21AIE201-INTRODUCTION TO ROBOTICS

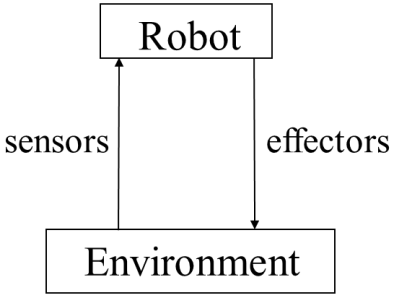
Lecture 3

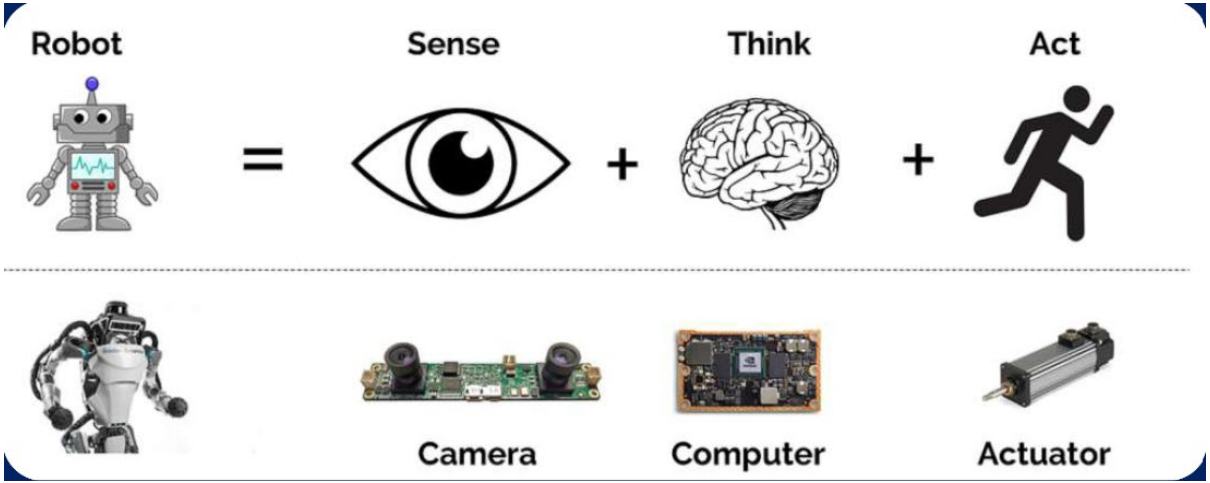
"Robotics is an interdisciplinary branch of engineering which deals with the conception, design, simulation, and manufacturing of a robotic system."

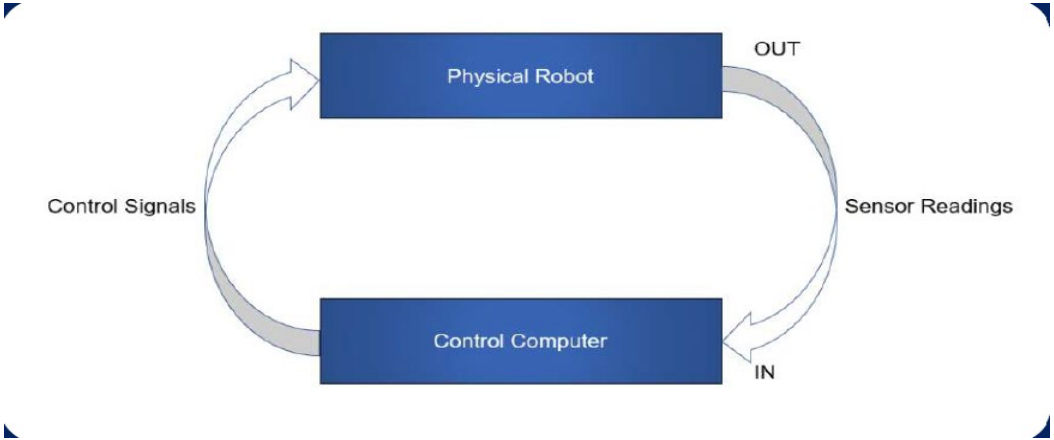
Definition:

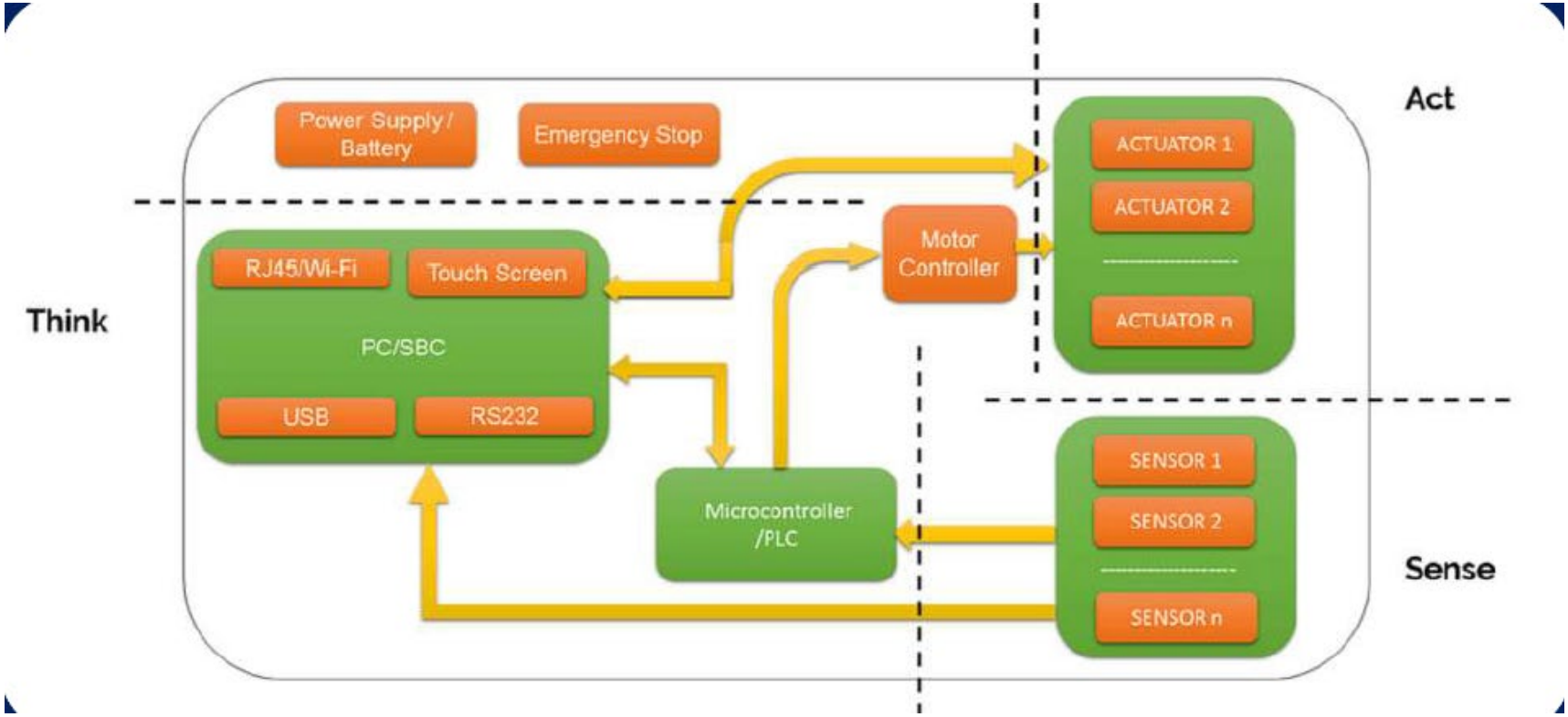
"A robot is an intelligent machine which has the capability to sense the environment around it, make decisions based on computations, and then perform some actions based on the decisions".

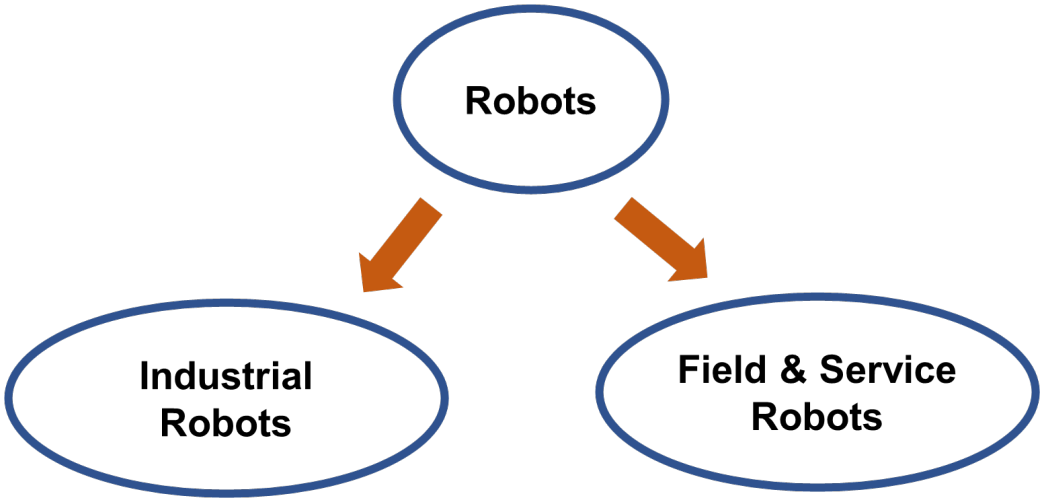
"A robot is an intelligent system that interacts with the physical environment through sensors and effectors".




Robot
Sense
Think
Act
=
+
+
Camera
Computer
Actuator


Physical Robot
OUT
Control Signals
Sensor Readings
Control Computer
IN


Act
Power Supply / Battery
Emergency Stop
ACTUATOR 1
ACTUATOR 2
ACTUATOR n
Motor Controller
Think
RJ45/Wi-Fi
Touch Screen
PC/SBC
USB
RS232
Microcontroller /PLC
SENSOR 1
SENSOR 2
SENSOR n
Sense



Robot Institute of America defines a robot as, “a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.

Field Robots

Non industrial robots:

Applications:

Medical Applications: ***Surgical Robots, Exoskeletons***

Defense and Surveillance: ***Mobile robots (Ground+ Aerial)***

Underwater Applications: ***Underwater Robots***

Space Applications: ***Space Robots***

Construction: ***Construction Robots***

Entertainment: ***Humanoids***

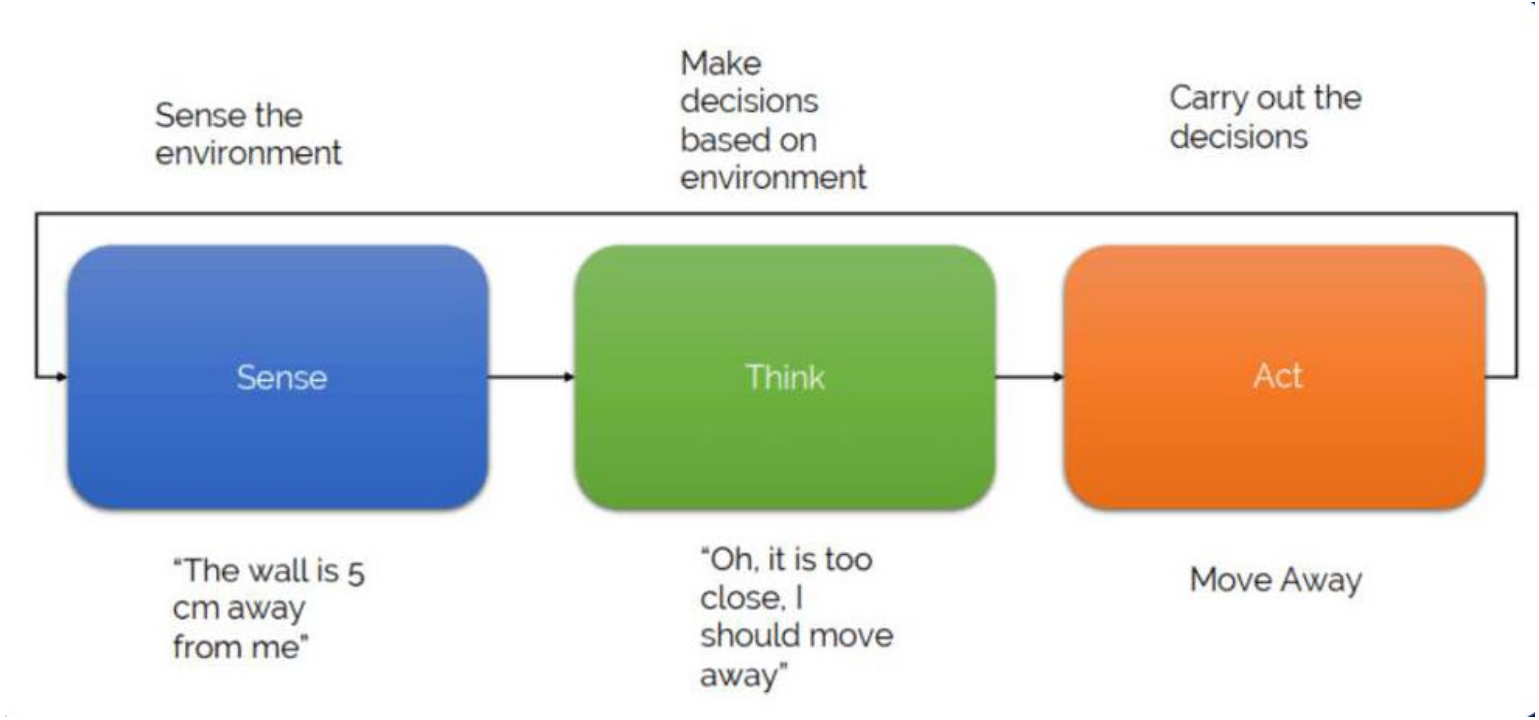
Domestic: **Domestic robots**

Utility: ***Intelligent Vehicles***

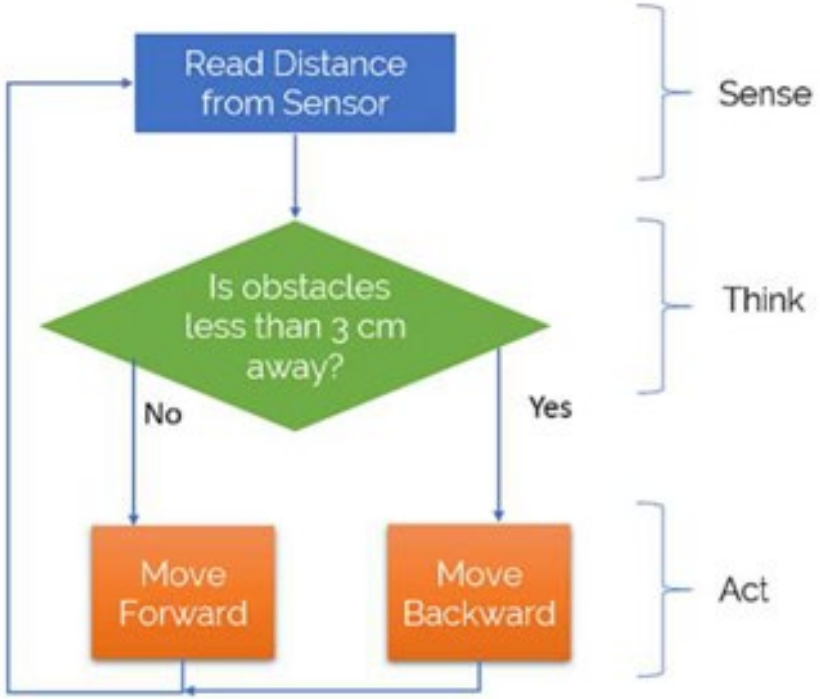
A Robot Must Have The Following Essential Characteristics

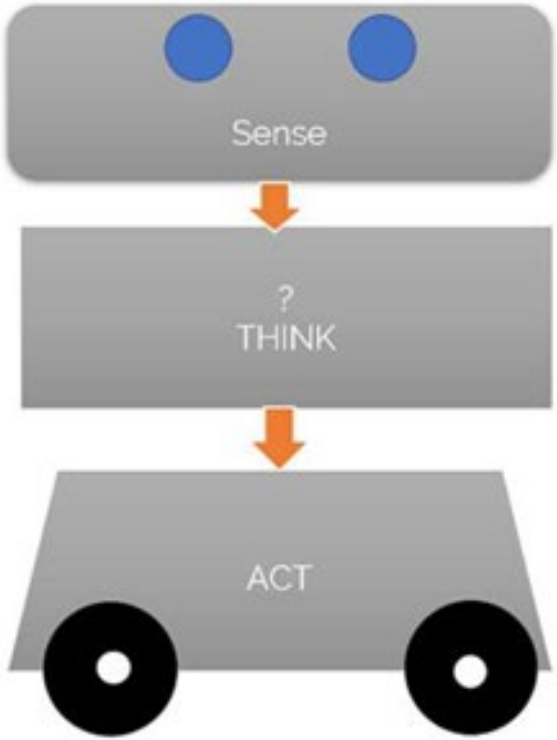
- **Mobility:** It possesses some form of mobility.
- **Programmability:** implying computational or symbol- manipulative capabilities that a designer can combine as desired (a robot is a computer). It can be programmed to accomplish a large variety of tasks. After being programmed, it operates automatically.
- **Sensors:** on or around the device that are able to sense the environment and give useful feedback to the device.
- **Mechanical capability:** enabling it to act on its environment rather than merely function as a data processing or computational device (a robot is a machine).
- **Flexibility:** it can operate using a range of programs and manipulates and transport materials in a variety of ways.

Block diagram of Obstacle avoidance robot



Block diagram of Obstacle avoidance robot

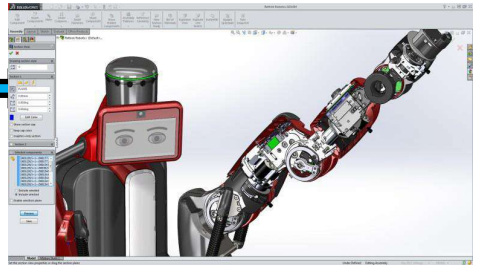




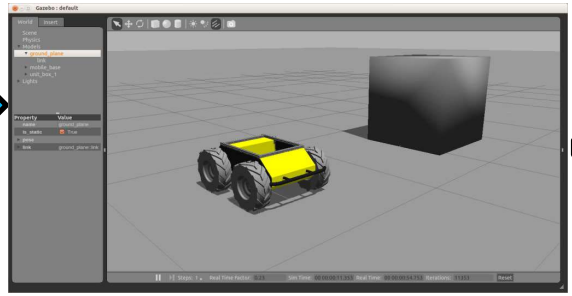
HOW TO BUILD YOUR OWN ROBOT?

Robot designing

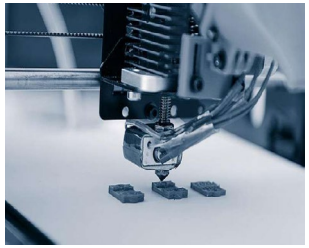
3D Modeling

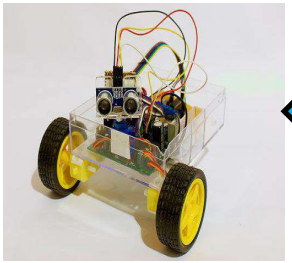


Simulation

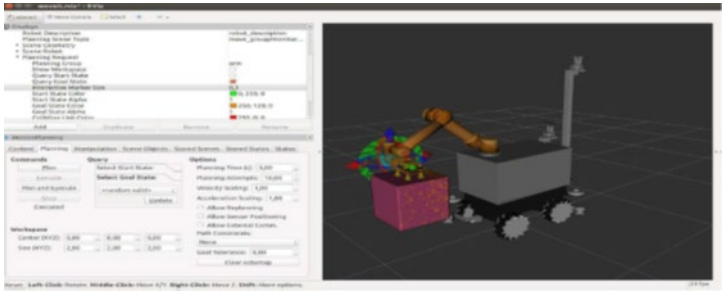


Prototyping





Robot Software



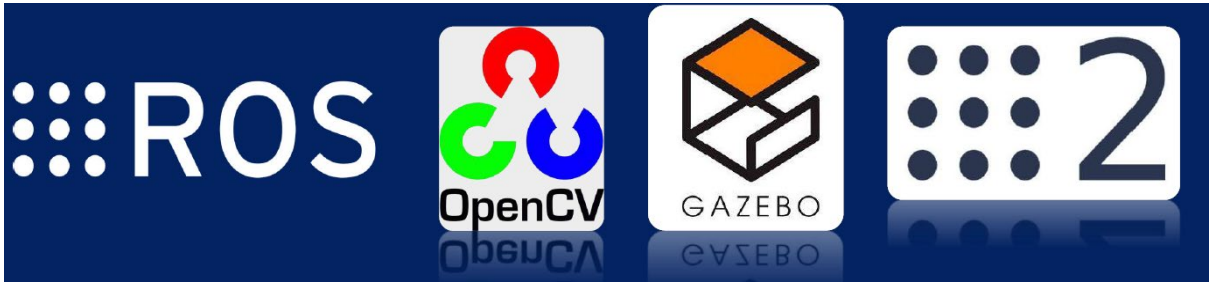
HOW TO PROGRAM A ROBOT?

Robot programming is programming the PC/SBC/microcontroller/PLC inside a robot for performing a specific application using actuators and feedback from various sensors.

SOFTWARE FRAMEWORKS FOR PROGRAMMING ROBOTS

Programming languages: C/C++, Python, Java, C#, SCADA, RAPID programming

Software frameworks: ROS, OpenCV, PCL, Gazebo, Open Rave, Webots, V-REP



botic Software frameworks

Operating System: Communication Middleware Website: http://www.ros.org/ Note: ROS is not a real Operating System but a meta operating system	ROS
Open-CV: Computer Vision library Website: https://opencv.org/	OpenCV

PCL: Point Cloud Library Website: http://pointclouds.org/	
Gazebo: Robot simulator Website: http://gazebosim.org/	
Open-Rave: Robot framework for motion planning Website: http://openrave.org	

Proprietary Robotic Software frameworks

CoppeliamSim: Robot simulator Website: http://www.coppeliarobotics.com/	CoppeliaSim from the creators of V-REP
Webots: Robot simulator Website: https://cyberbotics.com/	Webots robot simulation

Popular Robot Programming Language	
C++	
Python	
Java	
C#/.NET	
MATLAB	

ISAAC ASIMOV'S THREE LAWS OF ROBOTICS

WHO IS ASIMOV'S ?

Isaac Asimov was an American author and professor of biochemistry at Boston University, best known for his works of science fiction and for his popular science books.

- **First Law:** A robot may not injure a human being, or, through inaction, allow a human being to come to harm. (*Human safety*)
- **Second Law:** A robot must obey orders given it by human being1s, except where such orders would conflict with the First Law. (*Robots are slaves*)
- **Third Law:** A robot must protect its own existence as long as such protection does not conflict with the First or Second Law. (*Survival of robots*)
- **Zeroth Law:** A robot may not harm humanity, or, by inaction, allow humanity to come to harm (*Survival of humanity*)

ASSOCIATION OF ROBOTICS

There are many robotics association in world

- **JIRA** (Japan industrial robotics association)
- **WRO** (world robotic Olympiad)
- **RIA** (robotics institute of America)
- **IFR** (international federation of robotics)
- **CRIA** (China Robot Industry Alliance)
- **IEEE robot & automation society**

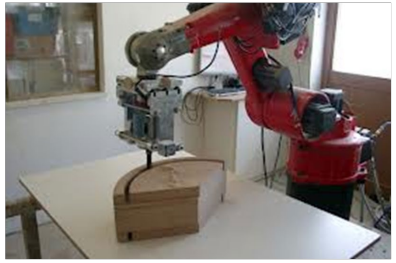
CLASSIFICATION OF ROBOTS -1 (JIRA) and (RIA)

Class 1: Manual Handling Device

- This type of robot has multiple degrees of freedom, but all of its actions are performed under the direct control of an operator.

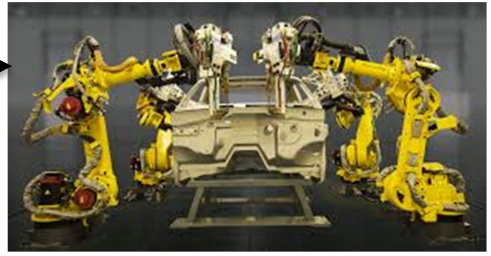
Class2: Fixed-Sequence Robot

- This type of robot repeats a fixed sequence of actions without needing to be controlled by an operator



*Class3: Variable Sequence Robot: same as in class 2, but easy to modify

- This type of robot is similar to class 2, except that the sequence of actions can be reprogrammed easily allowing it to be quickly adapted to perform new tasks



*Note: * -Classification of robots according to **RIA***
JIRA : *Japanese Industrial Robot Association*
RIA *: The Robotics Institute of America*

CLASSIFICATION OF ROBOTS -1 (JIRA) and (RIA)

*Class4: **Playback Robot:** a human operator performs the task manually by leading the robot, which records the motions for later playback. The robot repeats the same motions according to the recorded information

*Class5: **Numerical Control Robot:** The operator supplies the robot with a movement program rather than teaching it the task manually

*Class6: **Intelligent Robot:** A robot with the means to understand its environment, and the ability to successfully complete a task despite changes in the surrounding conditions under which it is to be performed

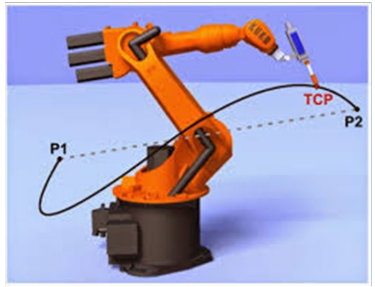
*Note: * -Classification of robots according to **RIA***

JIRA : *Japanese Industrial Robot Association*

RIA *: The Robotics Institute of America*

Playback Robot

- This type of robot is first guided through a sequence of actions by an operator, then repeats the same actions automatically.

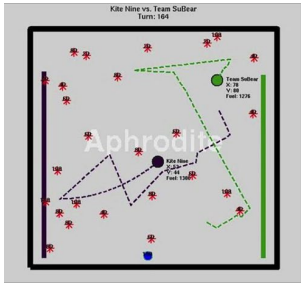


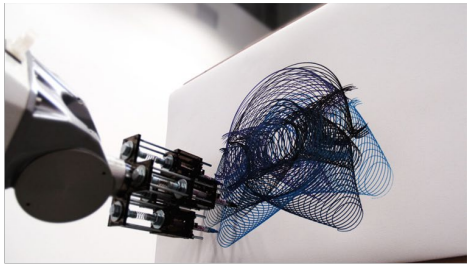
Intelligent Robot

- A robot that senses its environment and responds to changes in it in order to continue performing its function.

Numerical Control Robot

- This type of robot moves through a sequence of actions, which it receives in the form of numerical data.





CLASSIFICATION OF ROBOTS -2 (AFR)

Type A: Handling Devices with manual control

Type B: Automatic Handling Devices with predetermined cycles

Type C: Programmable, servo-controlled robots

Type D: Type C with interactive with the environment

AFR: *The Association Française de Robotique*

OTHER WAYS OF CLASSIFYING A ROBOT

- Fixed or mobile.
- Serial or parallel.
- According to degree of freedom (DOF).
- Rigid or flexible.
- Control — Point-to-point, autonomy and “intelligence”.

SERIAL VS. PARALLEL

Serial robot: A fixed base, links and joints connected sequentially and ending in a end-effector

Parallel robot: More than one loop, no natural end-effector

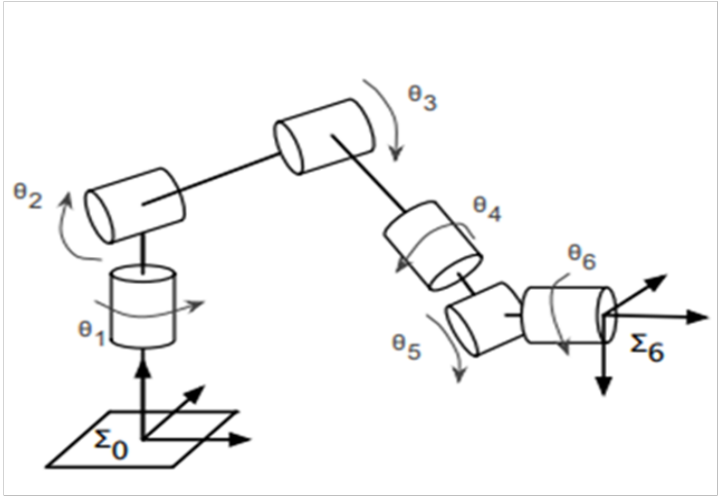


Figure: Serial robot

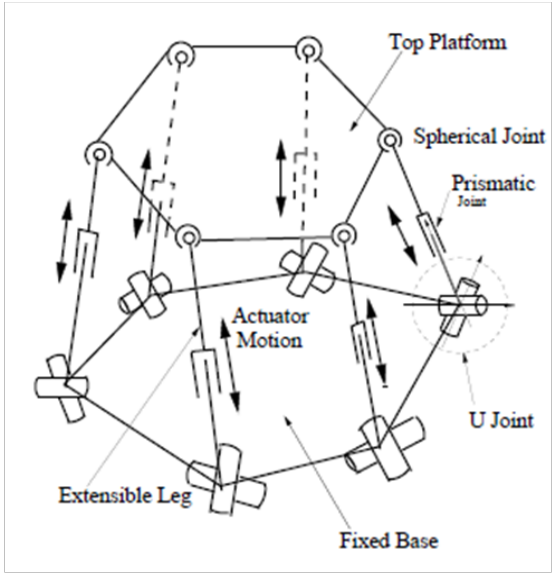


Figure : Parallel Robot

RIGID VS. FLEXIBLE

- Rigid robot: Most industrial robots are built heavy and rigid for required accuracy.
- Flexible robot:Minimising weight for space applications Links and joints are made flexible.

Figure : A rigid robot

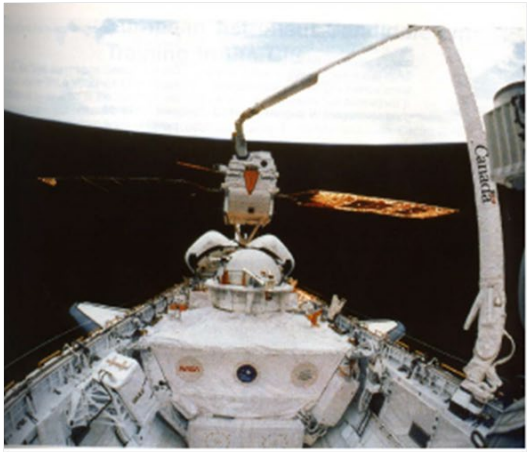


Figure : A flexible robot arm

MOBILE VS. STATIONARY

- There are two main types of robot -
- **Mobile** - that move around on legs, wheels or tracks
- **Stationary** - that have a fixed base

- Mobile robots can be used to move parts around a factory, to move people around museums and to act as security guards in buildings.

- Stationary robots - usually robot arms - can be used for picking up objects or doing some other job which involves reaching over to an object.

Robot Components

Main Robot components

- **Sensors:** Camera, Wheel encoders, Ultrasonic sensors, etc.
- **Actuators:** Servo, Stepper, DC motors, etc.
- **Computer: PC:** Intel NUC, Nvidia TX2…… ;

  Microcontroller platform: Arduino board, Texas Launchpad, ARM controller-based board

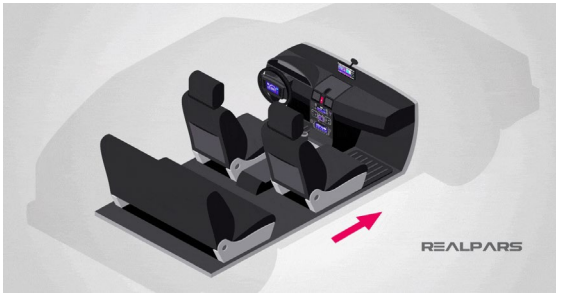
Actuators: An actuator is a device that makes something move or operate.

- "An actuator is a device that produces a motion by converting energy and signals going into the system".

RC Servo Motor

Stepper Motor

DC Gear Motor



Industrial Servo Motor

Dynamixel Smart Actuator

Sensors: A device that detects or measures a physical property and records, indicates, or otherwise responds to it.

Velodyne LiDAR

UTM – 30LX, Laser Scanner

Kinect, 3D Depth Sensor

Intel RealSense, 3D Depth Sensor

Computing units for Robots

- X86, X86_64 Based PC
  - Intel NUC
  - Industrial PC
- Single board Computer
  - Nvidia TK1, TX1,TX2
  - Raspberry Pi
  - Odroid

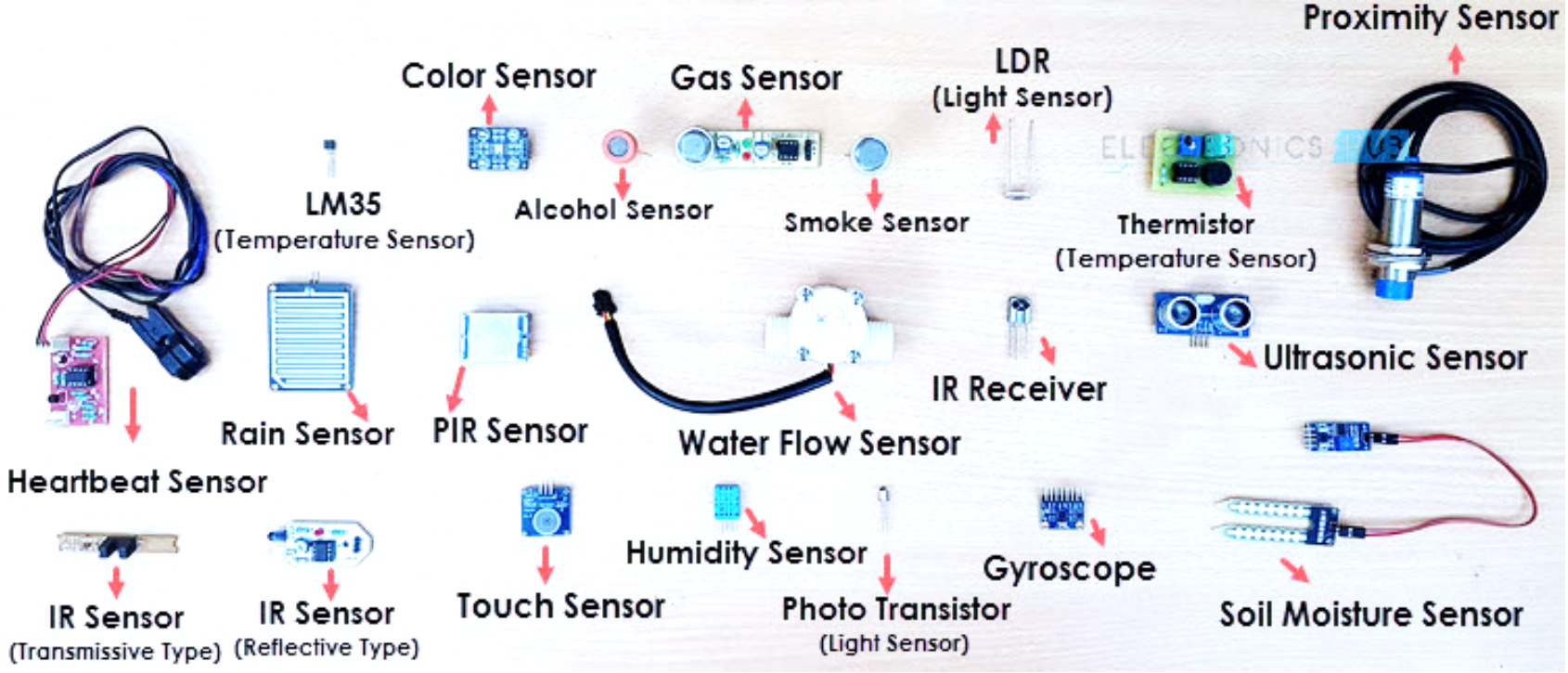
Intel NUC

Raspberry Pi

Nvidia TX2

Industrial PC

Odroid


Proximity Sensor
Color Sensor
Gas Sensor
LDR
(Light Sensor)
LM35
(Temperature Sensor)
Alcohol Sensor
Smoke Sensor
Thermistor
(Temperature Sensor)
Ultrasonic Sensor
IR Receiver
Rain Sensor
PIR Sensor
Water Flow Sensor
Heartbeat Sensor
Humidity Sensor
Gyroscope
Touch Sensor
Photo Transistor
(Light Sensor)
Soil Moisture Sensor
IR Sensor
(Transmissive Type)
IR Sensor
(Reflective Type)

Time for Discussions

Thank You!