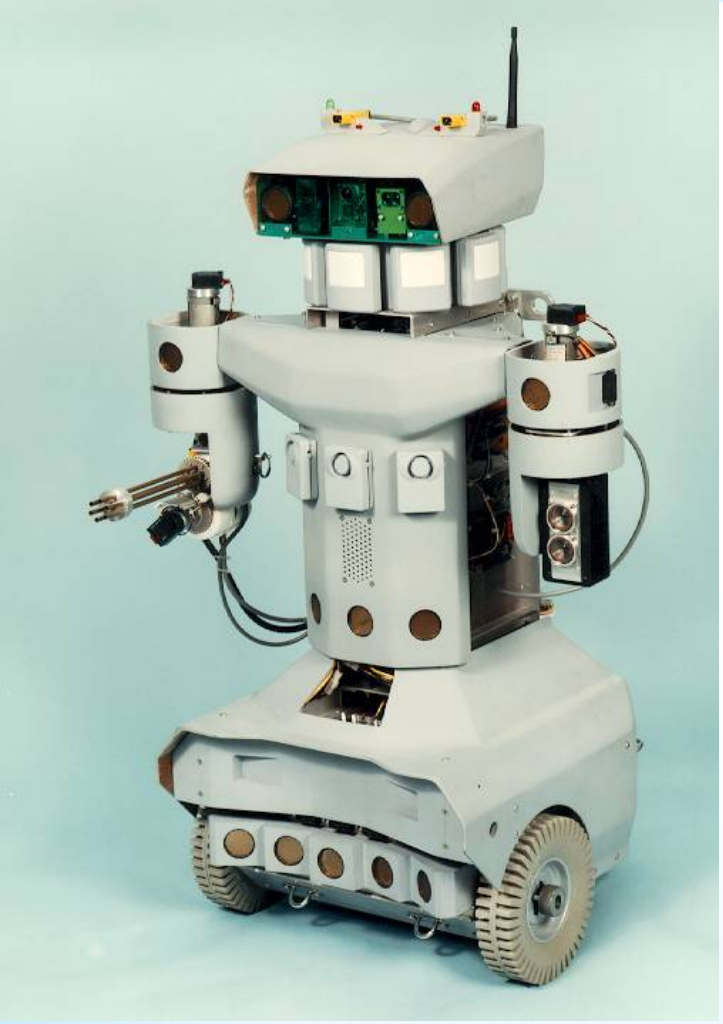

ΡΟΜΠΟΤΙΚΗ

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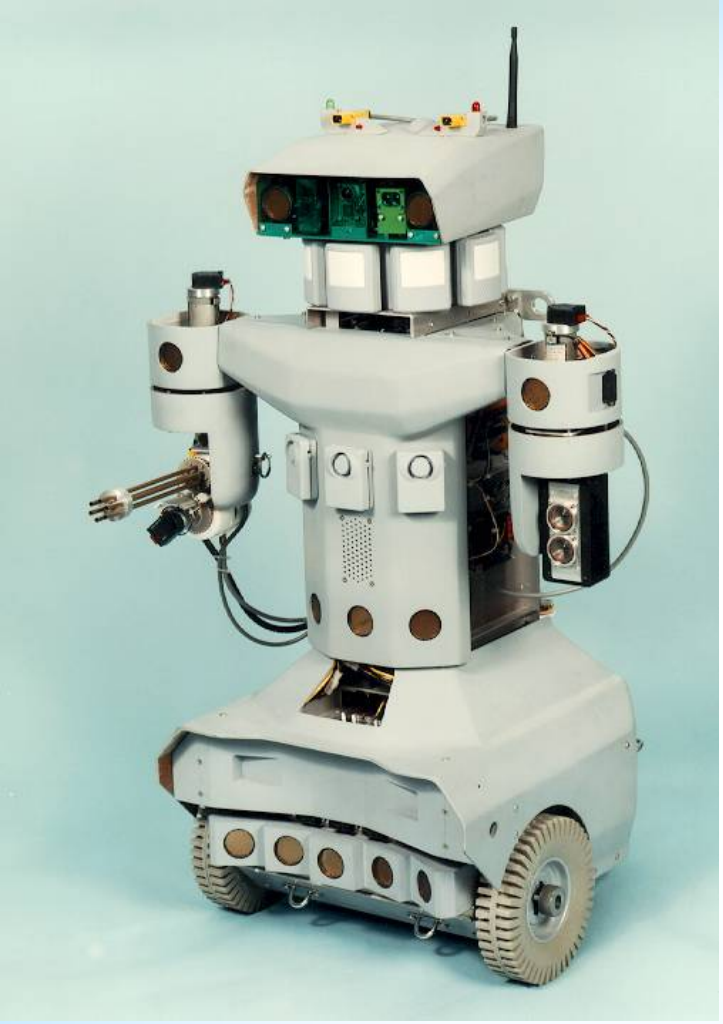

Intro to Robotics

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Intro

- **Robots**: machines expected to substitute human beings in (motion) tasks.
- "Substitution" concerns both (motion) execution and decision making !
- **Robotics**: engineering discipline concerning
  - Conception
  - Design
  - Manufacturing and
  - Operation

  of Robotic Devices

History

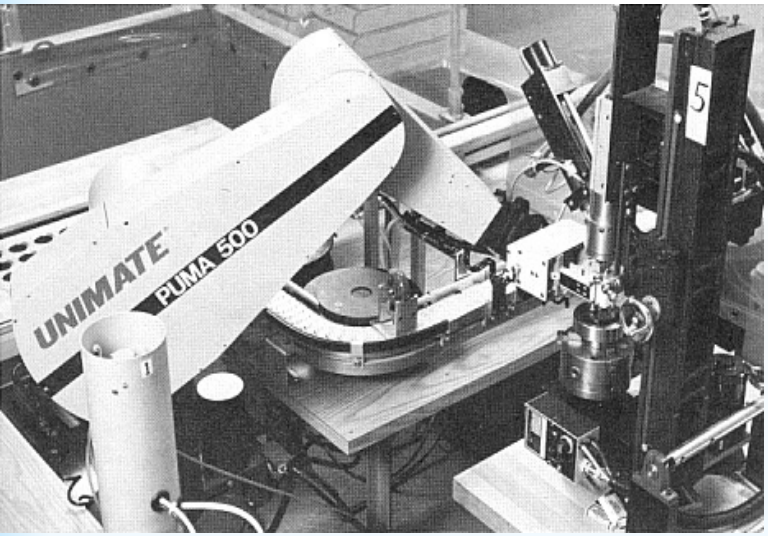
- First attempts to "conceive" human substitution appeared in ancient Greek mythology:
  - Titan Prometheus build human being using clay, and
  - Talos, a copper made giant built by Hephaestus to protect Crete, was the first "automaton" in human history (?).

- In 1921, the Czech theatric author Karel Čapek in his work "Rossum's Universal Robots" describes a machine automaton named … "**robot"** from the czech word **robota** describing compulsory work.
- In the '40s, Russian science fiction author Isaac Asimov conceived a human like "automaton" with no emotion and following certain (the 3 well known) rules.

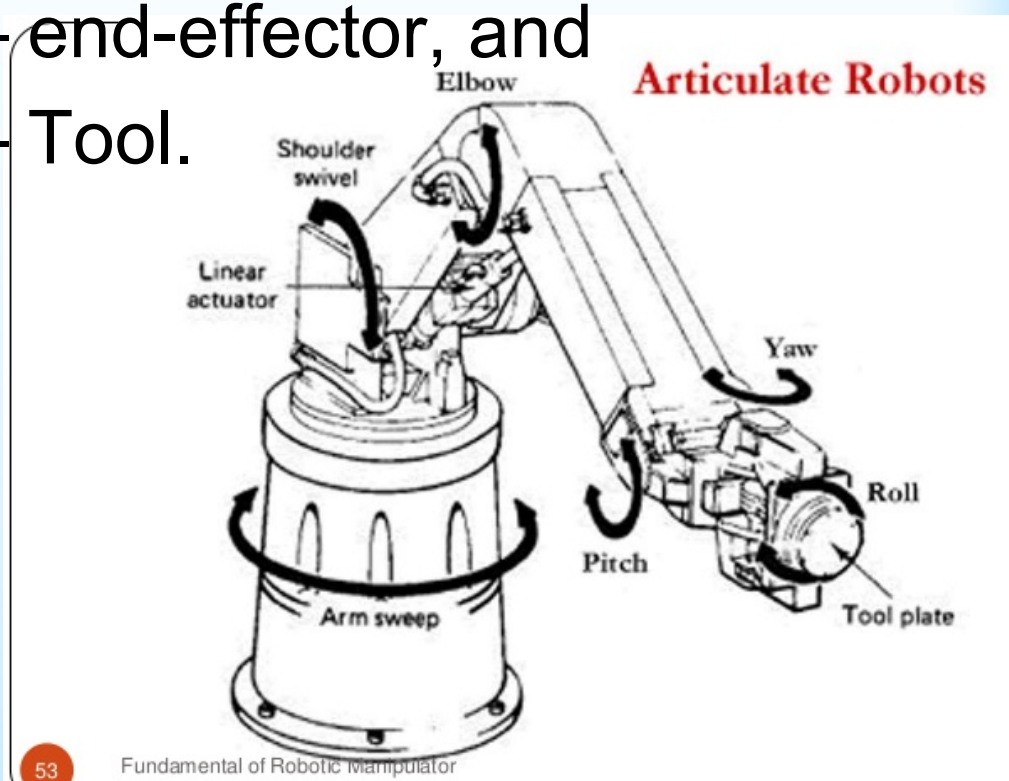
Robot "Definition"

- According to the Robot Institute of America, robot is a device meant to transfer material, parts, tools or special devices following a set of preprogrammed motions.
- Such a device is composed of the following components:
  - A **mechanical** subsystem
  - A **sensing** subsystem, and
  - A **control** subsystem

Robot Taxonomy: Stationary base

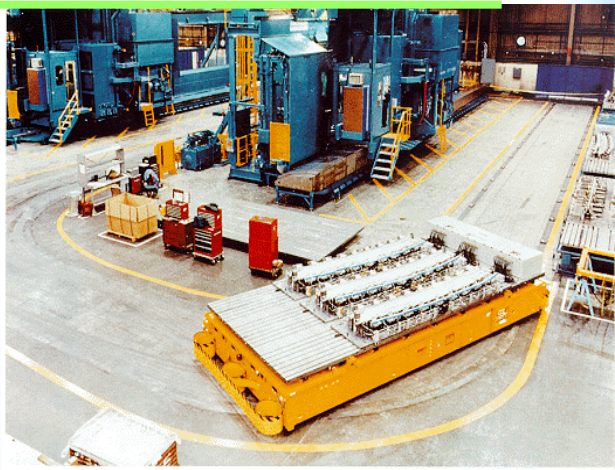


- Link – Joint structure.
  - First link is the “base”
- Traditional Industrial Robot:
  - arm,
  - end-effector, and
  - Tool.



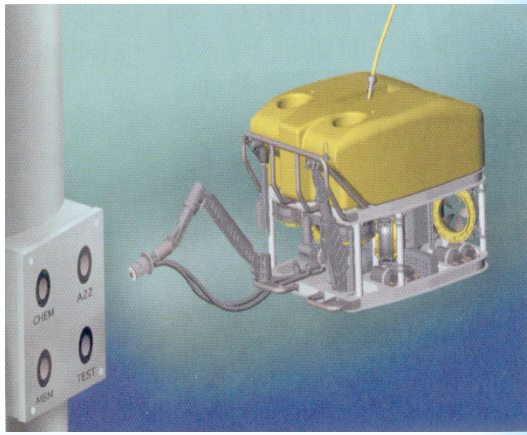
Robot Taxonomy: Moving base

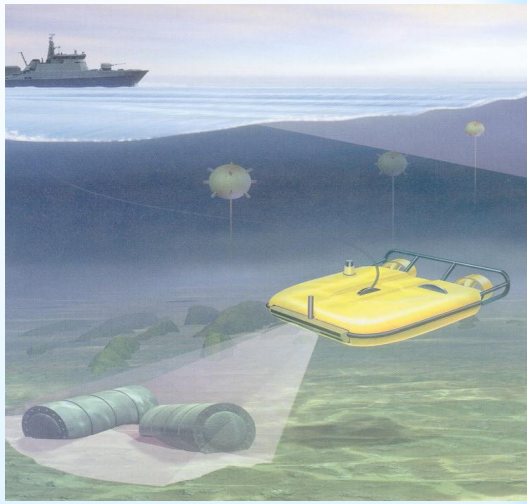
- They can move their base via a "propulsion" system.
- **AGVs (Automatic Guided Vehicles):** limited autonomy, fixed path.
- **Mobile Robots:** minor (or no) supervision – (semi-) autonomous operation.
- **Walking:** mechanical limbs, climbing capabilities
  - Humanoids



Robot Taxonomy: Moving base cont.

- **ROVs (Remotely Operated Vehicles):**
  - umbilical cable for energy and data transfer.
  - Limited autonomy
- **AUVs (Autonomous Underwater Vehicles):**
  - Autonomous (no umbilical)
  - Batteries limit range of operation
- **UAVs (Unmanned Aerial Vehicles):** Military / safety / security operations

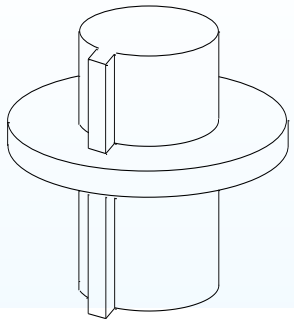




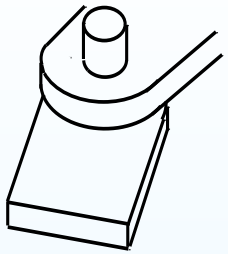
Robotic Manipulators : Introductory Notions

- Sequence of ***Links***
- Links are connected via ***Joints***, thus forming a *kinematic chain*.
- Joints can be:

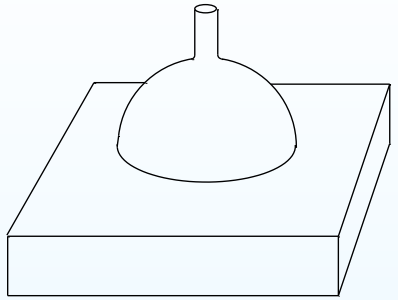
Prismatic

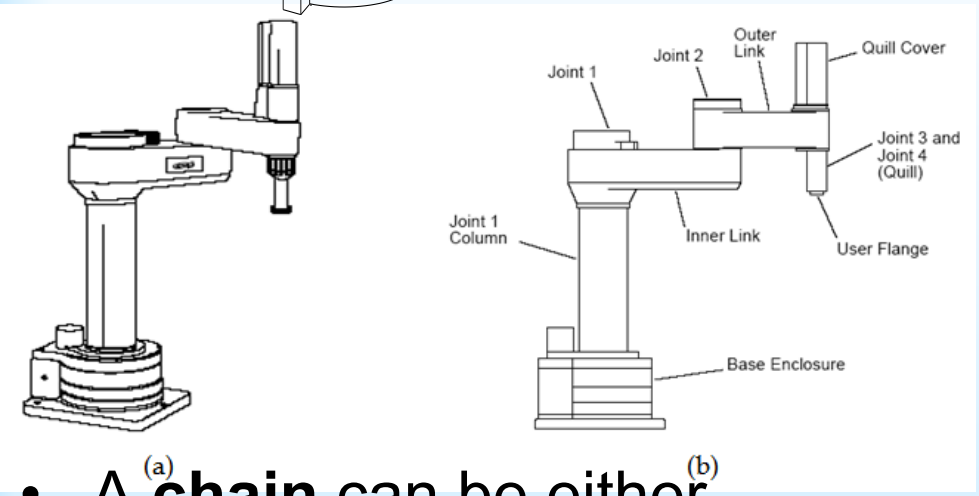


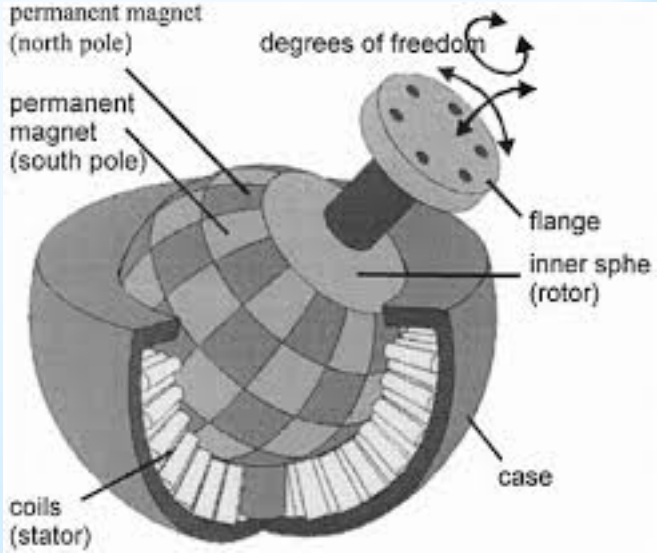
Rotational



Spherical



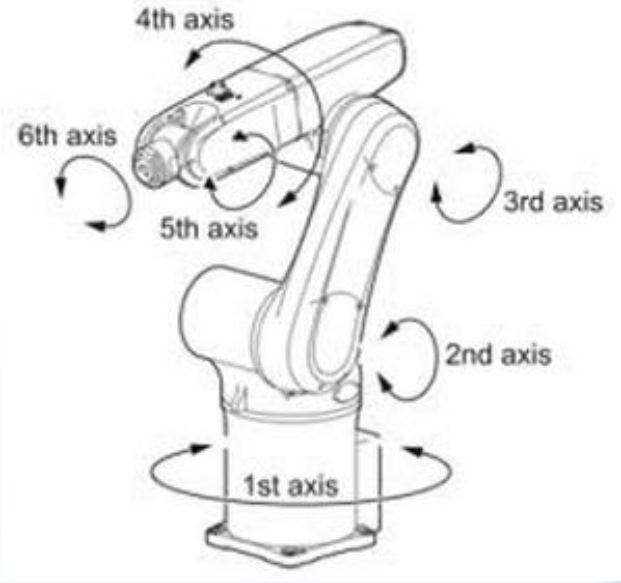




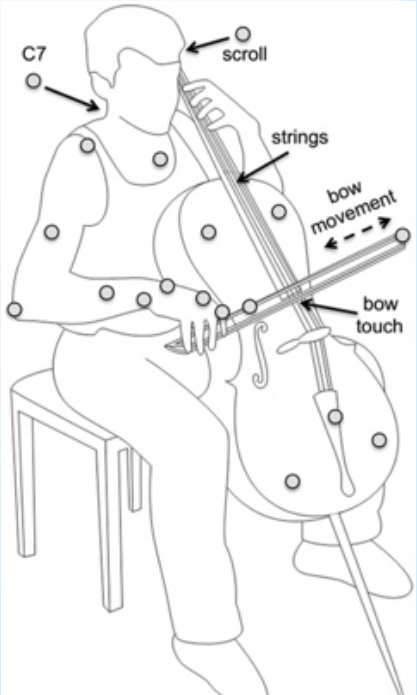
- A **chain** can be either
  - ***Open***, or
  - ***Closed***

Robotic Manipulators : Introductory Notions cont.

- **Degrees of Freedom (DOFs):**
  - for a **Manipulator**: related to **but not** determined by its number of joints



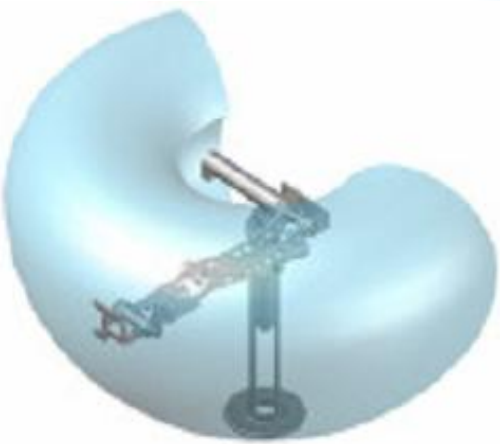
  - for a **Task**: relates to its nature e.g. 6-D (position and orientation etc.)



- A manipulator must be endowed with the DOFs required to accomplish a particular task.

Robotic Manipulators : Introductory Notions cont.

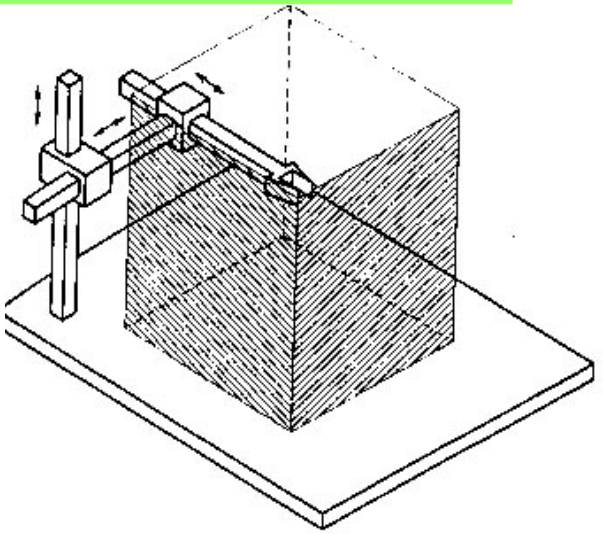
- **Work-Space:** 3-D space that can be accessed by the end-effector.
  - Size and shape related to robot structure.



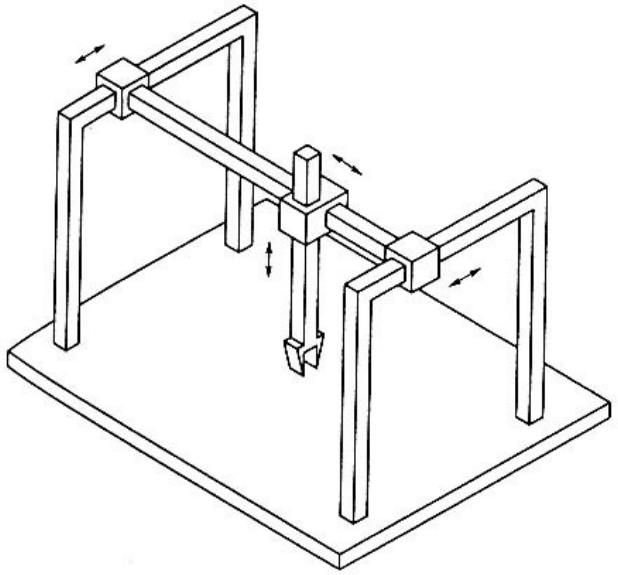
- **<u>Robotic Manipulator Opertional Features</u>**
  - **Load**
  - **Repeatability**
  - **Accuracy**

Robotic Manipulator Taxonomy: Geometric Structure based

- **Cartesian**: 3 prismatic joint according to cartesian system.
  - Robust and accurate.
  - Limited dexterity

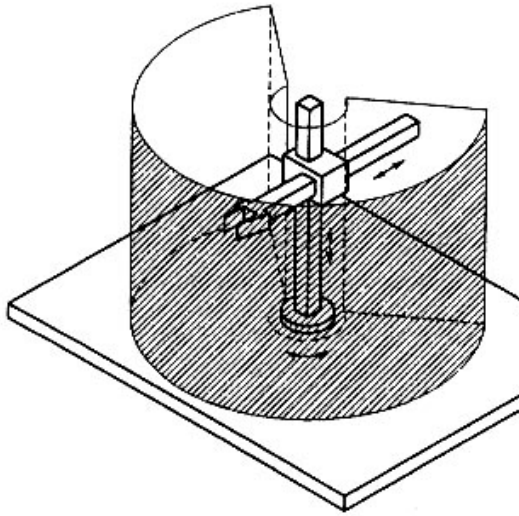


- **Gantry**: cartesian robots with vertical approach
  - Larger workspace
  - Higher robustness
  - Large and heavy loads

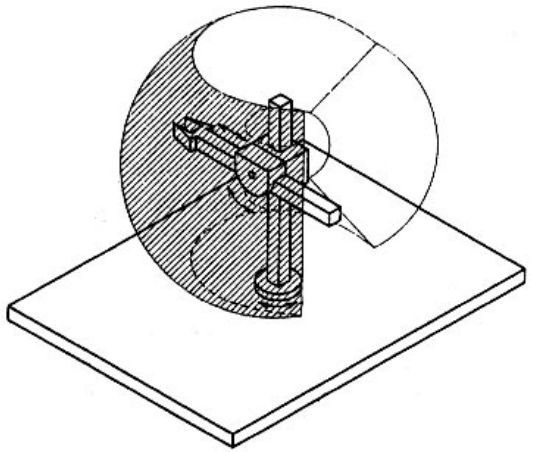


Robotic Manipulator Taxonomy: Geometric Structure based cont.

- **Cylindrical**: the first joint is rotational the rest prismatic
  - Robust & accurate
  - Workspace: cylindrical
  - Manipulator enters the workspace

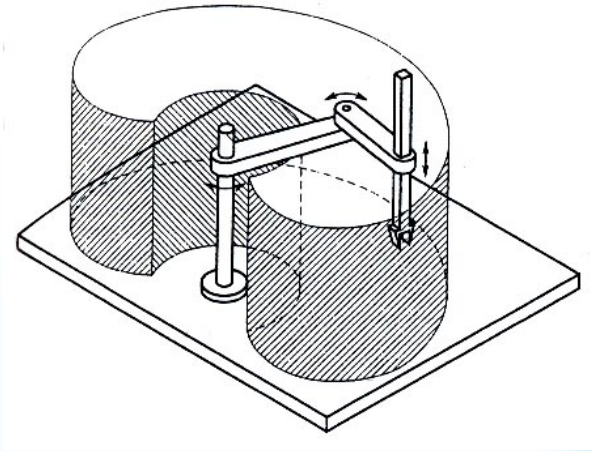


- **Spherical**: the 1st and 2nd joints are rotational while the 3rd is prismatic.
  - More complicated structure
  - Less robust and accurate

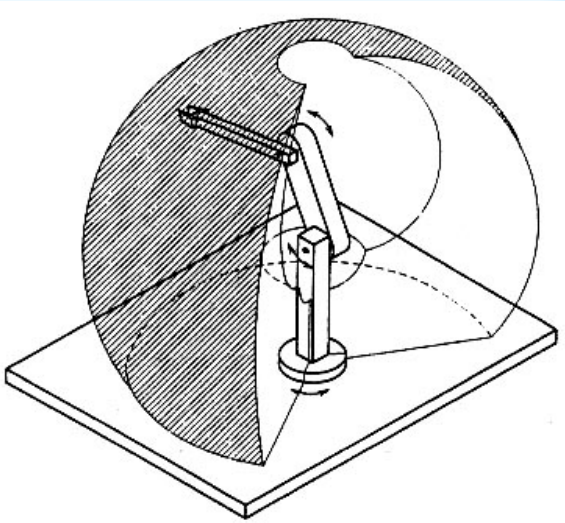


Robotic Manipulator Taxonomy: Geometric Structure based cont.

- **SCARA**: (Selective Compliance Assembly Robot Arm)
  - 2 rotational & 1 prismatic joints: parallel axis
  - Very Robust in vertical loads
  - Accuracy depends on radial distance



- **Anthropomorphic**:
- First 3 joints: rotational
- Axis of 1st: perpendicular to the remaining 2 (parallel).
- Very dexterous
- Spherical workspace
- Wrist accuracy not constant



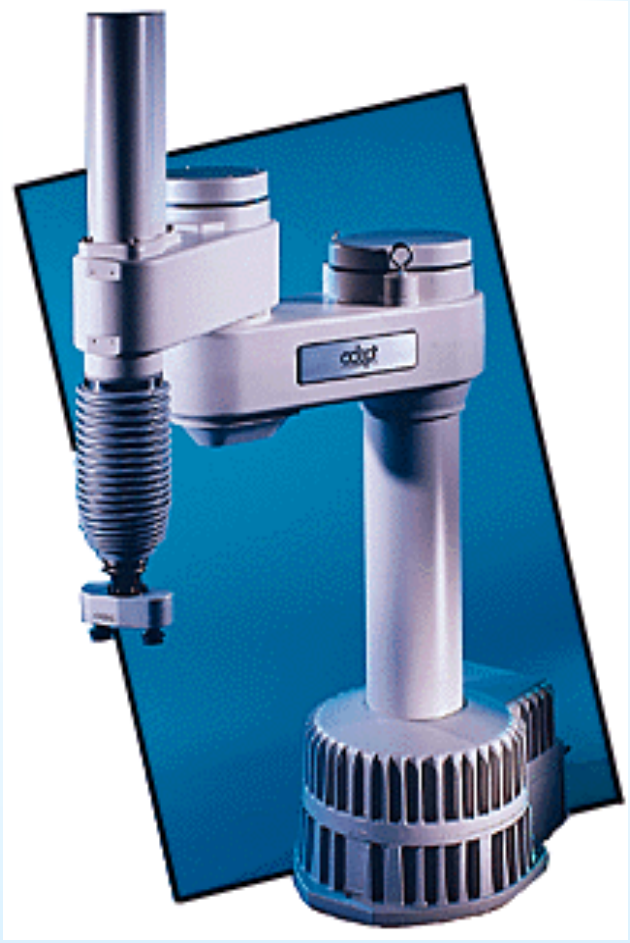
Typical Robotic Manipulators

- **PUMA:** Programmable Universal Machine for Assembly. Six (6) joints – Anthropomorphic. Very dexterous. Advanced Control architecture.

Industrial / Research Robot.
Originally made by Unimation Inc. and now by Staubli.

Typical Robotic Manipulators contd.

- Specs
  - Load: 9.09 kg (20 lbs)
    - Vertical constant:18.2 kg (40 lbs)
  - Max Moment of Inertia: 2900 kg-cm2 (1000 lb-in2)
  - Repeatability: 0.025 mm (0.001")
  - Accuracy: 0.076 mm (0.003")
  - Joint 1: 300˚
  - Joint 2: 294˚
  - Joint 3: standard 195 mm (7.7") stroke 295 mm (11.6")
  - Joint 4: 554˚



Typical Robotic Manipulators contd.

CRS ROBOTICS A465:

- Anthropomprphic
- 6 / 5 DOF
- Load: 3kg
- Repeatability: 0.05mm
- Large Speed.
- Applications:
  - Material Handling,
  - Tool loading on machine tools,
  - Assembly,
  - Painting,
  - Quality inspection etc.

Typical Robotic Manipulators contd.

CRS ROBOTICS G365:

- 3 DOF Gantry 3
- Possible 3 DOF wrist
- Applications: material handling, quality inspection, packaging, palletizing, assembly, etc.

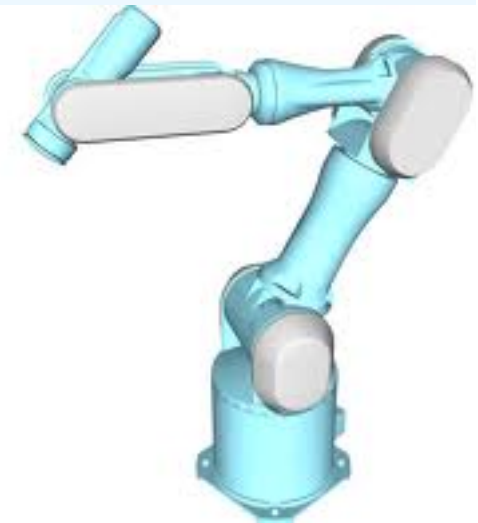
Typical Robotic Manipulators contd.

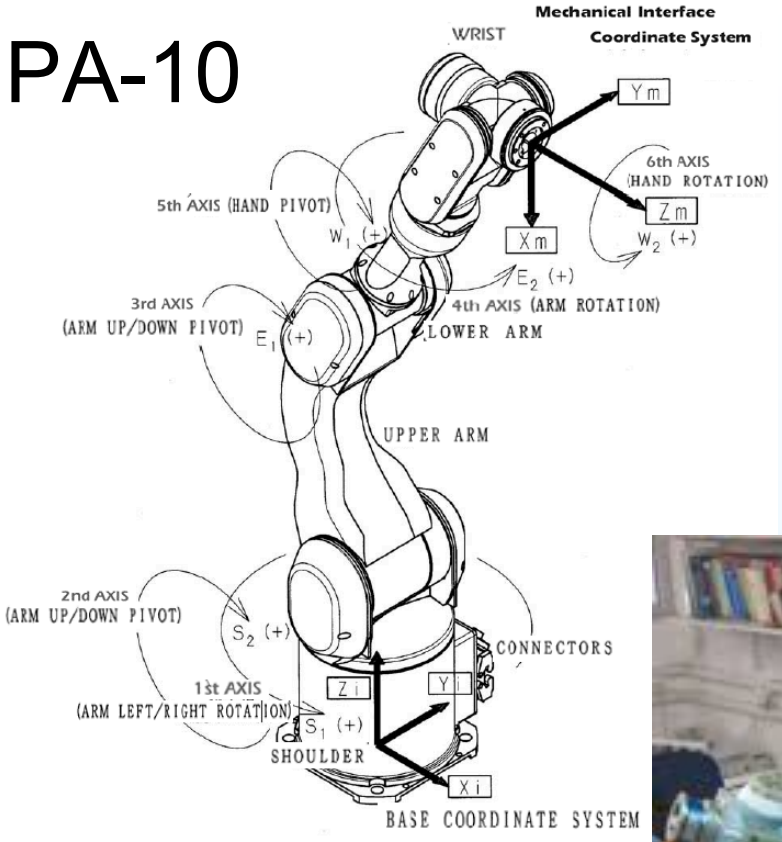
Komatsu LM15-1

- Essentially a teleoperated robotic crane
- Weight: 520kg
- Load: related to arm reach:
  - 1.2 m/350 kg
  - 2.1 m/225 kg
  - 3.0 m/150 kg
- Max reach height: 4.2m.

CONTEMPORARY, RESEARCH & PRODUCTION, MANIPULATORS

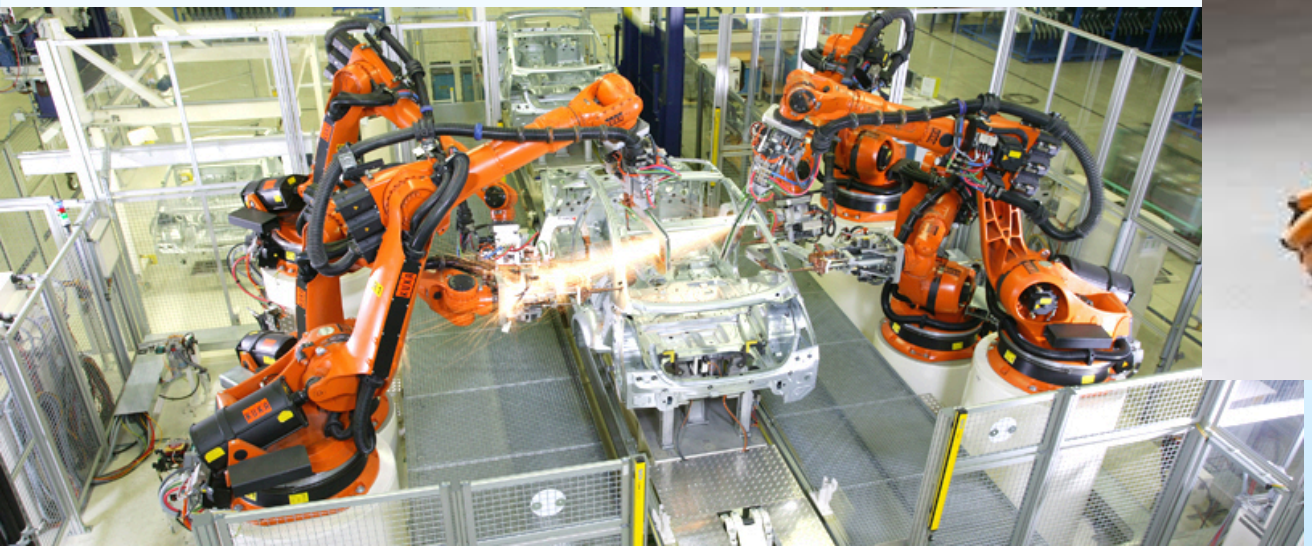
- Mitsubishi PA-10
- 7 DOF





CONTEMPORARY MANIPULATORS

- KUKA series of Robots
  - Industrial
  - Service
  - Research
- 5 – 7 DOF



Επι του Πιεστηρίου...

- By 2019, more than 1.4 million new industrial robots will be installed in factories around the world (IFR).
- The EU is currently one of the global frontrunners in automation for manufacturing: 65% of countries with an above-average number of industrial robots per 10,000 employees, are located in the EU.
  - The strongest growth figures are being posted by the Central and Eastern EU states: the rise in sales was about 25% in 2015.
  - Also, for 2016 a similar growth rate is observed (29 %).
  - The average growth remained almost steady, at around 14 % per year, for (2017-2019).
  - The biggest climbers in sales of industrial robots are the Czech Republic and Poland. Between 2010-15 the number of new robot installations climbed in the Czech Republic by 40%(compound annual growth rate) and in Poland by 26%
- USA: huge robotic automation programs ⇒ positive effect on employment
- German automotive sector: the number of employees increased parallel to the growth of robotic automation: The increase between 2010-15 averaged 2.5% - the operational stock of industrial robots showed a parallel increase averaging 3% /year. The positive effect of automation on the number of jobs is confirmed by a study recently published by Univ. Utrecht.
- In essence, reduced production costs result in better market prices. The increasing demand then triggers more jobs.

Science Fiction or State of the Art ?

- Boston Dynamics: Atlas
- Nutonomy: Driver-less Car
- TU-Delft: Ambulance Drone
- MIT: Robotic Capsule
- Amazon (Kiva): Warehousing