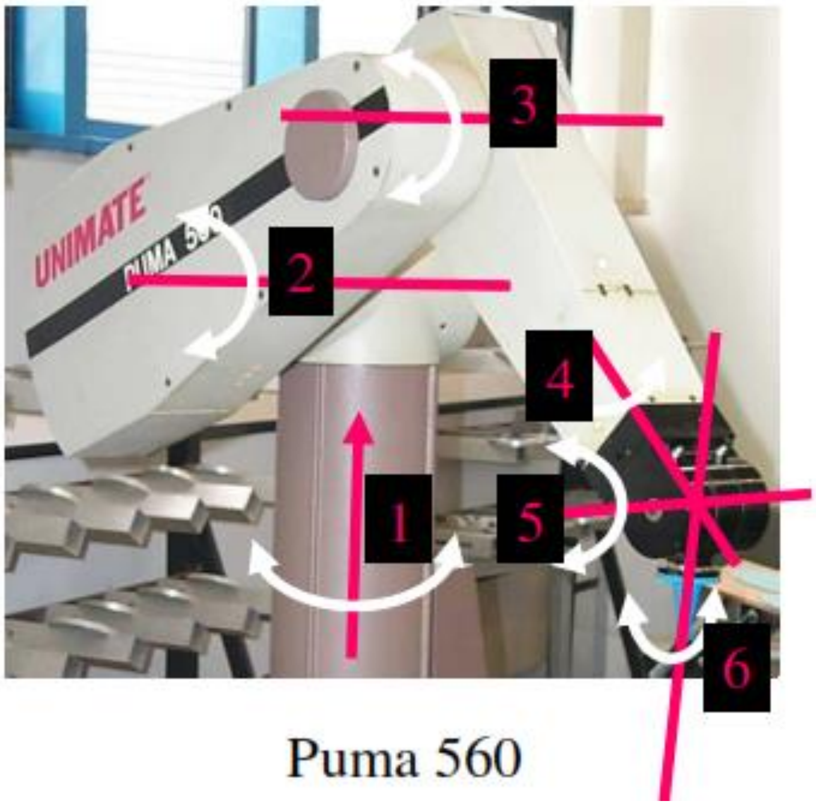
Closed chain



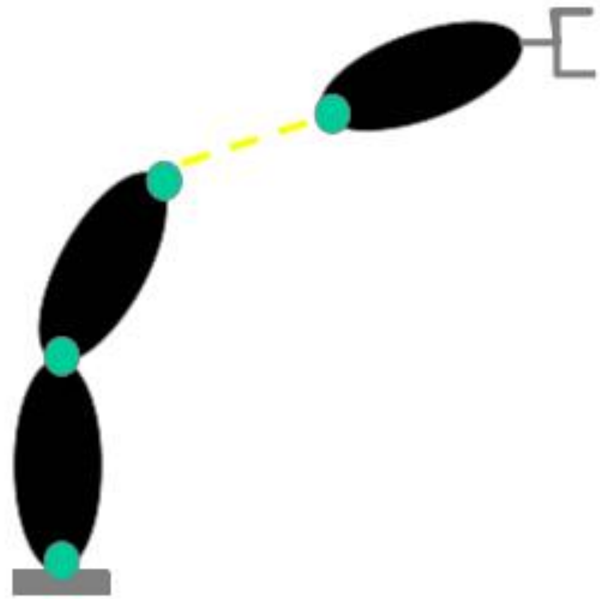
Parallel chain



Classification *Serial structure robot*

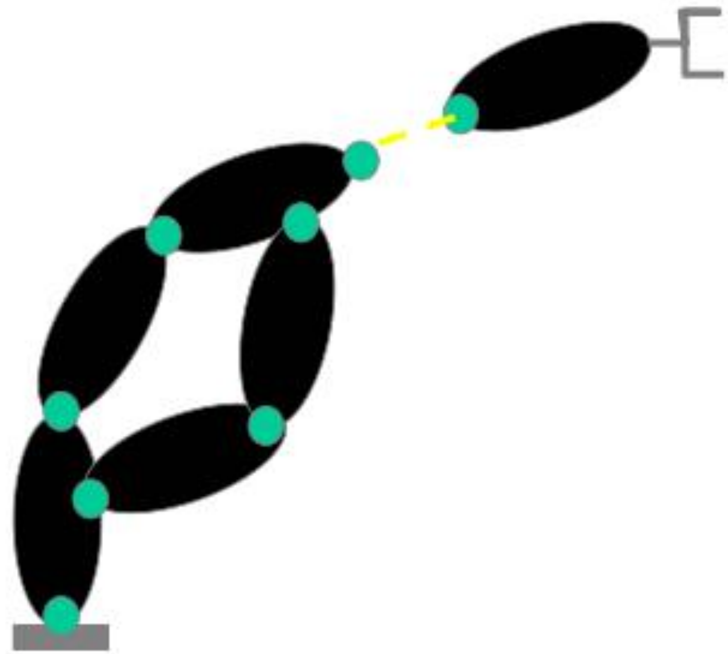


Puma 560

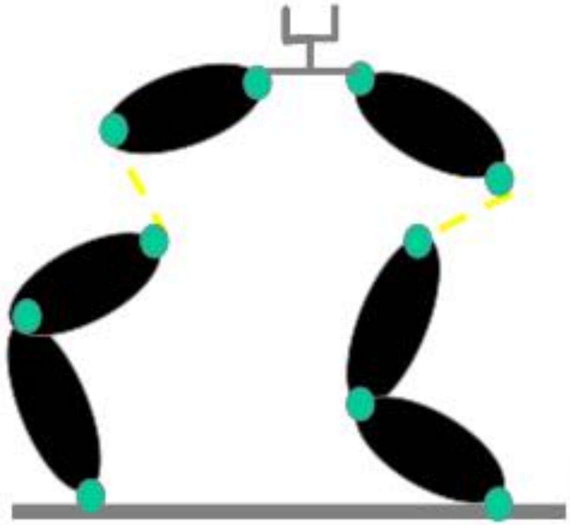


Open chain

Classification *Closed loop robot*

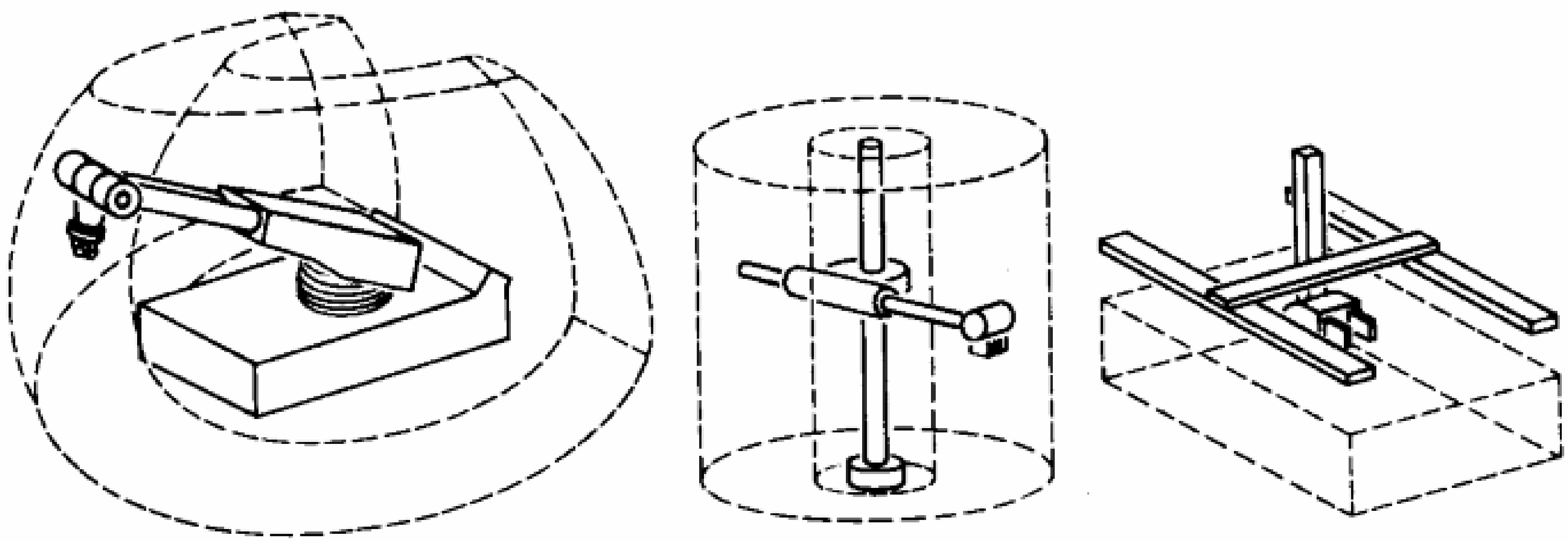


Classification *Parallel robot*



Delta “Flex-Picker"

Classification *Robot workspace*



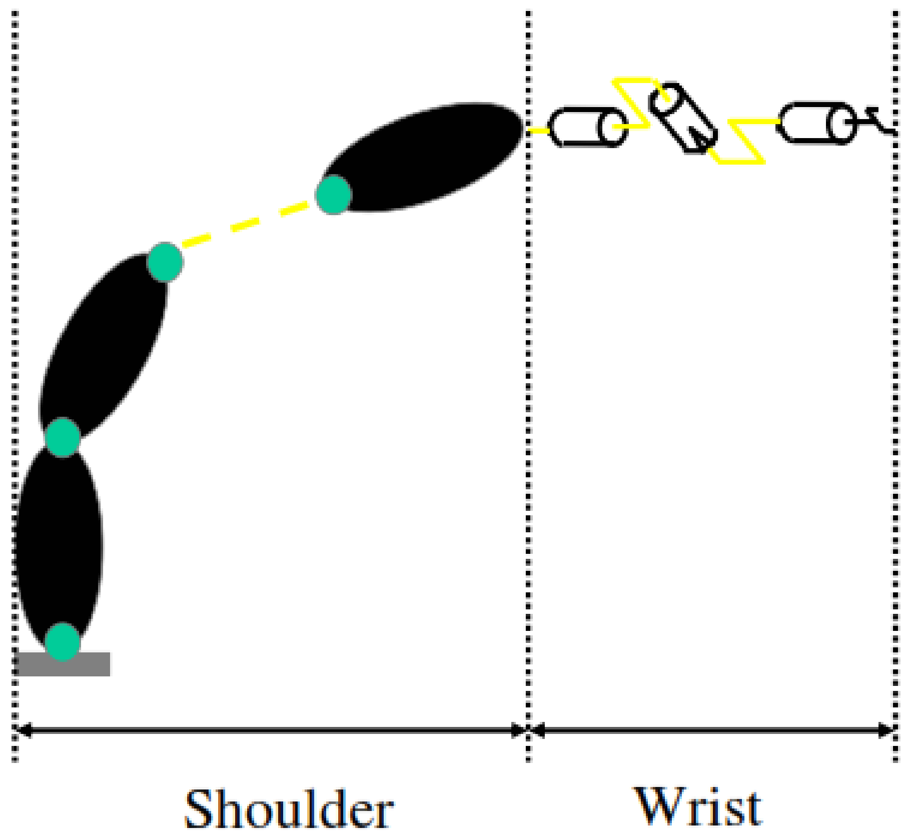
(a) (b) (c)

a) Spherical workspace

b) Cylindrical workspace

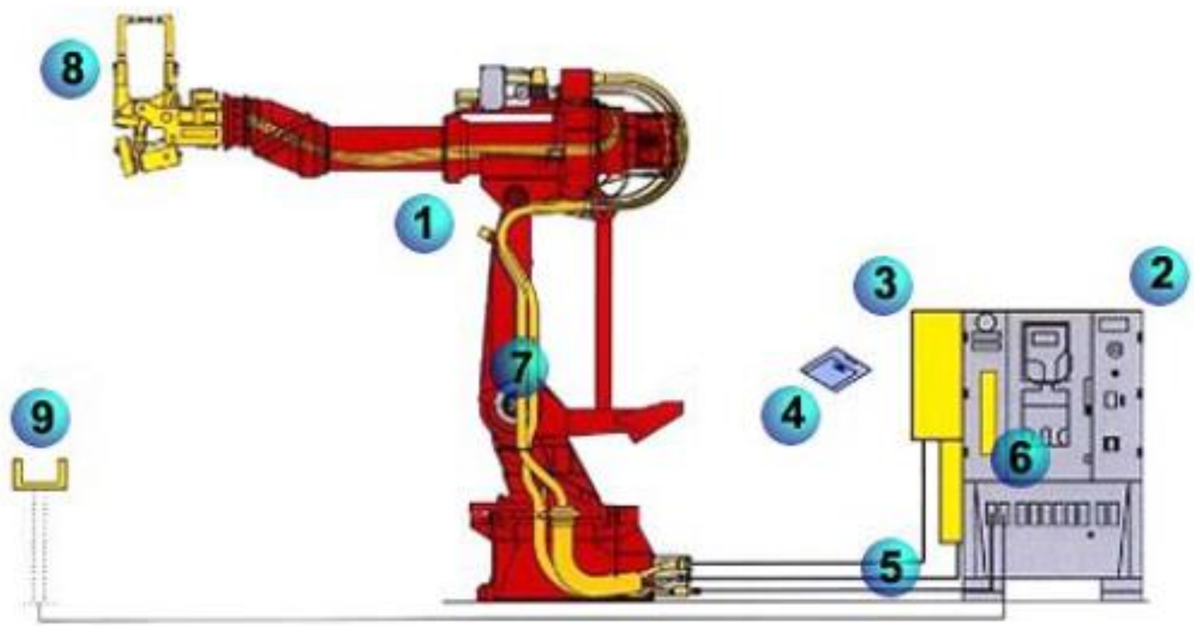
c) Cartesian workspace

Classification *Shoulder and wrist*



Industrial robot
and its auxiliary equipments

1. Comau SMART H robot
2. C3G Plus controller
3. Welding control box
4. Application software
5. Air/water supply
6. SWIM Board
7. Integrated cables
8. Welding gun
9. Auxiliary devices in the robotic cell (servo-controlled axes)



SWIM = Spot Welding Integrated Module

Robot manipulator kinematics

Kuka 150_2
(series 2000)
open kinematic chain
(rigid bodies
connected by joints)

Comau
Smart H4
closed kinematic chain

Fanuc
F-200iB
parallel kinematics

SCARA-type robots

Mitsubishi RP
(repeatability 5 micron,
payload 5 kg)

Mitsubishi RH
(workspace 850 mm,
velocity 5 m/s)

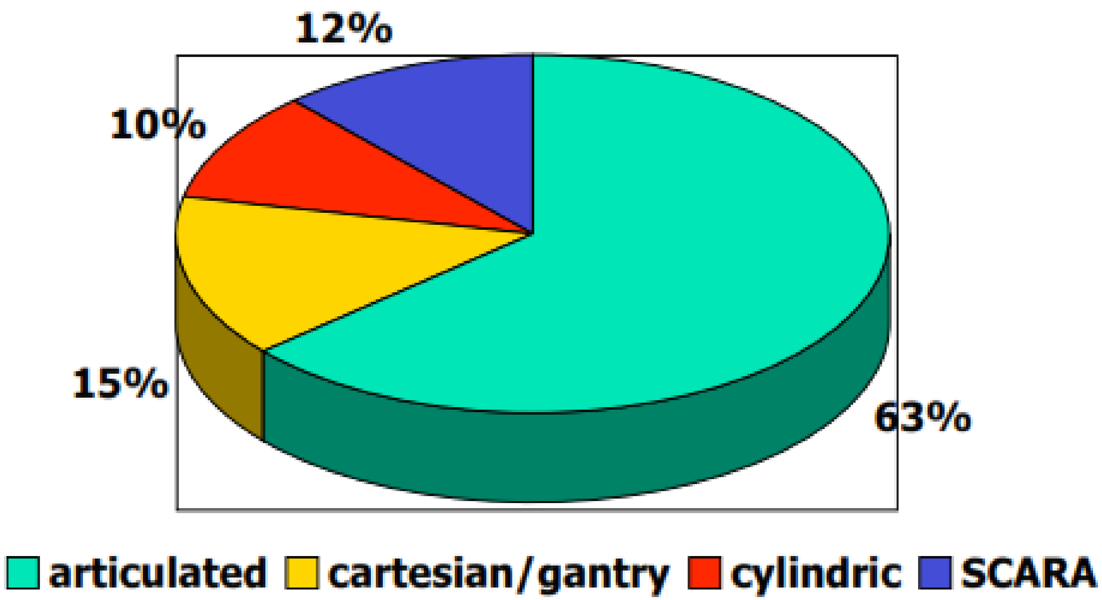
Bosch Turbo

SCARA (Selective Compliant Arm for Robotic Assembly)

- 4 degrees of freedom (= joints): 3 revolute + 1 prismatic (vertical) axes
- compliant in horizontal plane for micro-assembly and pick-and-place

Distribution by robot type

of kinematic configuration



What's next in industrial robotics?

changing nature of manufacturing and work

- shift from high volume/low mix to low volume/high mix is having a profound impact on manufacturing
- many industries are facing acute shortages of skilled labor
- quicker return-of-investment (ROI) of automation and rising wages are eventually discouraging labour arbitrage
- increased focus is being placed on workplace safety

What's next in industrial robotics?

addressing some real facts opens huge opportunities

	The Trends	The Challenges	The Enablers
	Low volume high mix	Automation complexity and unpredictability	Collaborative automation for greater flexibility
	Shorter cycles, faster launches	Shop floor disruptions and high engineering costs	Better software for engineering efficiency
	Increased need for automation and scalability in SMEs	Lack of robot integration and programming expertise	Easier to use robots with more intuitive programming
	Rising cost of downtime	Higher lifetime TCO due to increase in planned downtime	Advanced analytics and services for greater reliability
	Increased and sporadic human intervention	Lost productivity to maintain safety	Collaborative automation to maintain safety and productivity

answers to these challenges lie in
Simplification, Digitalisation, and Collaboration

What’s next in industrial robotics?

Simplification (critical for SME, but also for large global manufacturers)

- robots easier to install, program (with open source) and operate will unlock entry barriers to the large market of small and medium enterprises (SMEs)
- trend towards having production closer to the end consumer is driving the importance of standardisation & consistency across global brands

Digitalisation (Big Data allows taking better decisions on factory operations)

- “Industry 4.0”, linking the real-life factory with a virtual/digital one, will play an increasingly important role in global manufacturing
- vision and sensing devices, coupled with analytics platforms, will pave the way for new industry business models
- IoT/AI/Machine Learning will drive many robotics developments in coming years

Collaboration

- collaborative robots are shifting the traditional limits of “what can be automated?”
- collaborative robots increase manufacturing flexibility as ‘low-volume, high-mix’ becomes the main standard
- collaboration is also about productivity with increased physical and cognitive human/robot interaction

What's next in industrial robotics?

"connected" future of robotics

self-optimizing production

- robots doing the same task connect across all global locations so performance can be easily compared and improved

self-programming robots

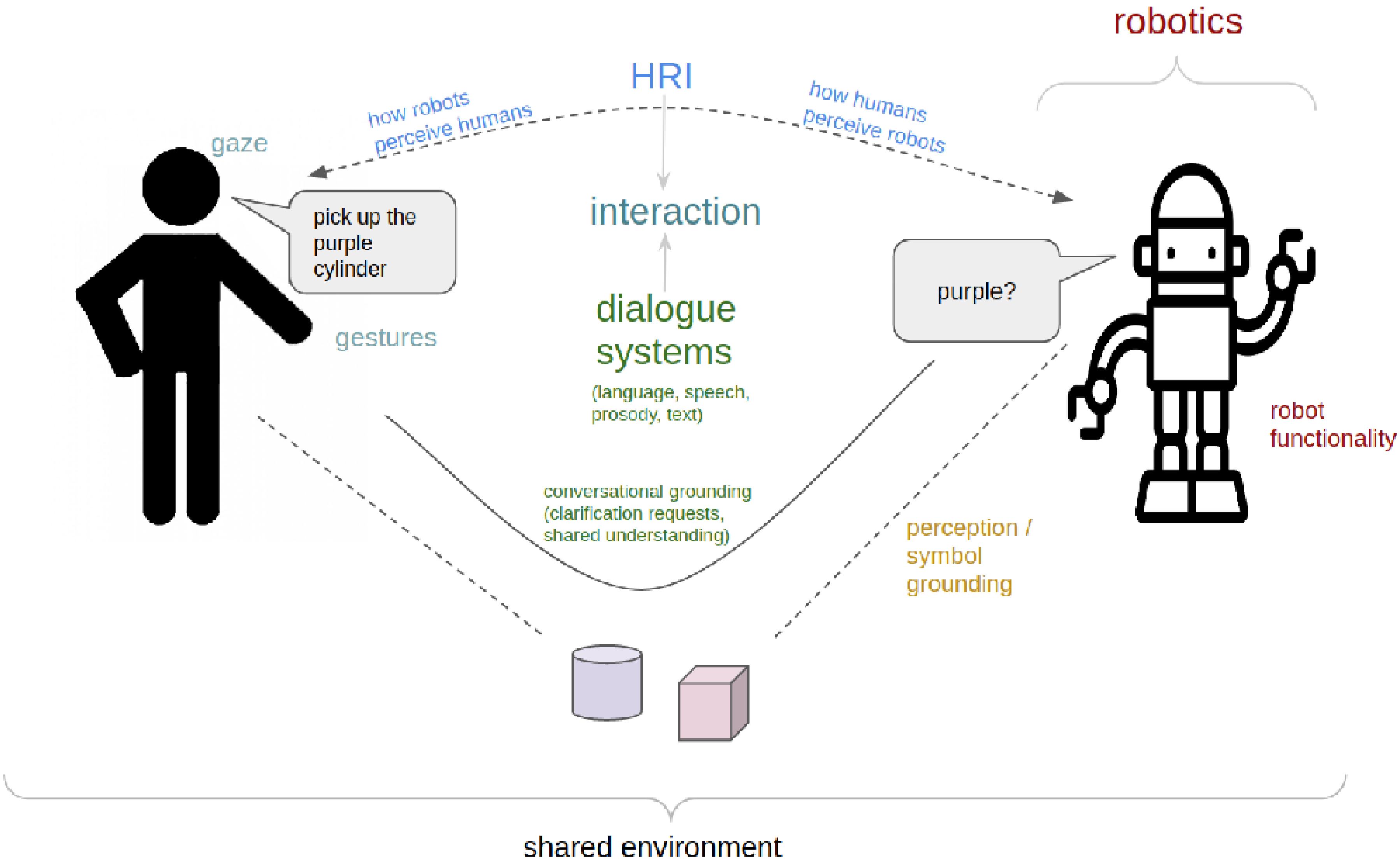
- robots automatically download what they need to get started from a cloud library and then optimize through "self-learning"

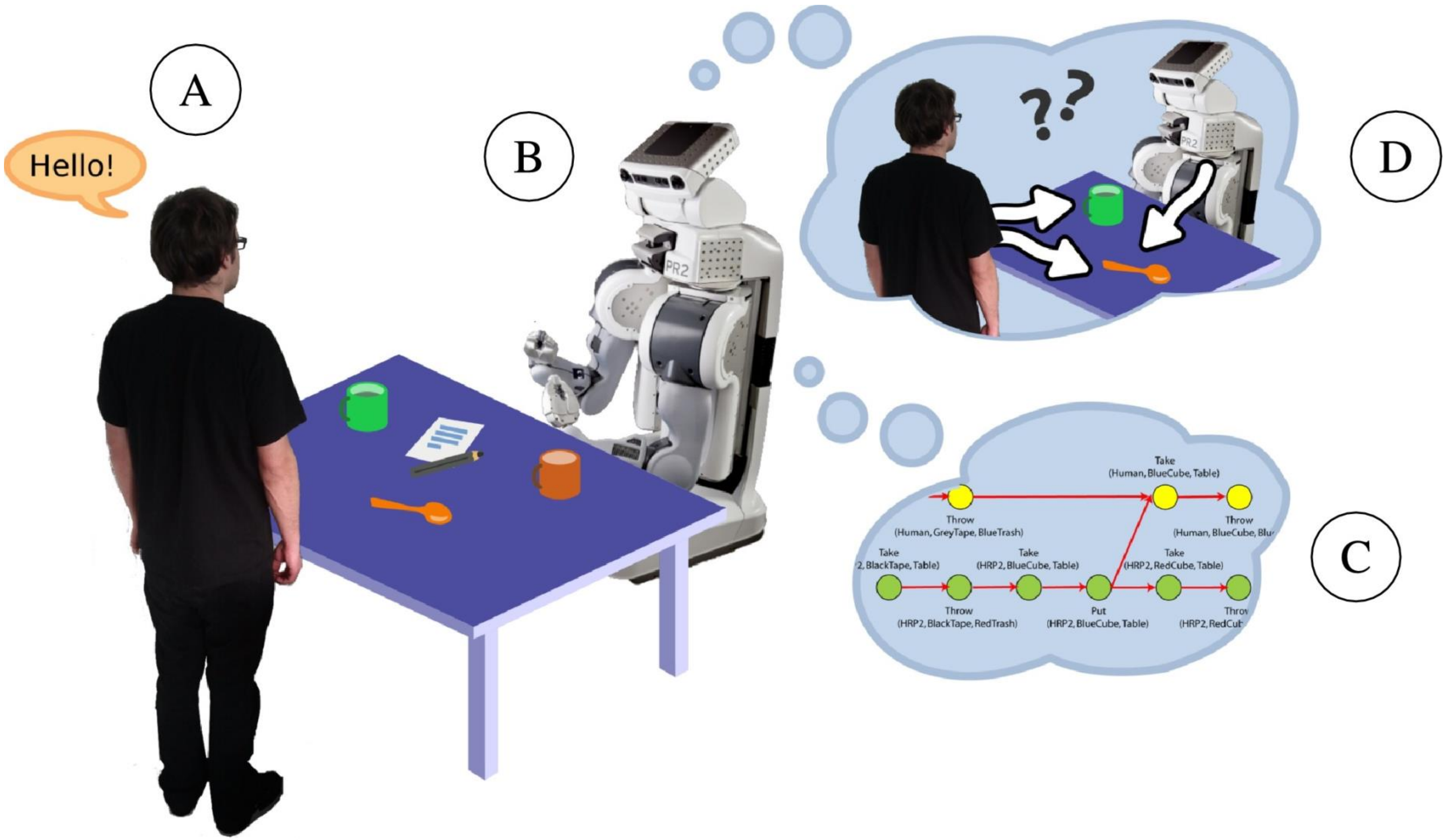
connected and collaborative robots will enable SMART Manufacturing for both SMEs & Global Enterprises

Human–robot interaction (HRI)

- Human–robot interaction (HRI) is the study of interactions between humans and robots. Human–robot interaction is a multidisciplinary field with contributions from human–computer interaction, artificial intelligence, robotics, natural language processing, design, and psychology.

- Human Robot Interaction deals with the study of new theories, models and advanced systems of human-machine interaction, and in particular robotic systems capable of cooperating with humans in a safe and intuitive way (physical human-robot interaction and collaborative robots) and multimodal interfaces (haptic interfaces), with applications in the medical and industrial fields.


robotics
HRI
how robots perceive humans
how humans perceive robots
gaze
pick up the purple cylinder
interaction
purple?
gestures
dialogue systems
(language, speech, prosody, text)
robot functionality
conversational grounding (clarification requests, shared understanding)
perception / symbol grounding
shared environment


A
Hello!
B
PR2
D
C
Take
(Human, BlueCube, Table)
Throw
(Human, GreyTape, BlueTrash)
Throw
Take
Take
(HRP2, BlueCube, Table)
Take
(HRP2, RedCube, Table)
Throw
(HRP2, BlackTape, RedTrash)
Put
(HRP2, BlueCube, Table)

- Simply put, human-robot interaction in the field of robotics deals with the interaction between humans and robots. There are several aspects to human-robot interaction, including the interactions between humans and computers, artificial intelligence, natural language processing, design, robotics, and psychology.

- Interestingly, HRI is a field of study that is much older than the field of robotics itself. HRI is known to have close associations with thinking and human communication. Humans have been studying HRI ever since the advent of robots. The fundamentals of human-robot interaction are reflected in Isaac Asimov's "Three Laws of Robotics," stating that a robot cannot injure a human or allow one to come in harm's way, must obey all orders except ones that indicate that it must do so, and must protect itself as long as the previous two laws are not broken by doing so.

- Robots were originally to be used in the industrial context and continue to be used in various industries. However, over the past years, the use of robots has also increased in search and rescue, bomb detection, research, law enforcement, and hospital care. These fields require a much greater interaction with human beings. Humans and robots will have a shared workspace and a common motive in working in that workspace in several cases.

- With the development of human-like robots increasing and their applications coming close to actual human tasks, this interaction will only increase in the future. There is a need for mutually beneficial interaction between robots and humans and communication that is appropriate and socially correct. These are themes that the field of HRI explores.

- HRI spans many different research topics. A major topic is how robots must perceive humans and communicate with them. Another topic explores the coordination between humans and robots carrying out complementary tasks. HRI does not just apply to humanoid robots but also other robots with physical or other interactions with humans.