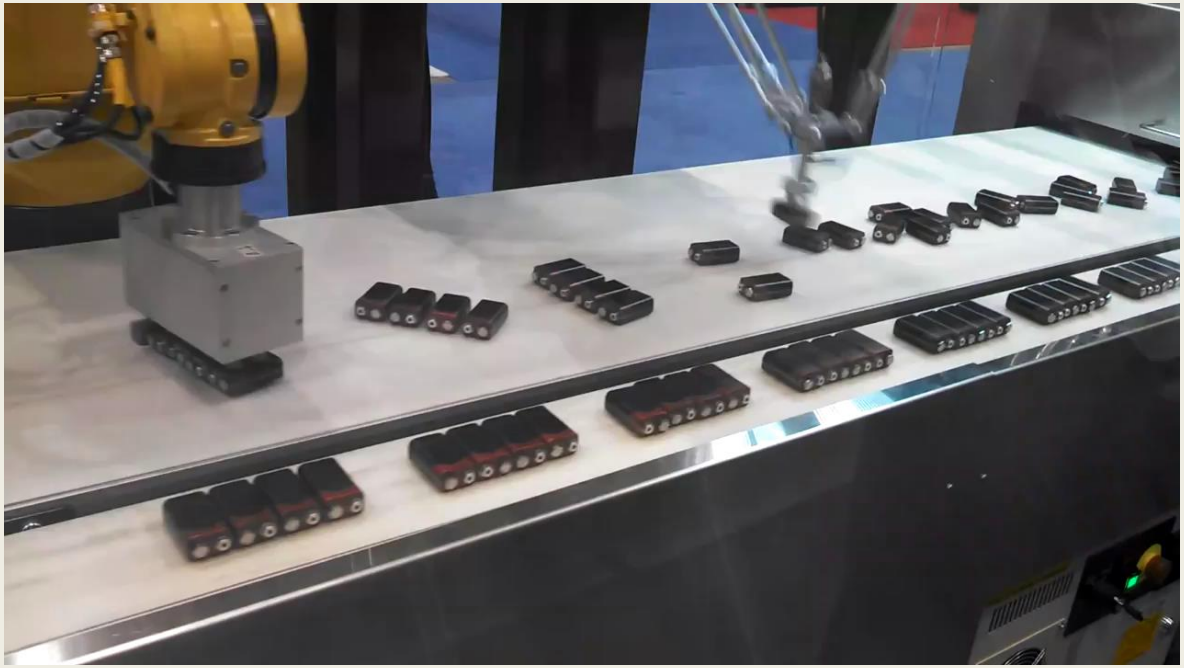
# ENGINEERING SYSTEMS: ROBOTICS

Dr. Abhishek Sarkar
RRC, IIIT-H

- Robot manipulator
  - *Pick and Place*
  - *Assembly*
  - *Welding etc.*

# Pick and Place



https://www.youtube.com/watch?v=hLgDn6m3bZc

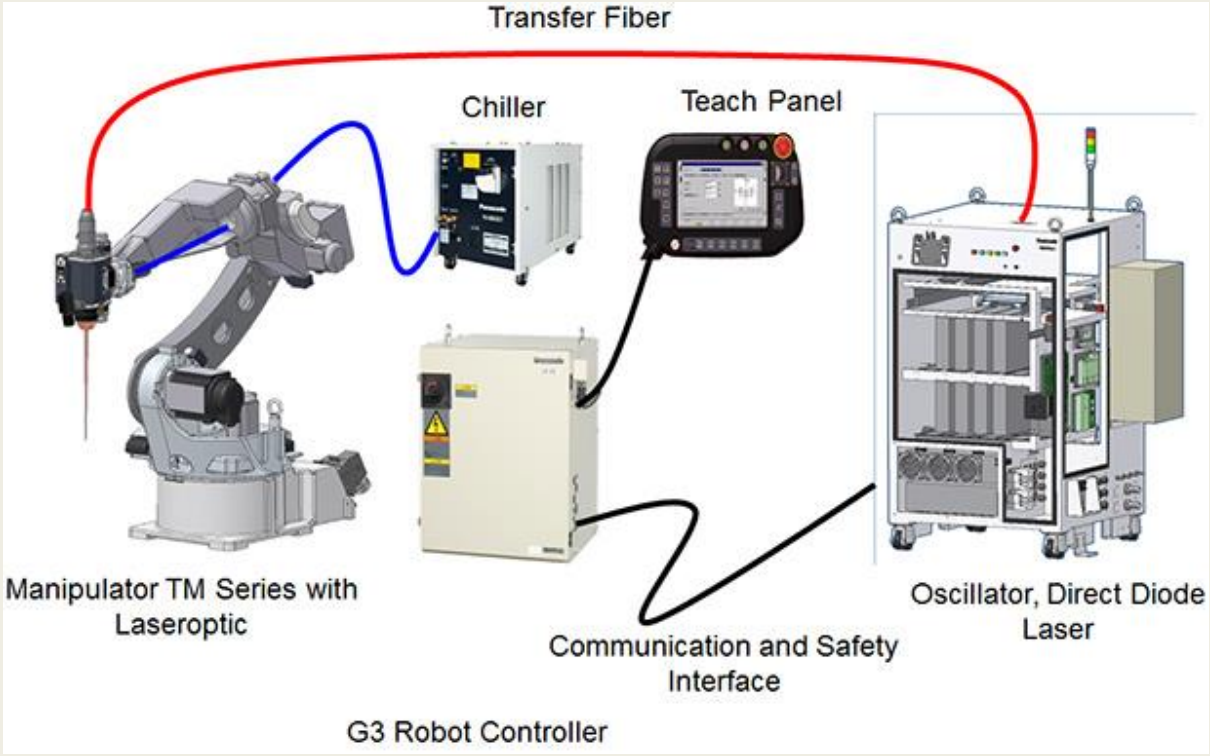
# Assembly Robot


https://www.youtube.com/watch?v=heOXsEnGb20

# CPU Assembly

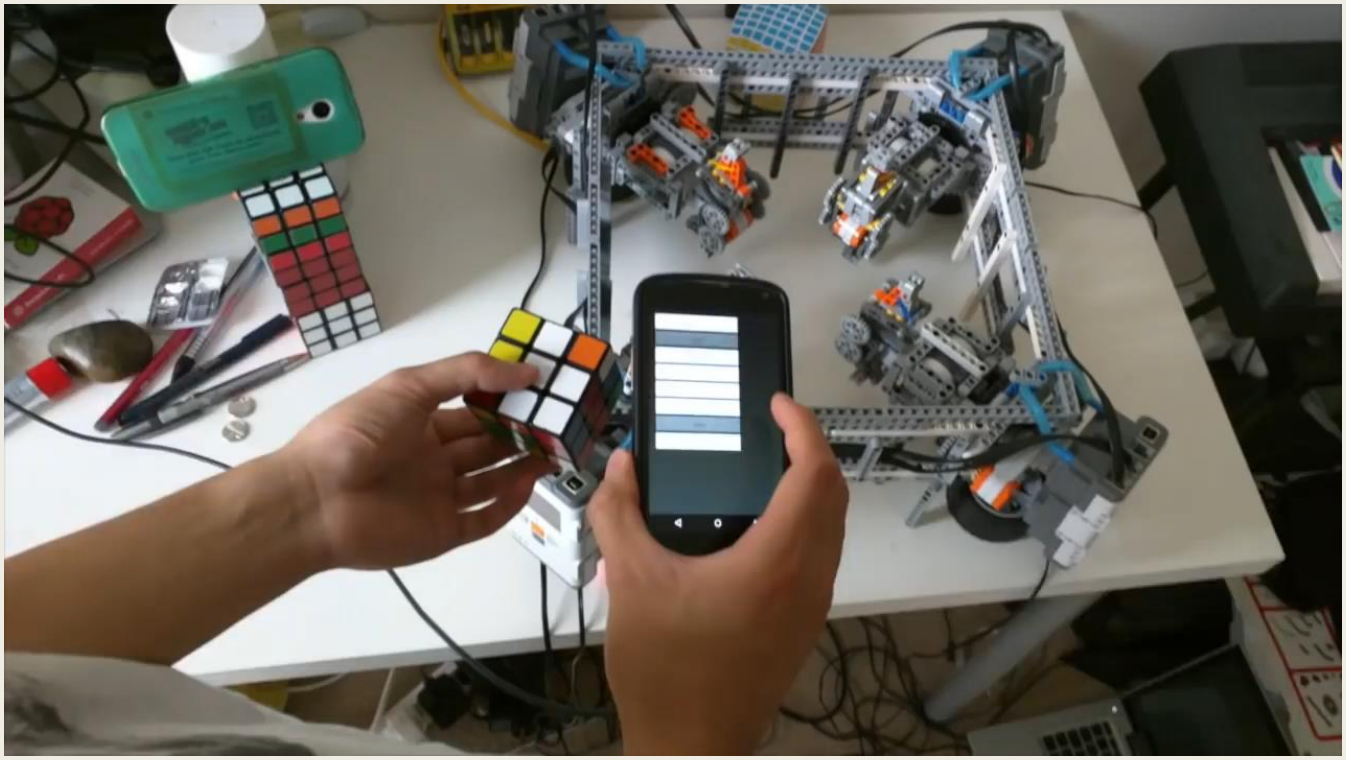
https://www.youtube.com/watch?v=ym64NFCWORY

# Panasonic-LAPRISS Laser-Welding-System



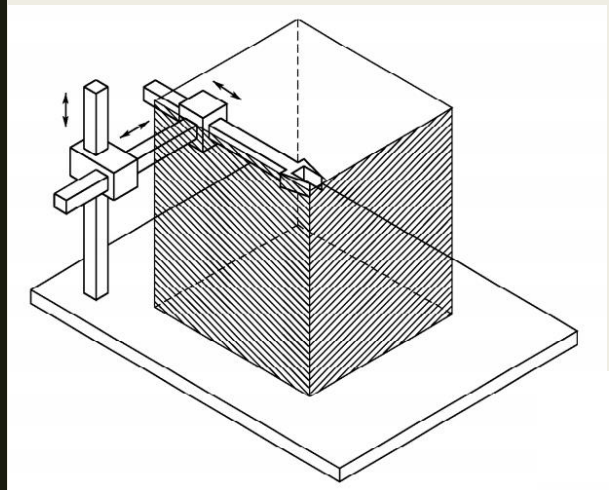
# Flex MedRobotics

# Rubik’s Cube Solving Robot

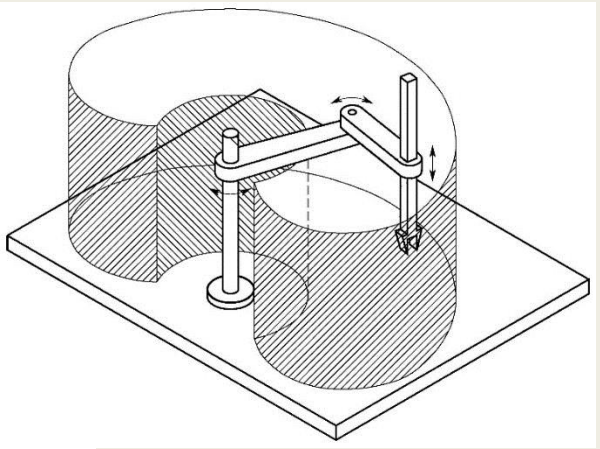


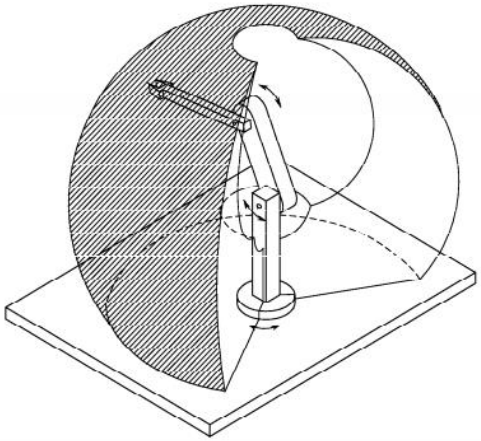
https://www.youtube.com/watch?v=Q8BYKwbwZSM

Cartesian



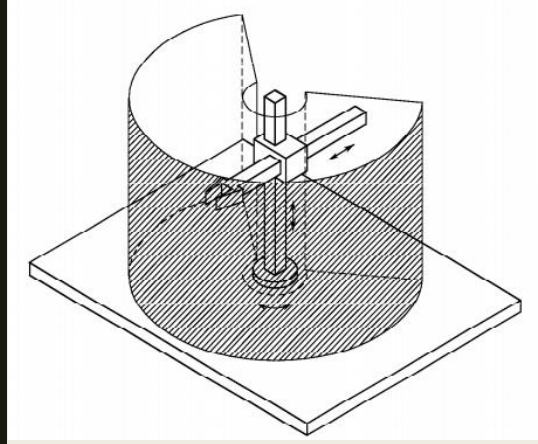
SCARA



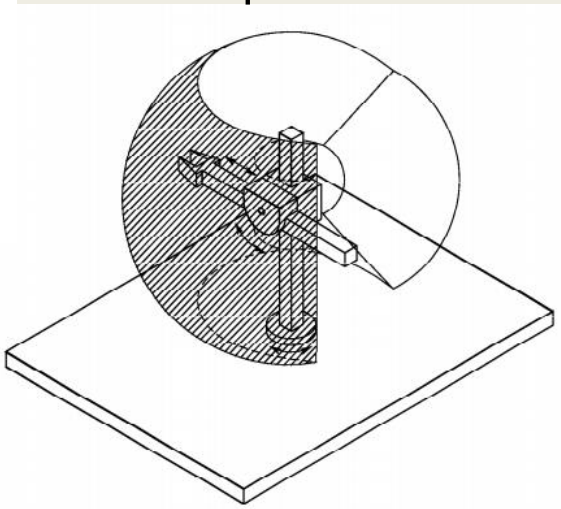


Anthropomorphic

Cylindrical

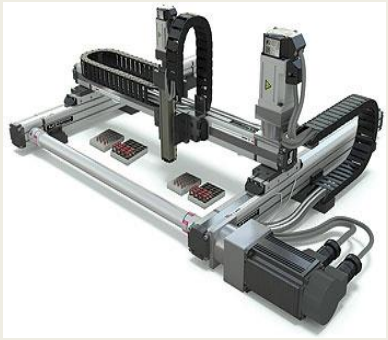


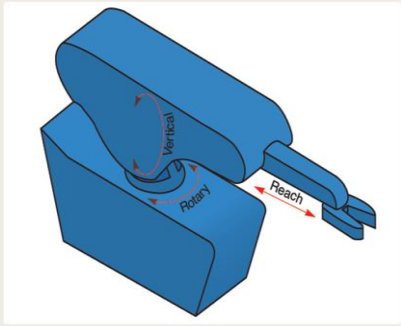
Spherical

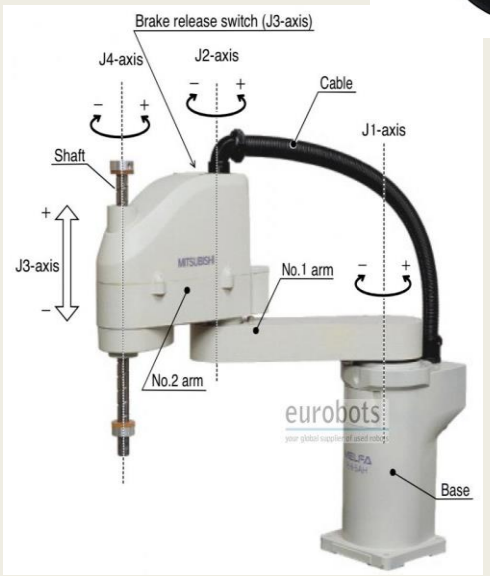


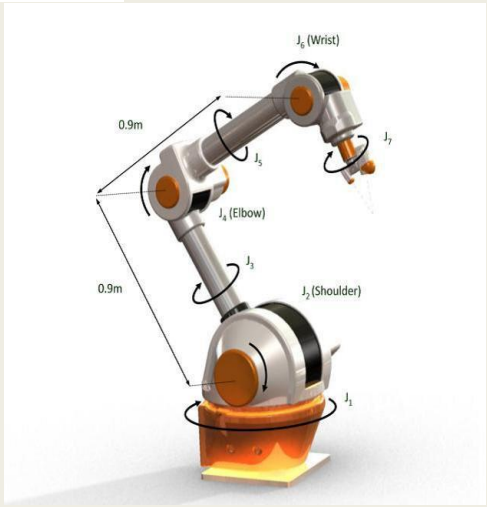
# Common Kinematic Arrangements

- Cartesian (PPP)
- Cylindrical (RPP)
- Spherical (RRP)
- Selective Compliance Articulated Robot Arm or SCARA (RRP)
- Articulated (RRR)





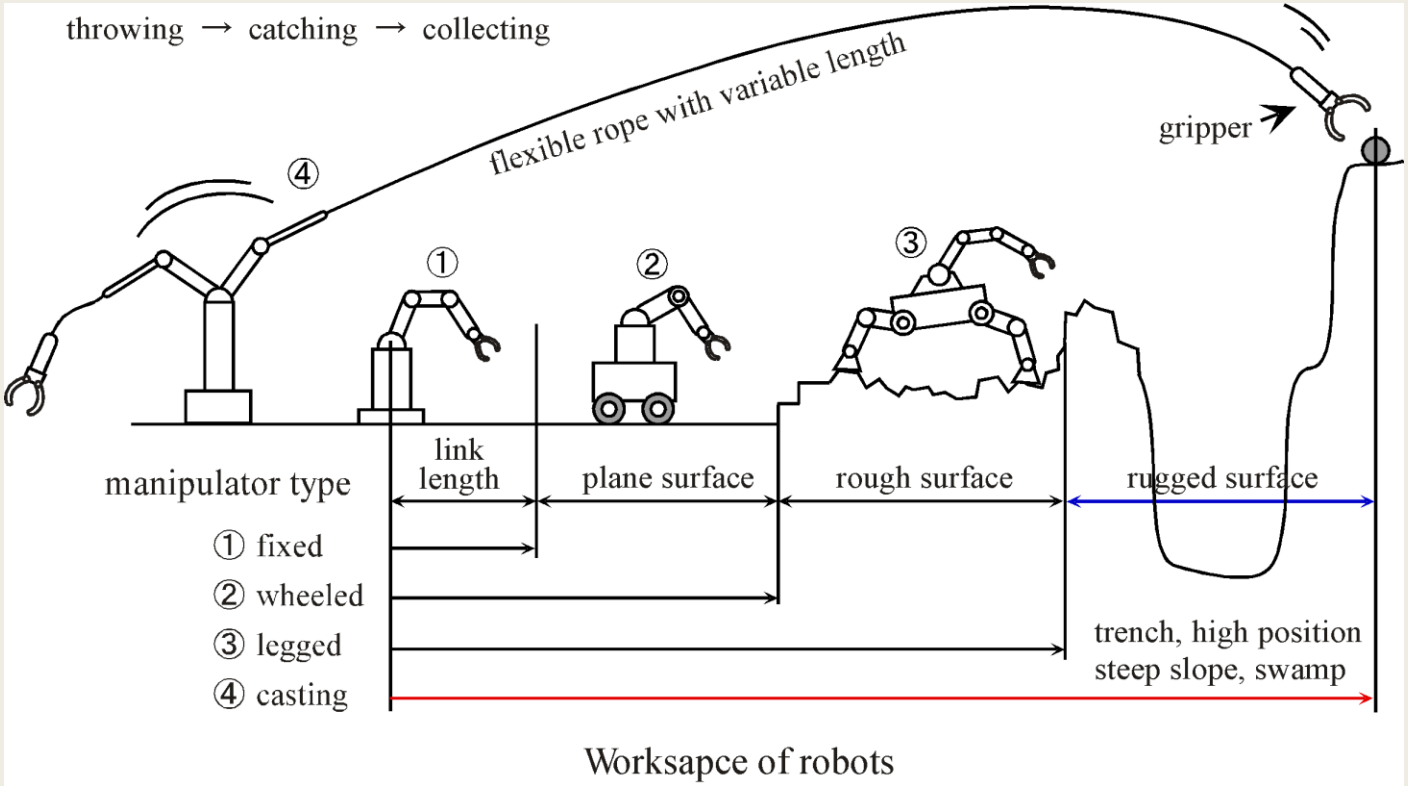



# Parallel Robot

https://www.youtube.com/watch?v=dnixuCu49o4

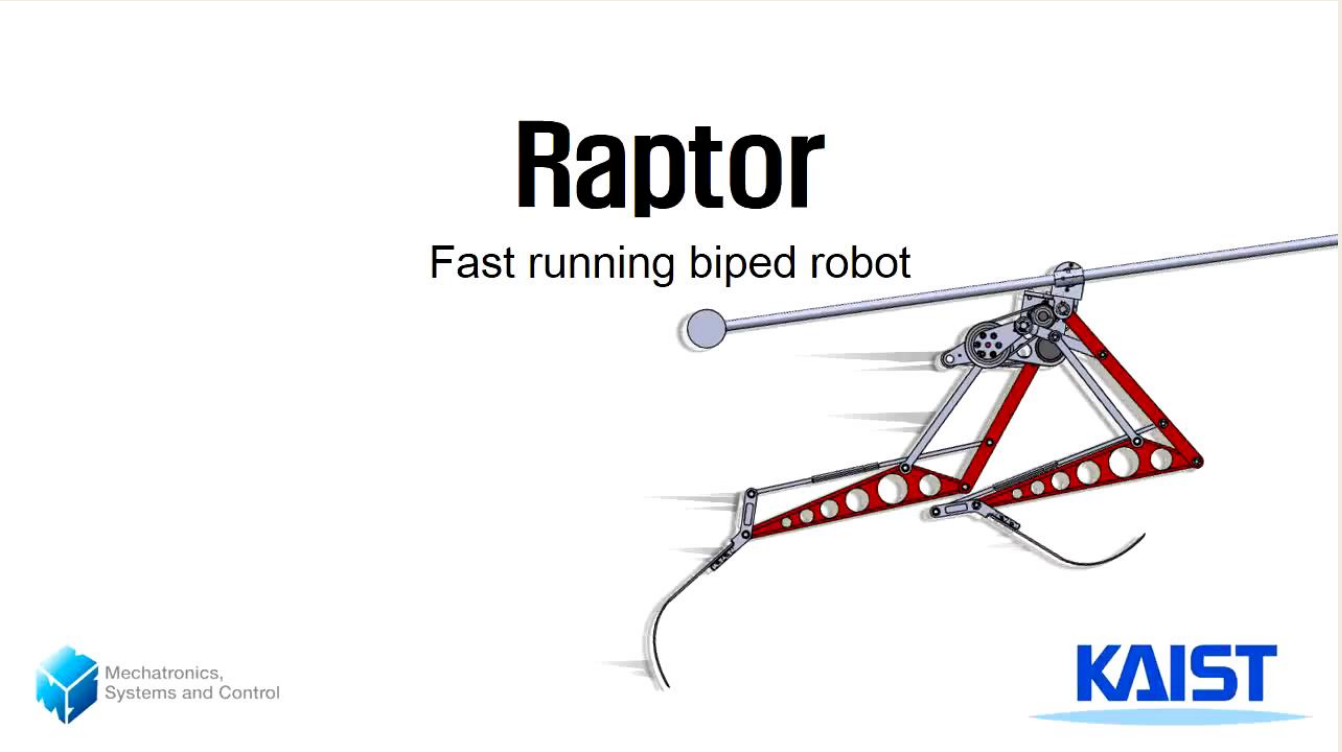
# Workspace


throwing → catching → collecting
flexible rope with variable length
gripper
④
①
②
③
manipulator type
link length
plane surface
rough surface
rugged surface
① fixed
② wheeled
③ legged
④ casting
trench, high position
steep slope, swamp
Worksapce of robots

# Examples of Mobile Robotic Systems

- Mobile Robots:
  - *Legged Robot*
  - *Wheeled Robot*
  - *Others*

# KAIST Raptor




https://www.youtube.com/watch?v=IPEg83vF_Tw

# Colour Tracking robot

https://www.youtube.com/watch?v=3BJFxnap0AI

# Soccer Bots

https://www.youtube.com/watch?v=aLy5pUsmpKE

# What are the Attributes of a Robot?

- A Robot
  - *Acting: Performs Work on the Environment*
  - *Sensing: Gathers Information about its Environment*
  - *Thinking: Processes that Information to Make Decisions*

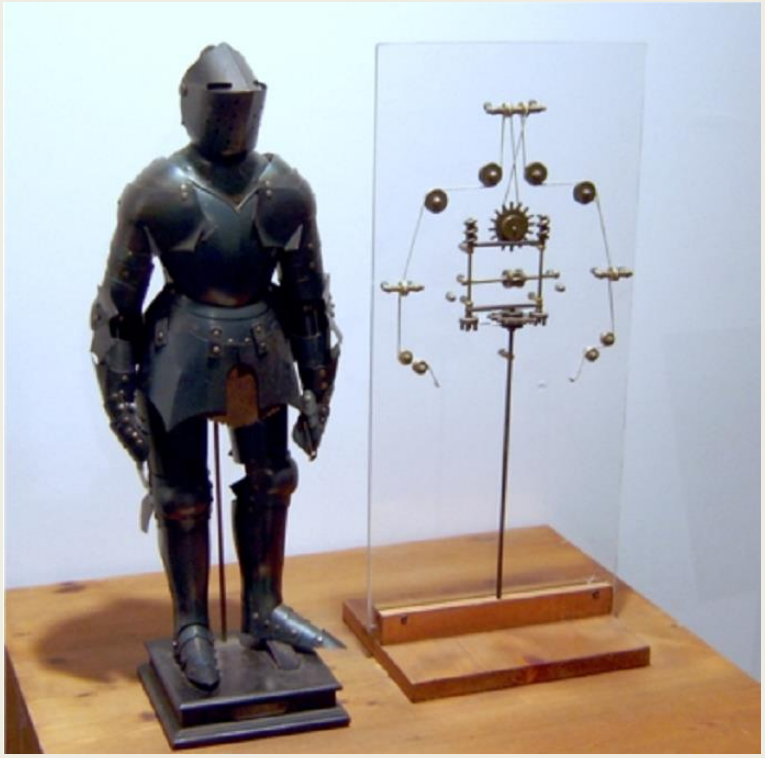
# What is Robotic Systems?

- A Robot is a Mechatronic System at the heart of which is Feedback Control.
- Feedback Control allows:
  - *Autonomy*
  - *Performance in Unstructured Environments*
  - *Learning*
- So, to be called a robot, an entity must be a machine, i.e.
  - *a physical entity capable of 'doing real work',*
  - *operate in a closed-loop fashion under computer control transforming sensing into action*

# Brief history of robotics

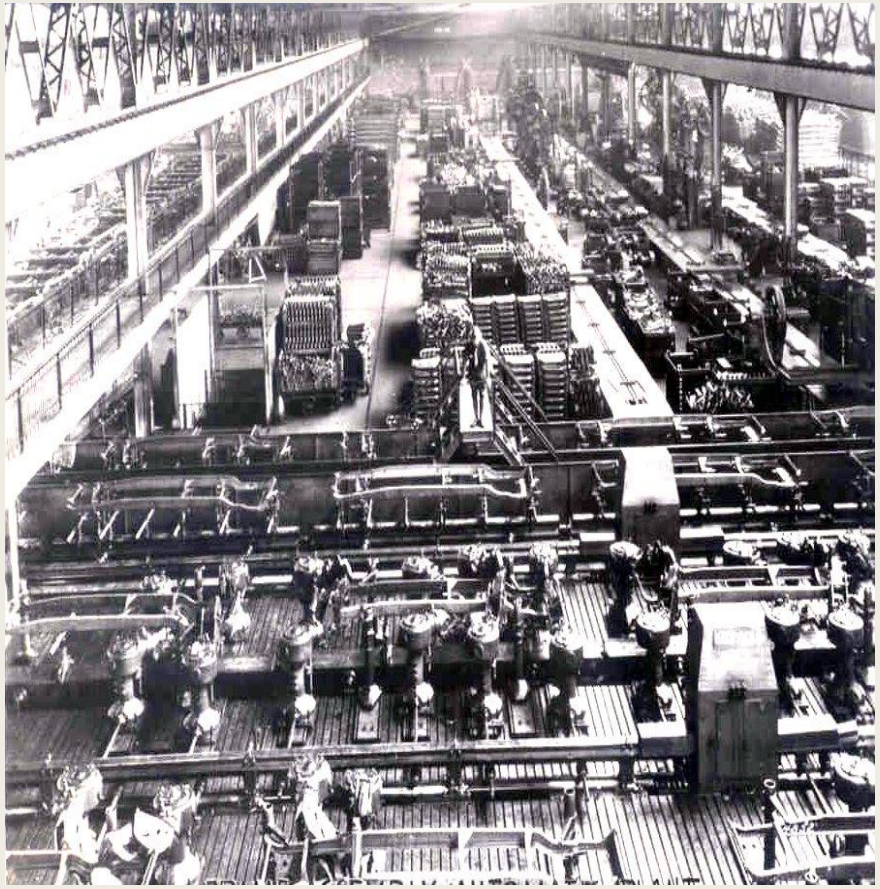
- Toys of medieval time

# The da Vinci humanoid robot (1495)



# Mechanical Marvel

- 1904 Henry Ford's mass production of vehicles in the USA.
- Idea of transfer lines in which a car was assembled at different stations.
- First use of hard automation – alignment devices, transfer devices etc.

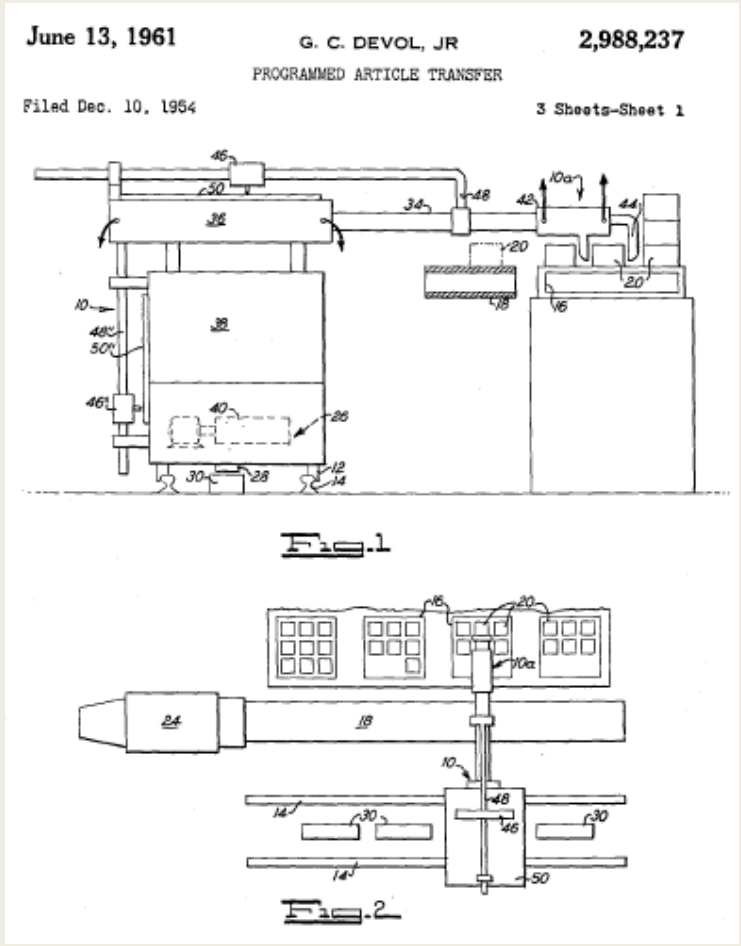


# Beginning of Robotics

- Origin of the word robot in 1923 — Translation of Czech play R. U. R. (Rossum's Universal Robot, 1921) by Karel Capek (Capek, 1975).
- From Czech word 'robota' meaning slave labour!
- Designed to replace human beings, and depicted as very efficient and lacking emotion – Even now this description is prevalent!
- Asimov (Asimov, 1970) in Roundabout coins robotics in his three laws of robotics — Robots are portrayed as harmless and in control of humans!

# Beginning of Robotics

- First industrial robot patent in 1954 by George C. Devol (US Patent No. 2,988,237) for Universal Automation or Unimation.


June 13, 1961 G. C. DEVOL, JR 2,988,237

PROGRAMMED ARTICLE TRANSFER

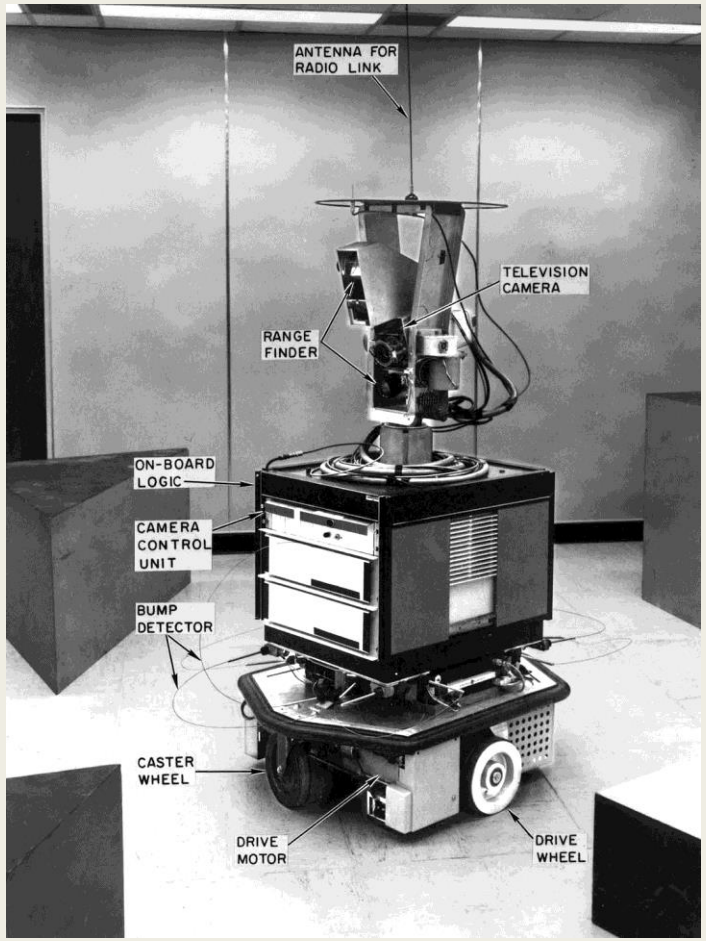
Filed Dec. 10, 1954 3 Sheets-Sheet 1

Fig. 1

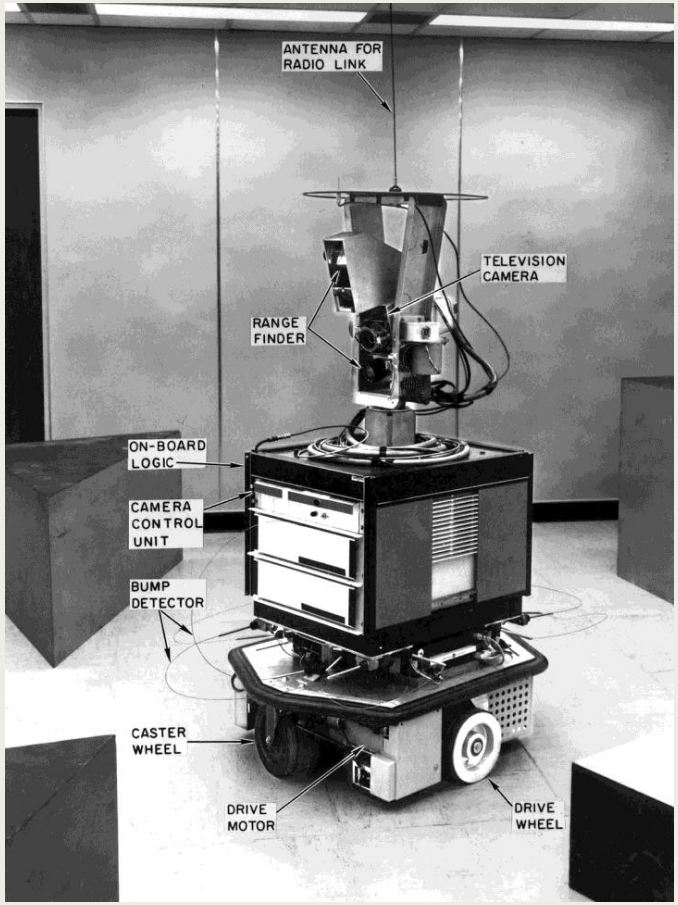
Fig. 2

# Shakey (1969)

- First autonomous robot: Stanford University
- It had
  - *Camera*
  - *Range finder*
  - *Bump detector*
  - *On board logic*



# Clumsy robots to sophisticated humanoids




# First generation of robots

- Simple pick and place devices with no external sensors.
- Simple internal sensors were used
  - *position : potentiometers, encoders*
  - *velocity : encoders, resolvers,*
  - *acceleration : encoders, tacho-generators,*
- DC servo motors
- Stepper motors

# Second generation of robots (1970 …1990)

- **Electronics:** smaller, faster and cheaper processors
- **External sensors** : interaction with the environment
  - *vision*
  - *advanced sensors : gyros, inclination, force, slip.*
  - *advanced controllers : microcontroller*
  - *speech recognition*
  - *AI*

# Third generation robots (1990 – 2000)

- New materials – smart materials, smart actuators.
- Interest in emulating biological design paradigms.
- New areas like:
  - *Micro, Nano-robotics, Vision, bio-robotics, etc.*

# Present Robotics

- **Bionics**: **Robots** that emulate or simulate living biological organisms mechanically or even chemically.
- **Cyborgs**: A fictional or hypothetical person whose physical abilities are extended beyond normal human limitations by mechanical elements built into the body.
- **Android** is a humanoid **robot** or synthetic organism designed to look and act like a human.

# Snake Robot

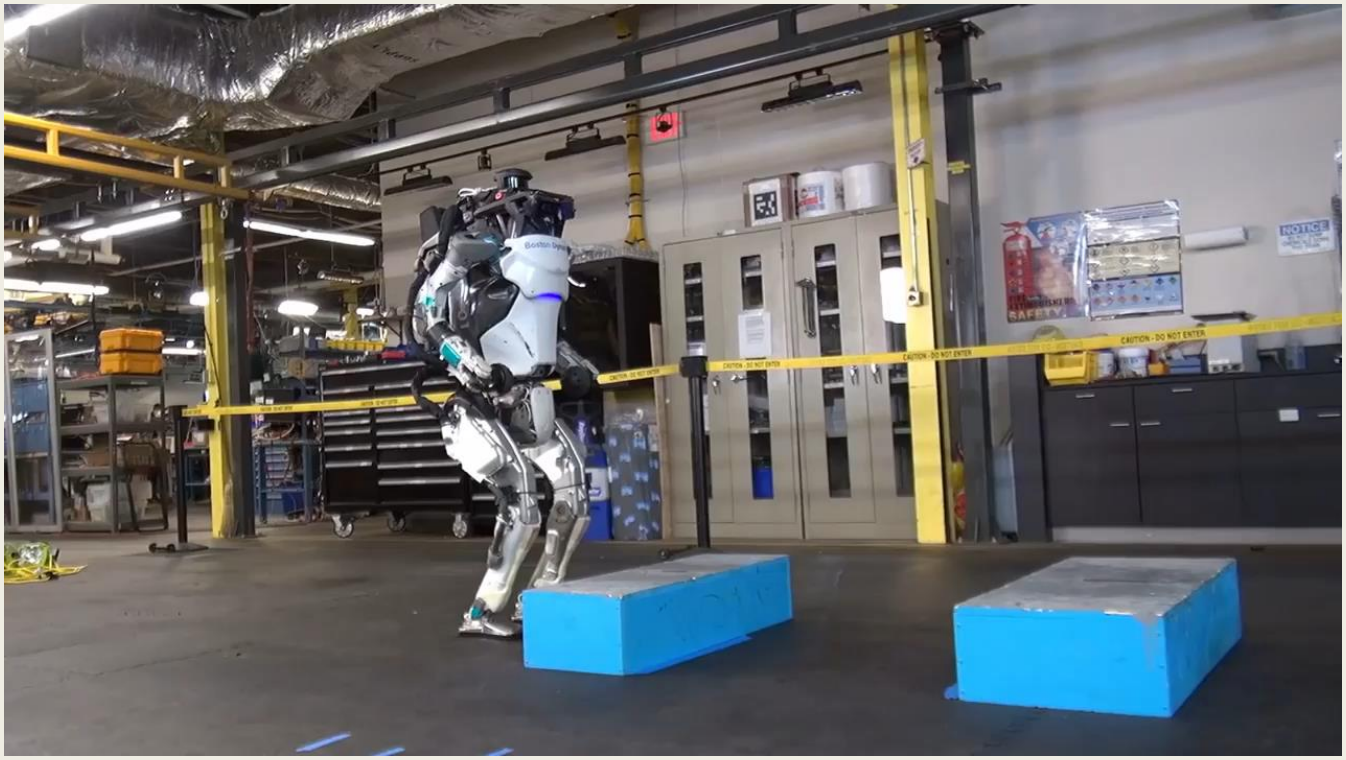
https://www.youtube.com/watch?v=lMkGDHdDpC0

# Bird Robot - Festo


https://www.youtube.com/watch?v=nnR8fDW3Ilo

# Cyborg

# Humanoid - Atlas




https://www.youtube.com/watch?v=fRj34o4hN4I

# Case Study : Humanoid Robot

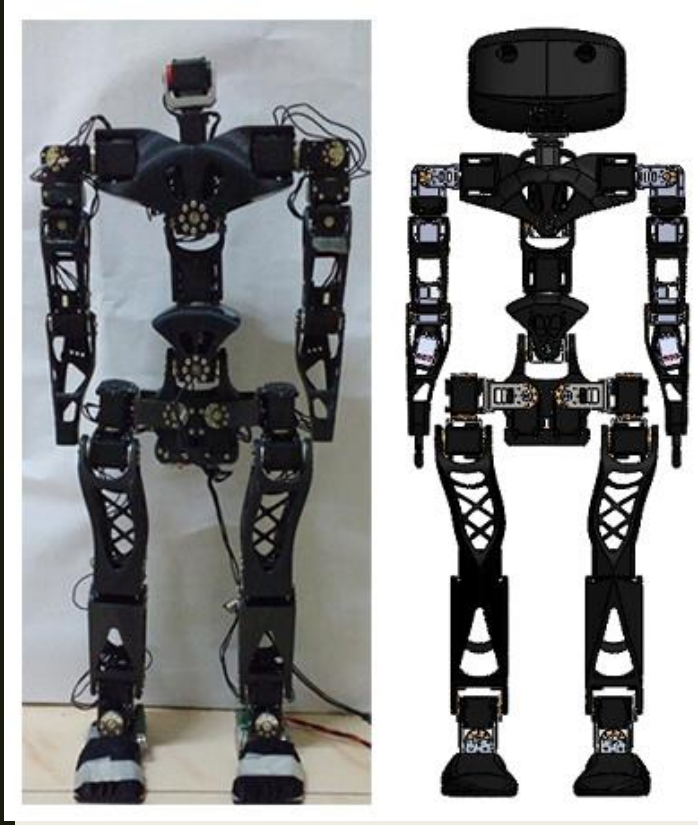
# Desirable Attributes of a Humanoid Robot

- Need a Robot With a Soft Touch
- Robots Should Move Like People
- A Look Can Say It All
- Talk to Me
- Giving Robots Emotions
- A Thinking Robot
- Can a robot tell right from wrong?

# Solution

- Self maintenance
- Autonomous learning
- Avoiding harmful situations to people, property, and itself
- Safe interacting with human beings and the environment
- Legged locomotion

# Design Factors



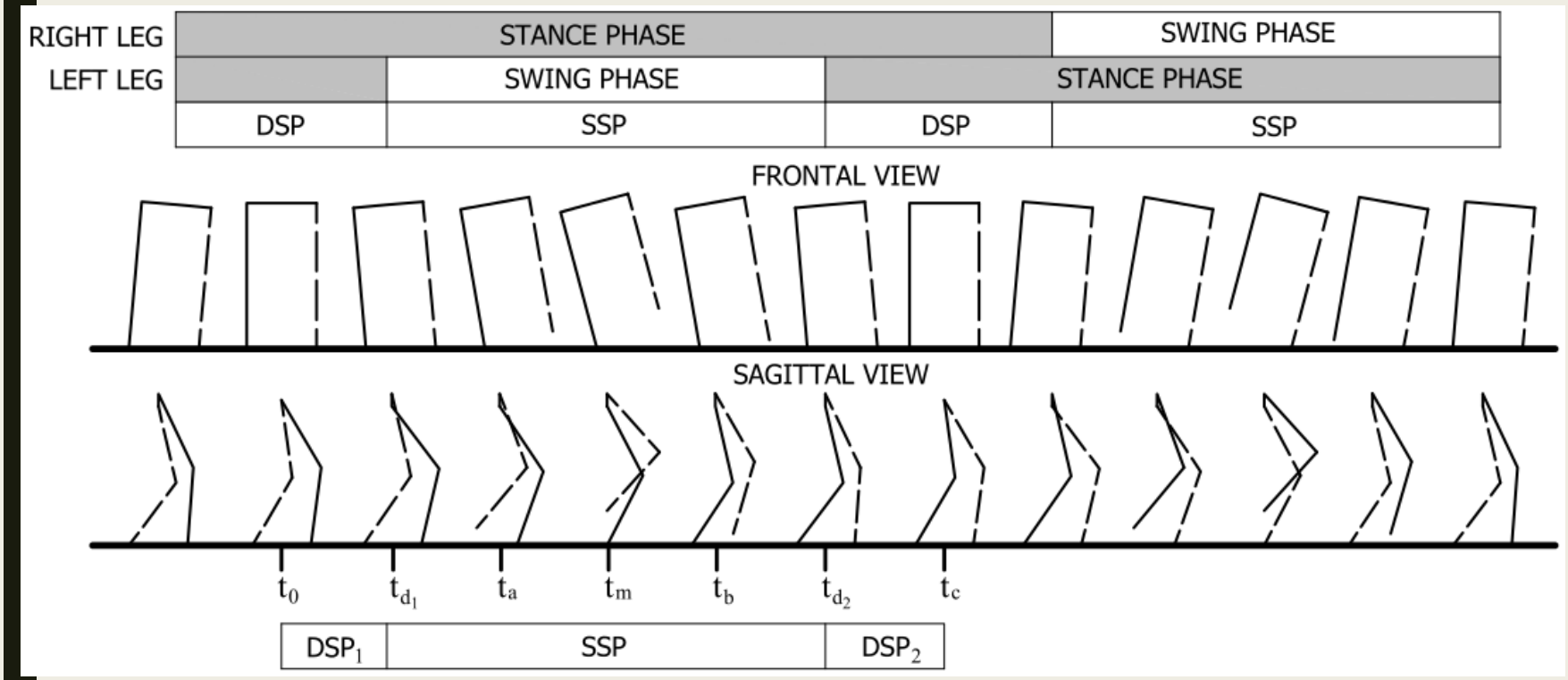
- The students of RRC built a humanoid robot (a modified design of Poppy, an open source platform), for heavier load carrying capacity.
- Highly articulated with 27 DoFs.
- High precision servos as joint activators, Dynamixel MX-64 (6 N-m torque).
- 3-D printed links – Light weight (5 kg).

# Actuators

- Actuators are the motors responsible for motion in the robot.
- Humanoid robots are constructed in such a way that they mimic the human body, so they use actuators that perform like muscles and joints, though with a different structure.
- To achieve the same effect as human motion, humanoid robots use mainly rotary actuators.
- They can be either electric, pneumatic, hydraulic, piezoelectric or ultrasonic.

# Path Planning

- Phases of Walking Gait



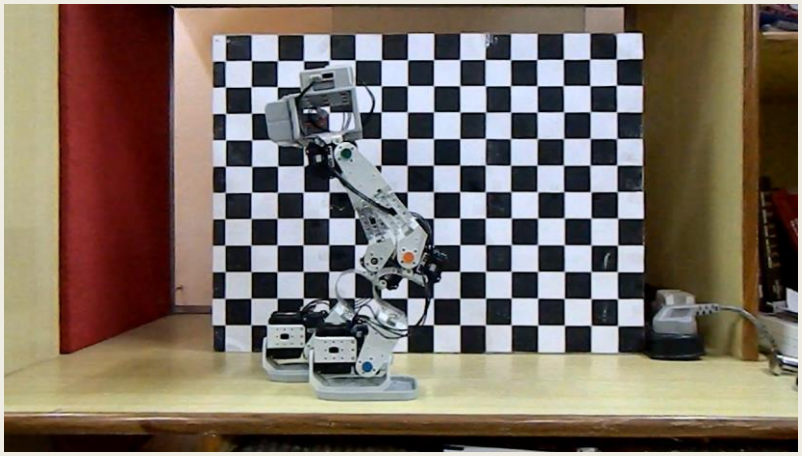
# Sensing Modalities

- **Internal Sensors:** sense the position, the orientation and the speed of the humanoid's body and joint
  - *Encoder*
- **External Sensors:** An artificial hand holding a lightbulb Arrays of tactels can be used to provide data on what has been touched.
  - *Inertia measuring Unit (IMU), Gyroscope*
  - *Force Sensing Resistor (FSR)*
  - *Vision*
  - *Force Plate*
  - *Touch*

# Control

- Open-Loop Control Systems
  - *Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.*

- Walking Experiments
  - *Horizontal terrain*



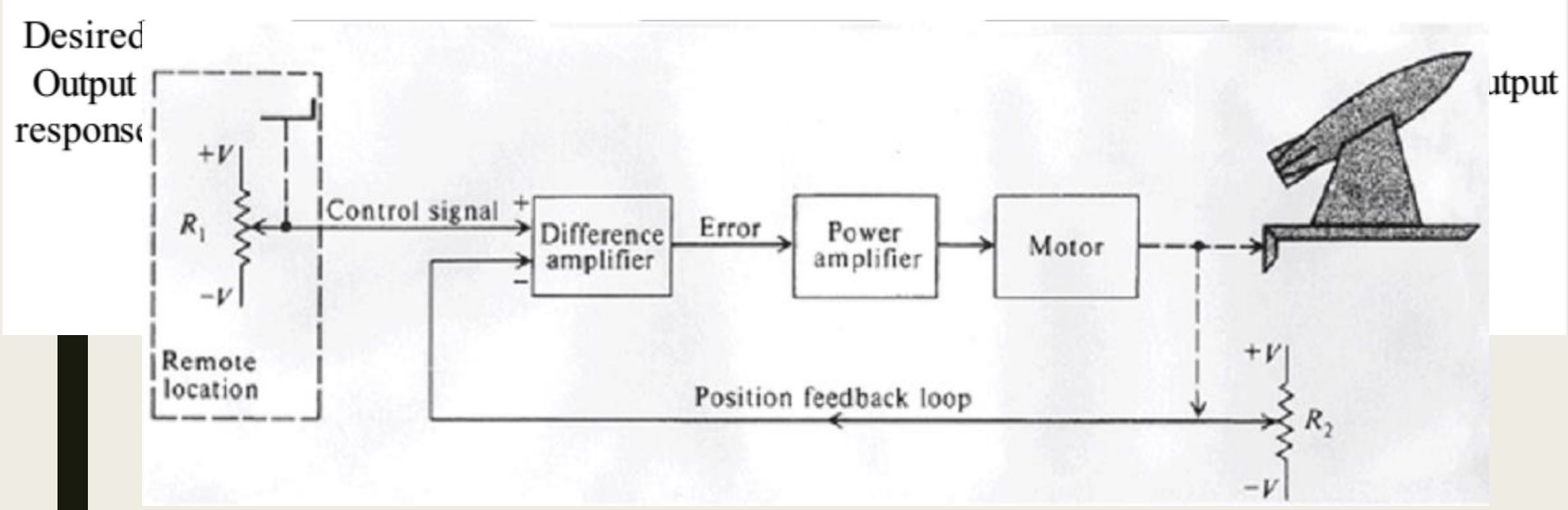
  - *Slopped terrain*

# Feedback

- Feedback is a key tool that can be used to modify the behavior of a system.
- Helps to achieve the objective of acting on a system to ensure that the desired performance specifications are achieved.

# Closed-Loop Control Systems

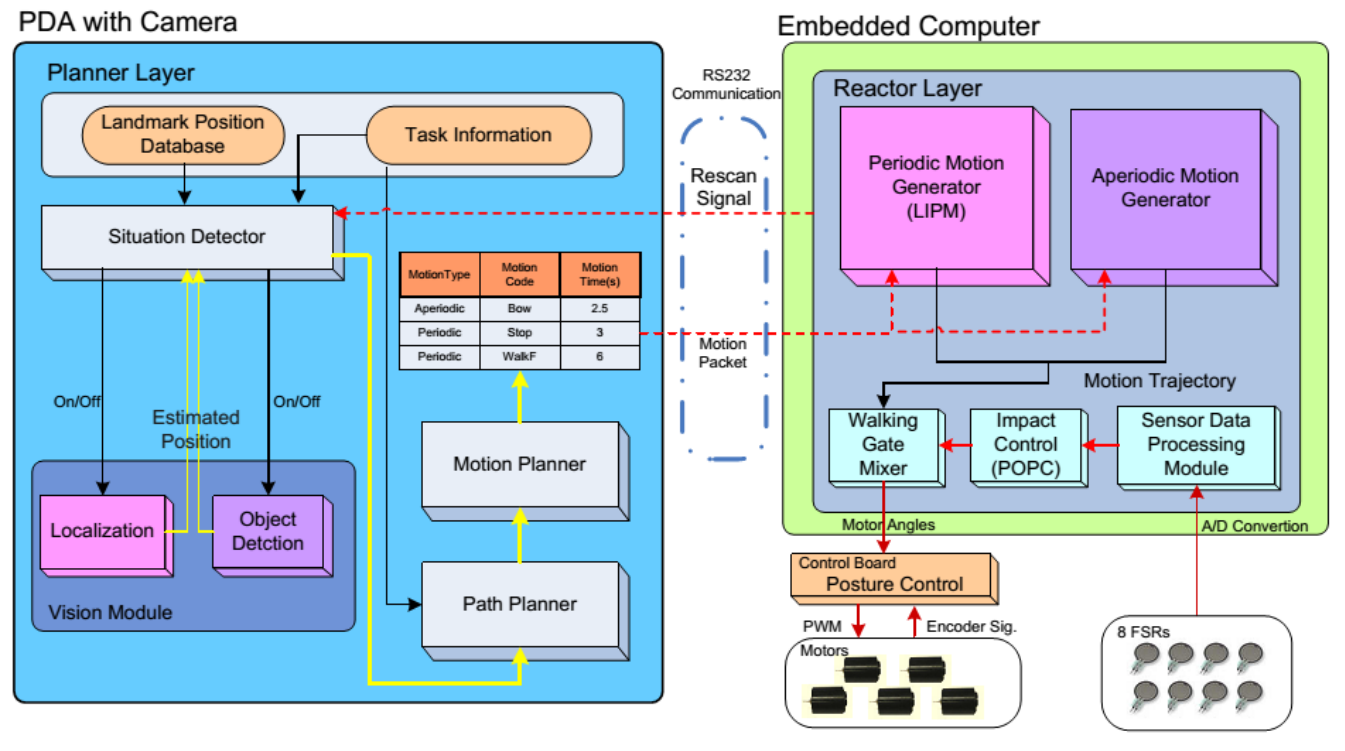
- Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.



# Software Architecture

- All of the sensor data, such as actuator encoder values, reaction forces and camera images, are directly available to the PC.
- Control commands are sent from the PC to the motor drivers directly.
- This requires an operating system in which many different cycle control loops can be executed concurrently.
- RTOS

# Distributed control architecture for HSR-VII




Jeong-Ki Yoo et al., Humanoid Robot System, HanSaRam-VII for RoboMarathon in HuroCup.

Thank you