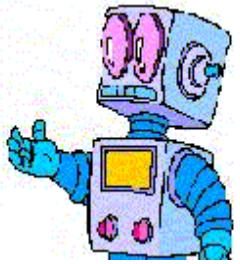
INTRODUCTION TO ROBOTICS

(Kinematics, Dynamics, and Design)

SESSION # 6:

GEOMETRICAL CONFIGURATIONS



Ali Meghdari, Professor

School of Mechanical Engineering

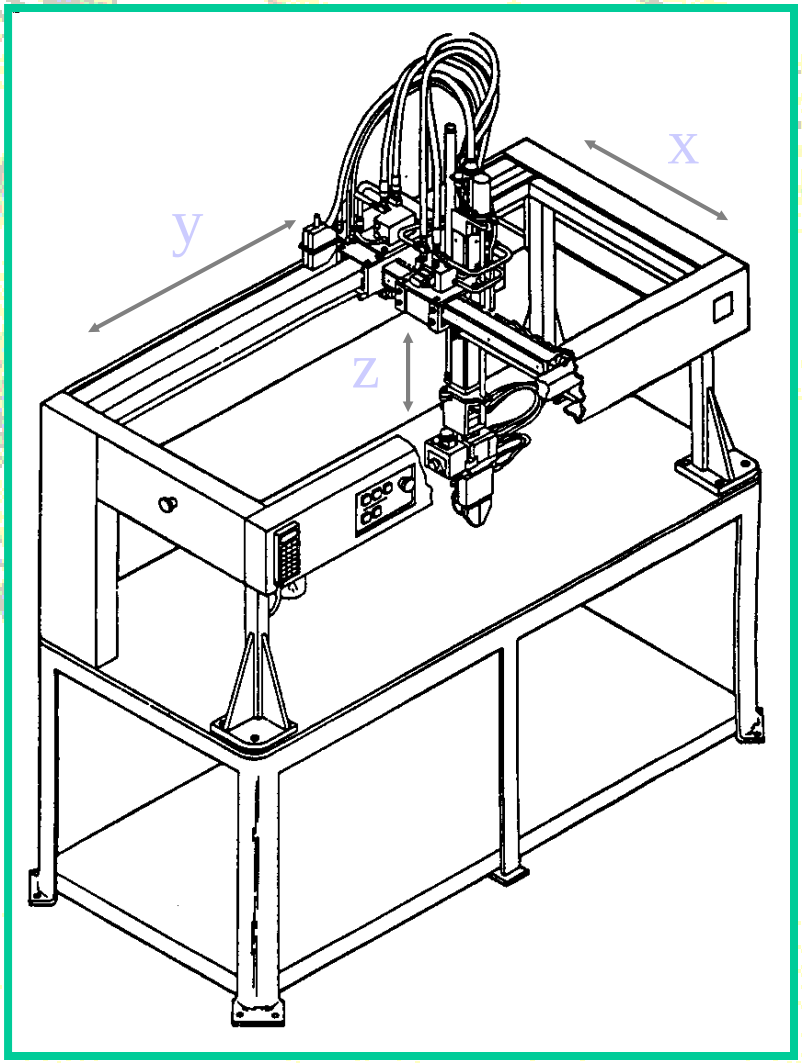
Sharif University of Technology

Tehran, IRAN 11365-9567

Homepage: http://meghdari.sharif.edu

Robots Geometrical Configurations

Cartesian/Rectangular **(PPP)** Robots (i.e. IBM-7565)



Advantages:

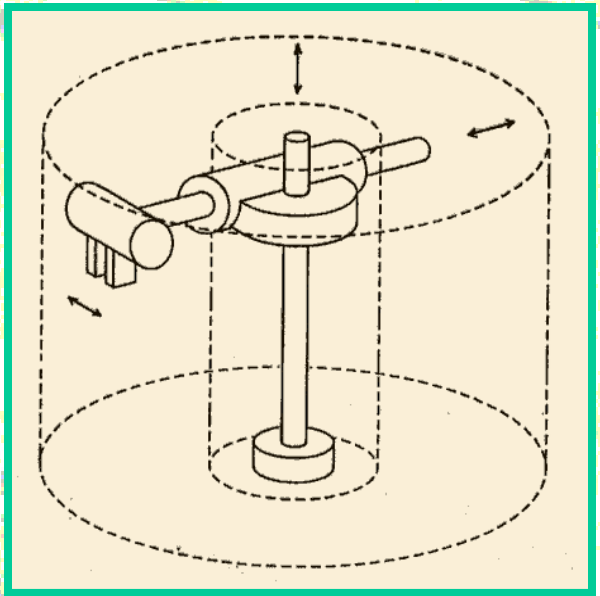
- High resolution and accuracy.
- No counterbalance problem.

Disadvantages:

- Large structural framework.
- Complex mechanical design for linear sliding motions.
- Confinement of the workspace (limited).

Robots Geometrical Configurations

Cylindrical Robots **(RPP)**
(i.e. Zymark Robot)



Advantages:

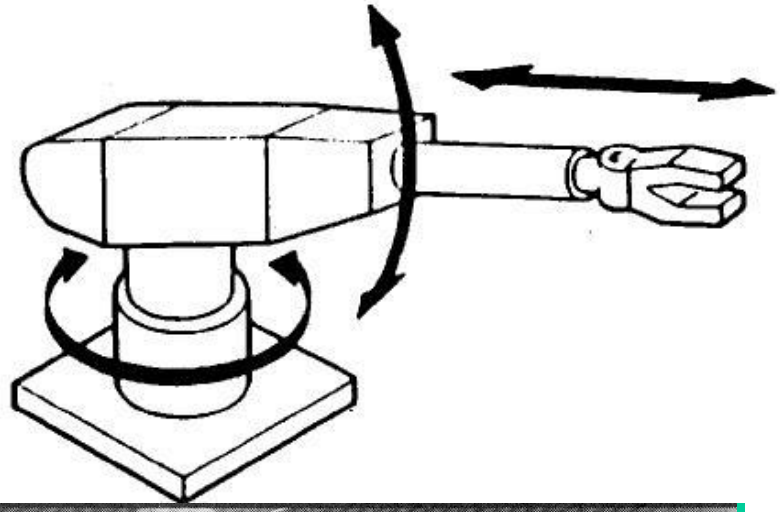
- Almost no counterbalance problem.
- Mechanical design is less complex than Cartesian robots.

Disadvantages:

- Large structural framework.
- Lower accuracy compared with the Cartesian robots.
- Restriction of the workspace.

Robots Geometrical Configurations

Spherical/Polar Robots **(RRP)**
(i.e. Unimation-2000B)

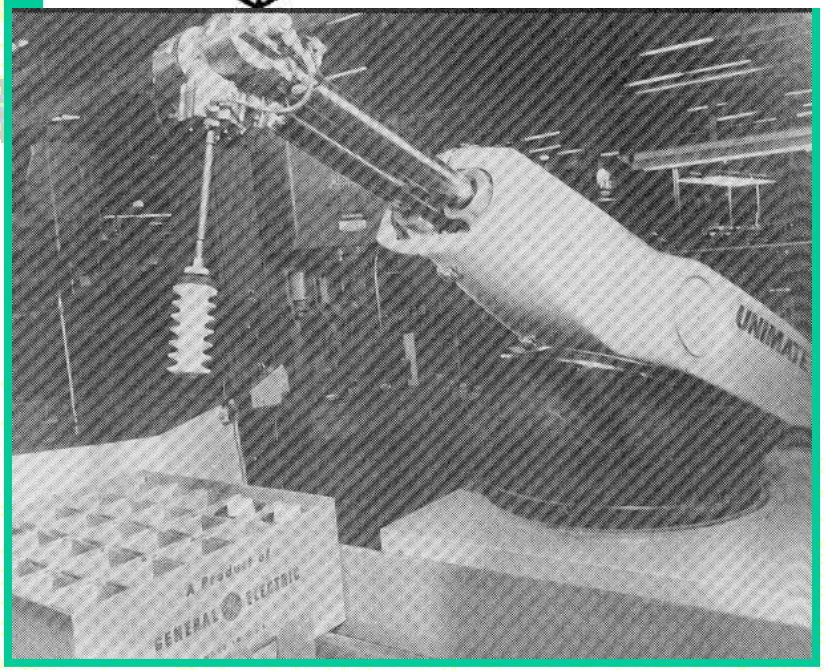


Advantages:

- Low weight and minimal structural complexity.
- Short joint travel for many motions.
- Good accuracy and resolution.

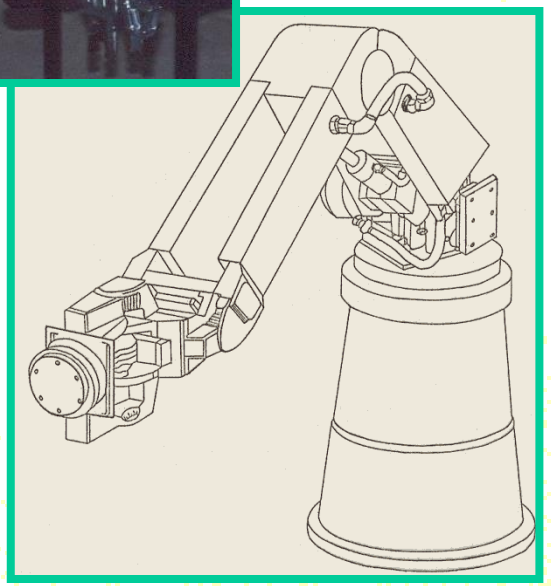
Disadvantages:

- Large variable torque on second joint creating counterbalance problem.
- Position error is large due to rotary joints.



Robots Geometrical Configurations

Revolute/Articulated Robots
(i.e. PUMA-500/600/250)



Advantages:

- Flexibility to reach over or under an object.
- Good workspace.

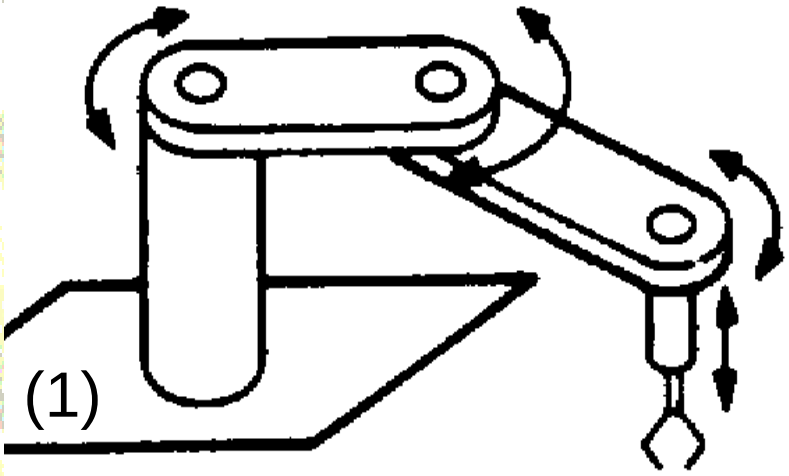
Disadvantages:

- Counterbalance problem.
- Poor resolution and accuracy due to rotary joints.
- High moment of inertia, and dynamic instability (i.e. vibrations).

Robots Geometrical Configurations

Revolute/Articulated Robots

1. SCARA
2. Intelledix



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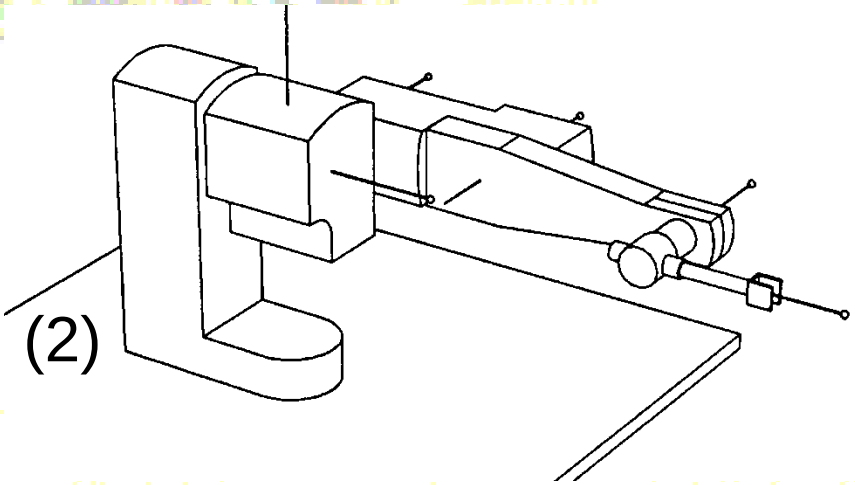
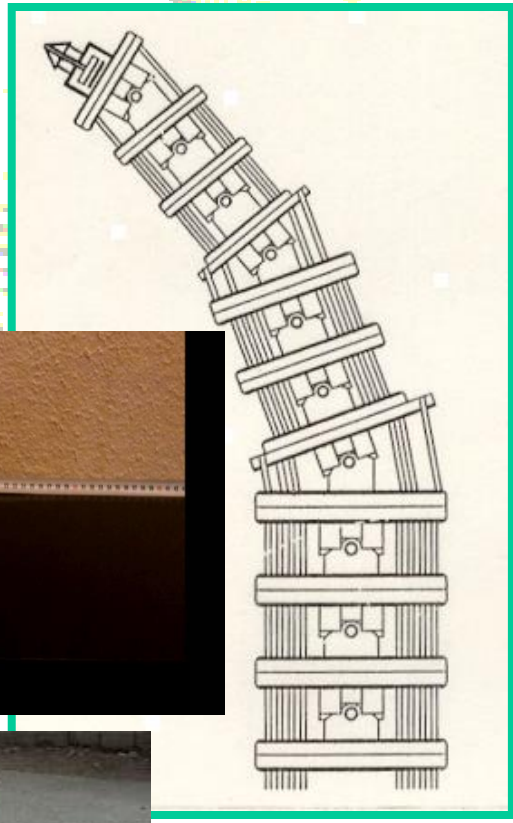
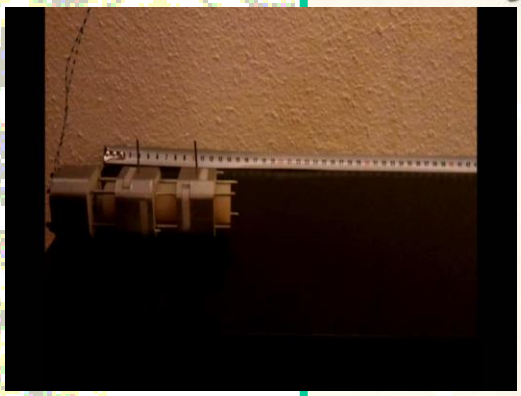


Robots Geometrical Configurations

Snakelike/Tensor-Arm Robots
(i.e. Anderson & Horn Arm 1970)





Advantages:

- Flexibility to take any shape in 3-Dim. space.
- Great workspace.
- Ability to pass through a restricted passage or canal.

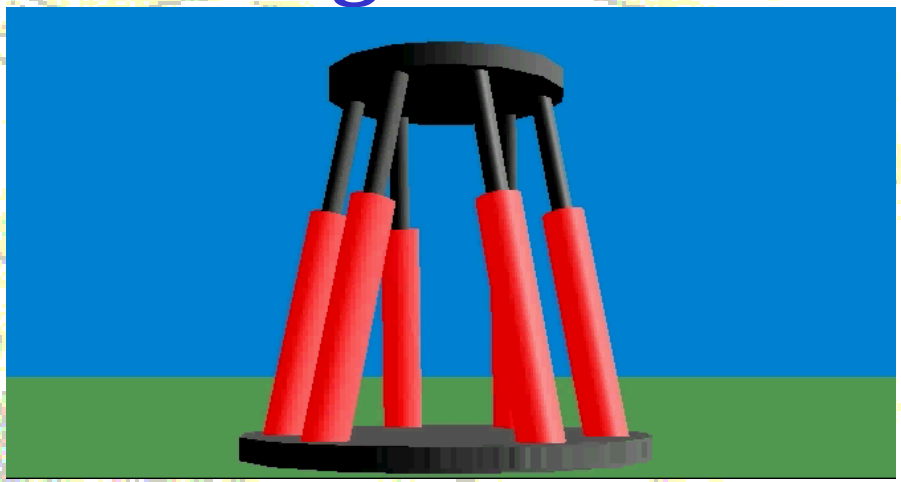
Disadvantages:

- Direct drive arm.
- Low payload.
- Complex dynamics and control.

Robots Geometrical Configurations

Parallel Manipulators

(i.e. Stewart Platform with 6-DOF)

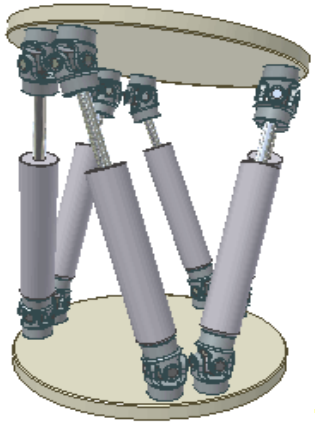


Advantages:

- Flexibility to take any shape in 3-Dim. space.
- Great workspace.
- Higher payload due to the increased stiffness for being a closed-loop structure.

Disadvantages:

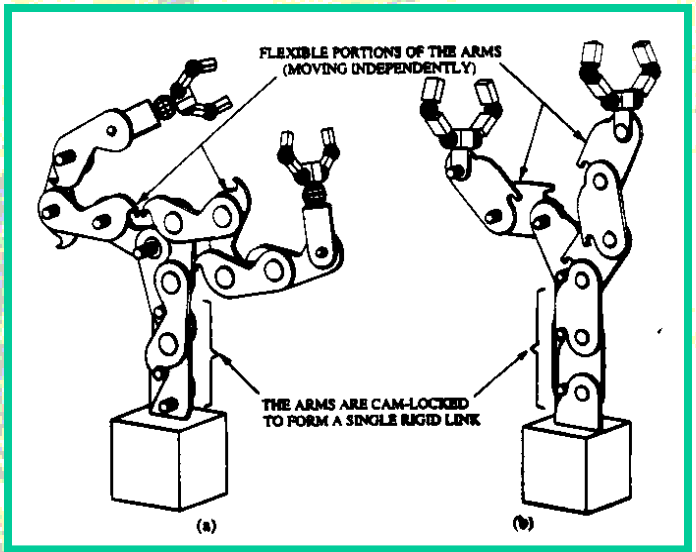
- Complex dynamics and control.

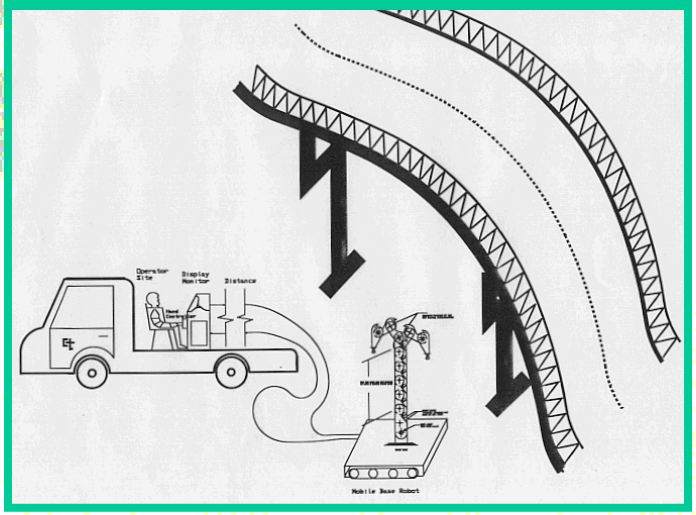


6DOF Stewart platform

Robots Geometrical Configurations

Dual-Arm Cam-Lock Robots
(i.e. Meghdari-Arm 1993)





Advantages:

- Flexibility to take many shapes in 3-Dim. space.
- Great reachable workspace that can be readily extended.
- Variable Geometry Variable Stiffness Arm.
- Can be placed in compact/portable form.

Disadvantages:

- Direct drive arm.
- Low payload.
- Complex dynamics and control.

Robots Geometrical Configurations

Mobile Robots and Manipulators

(AGV: Autonomous Guided Vehicles)

Advantages:

- Extended workspace.
- Applicable to various environments.

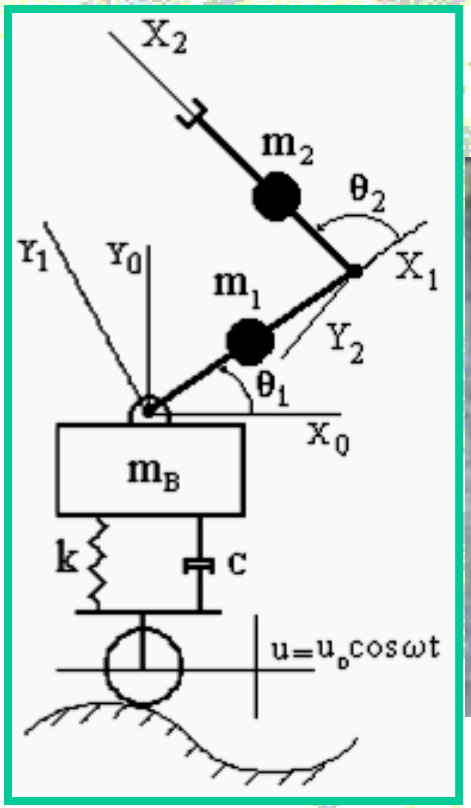
Disadvantages:

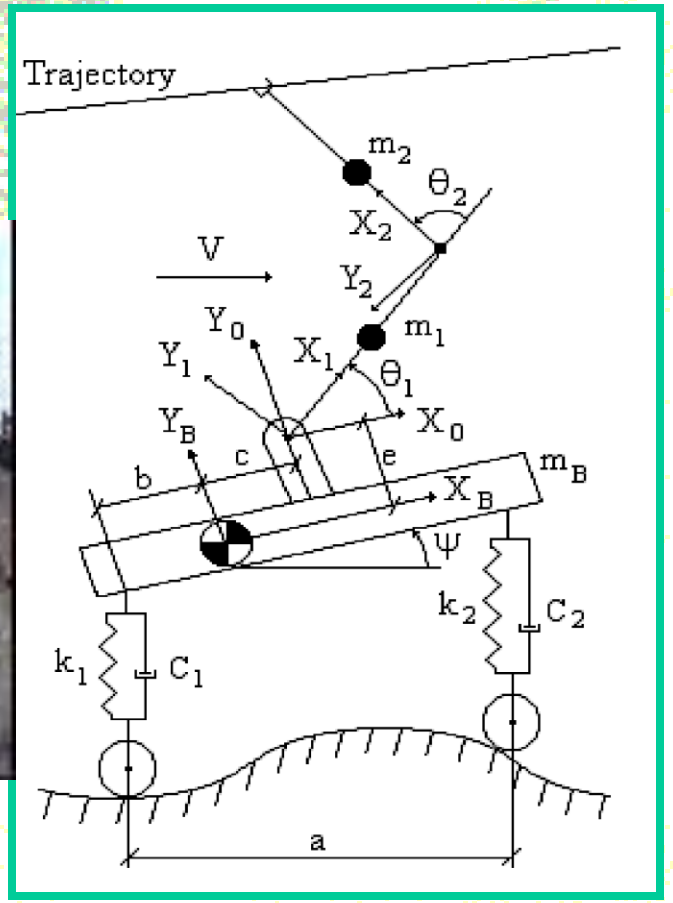
- Complex mechanical design.
- Complex dynamics and control.

Configuration

- A ***configuration*** of the manipulator is a complete specification of the location of every point on the manipulator.
- If you know the values for the **joint variable** (*joint angle for revolute joints or joint offset for prismatic joints), it is straightforward to infer the position of any point on the manipulator.*
- *A configuration is represented by a set of values for the joint variable*

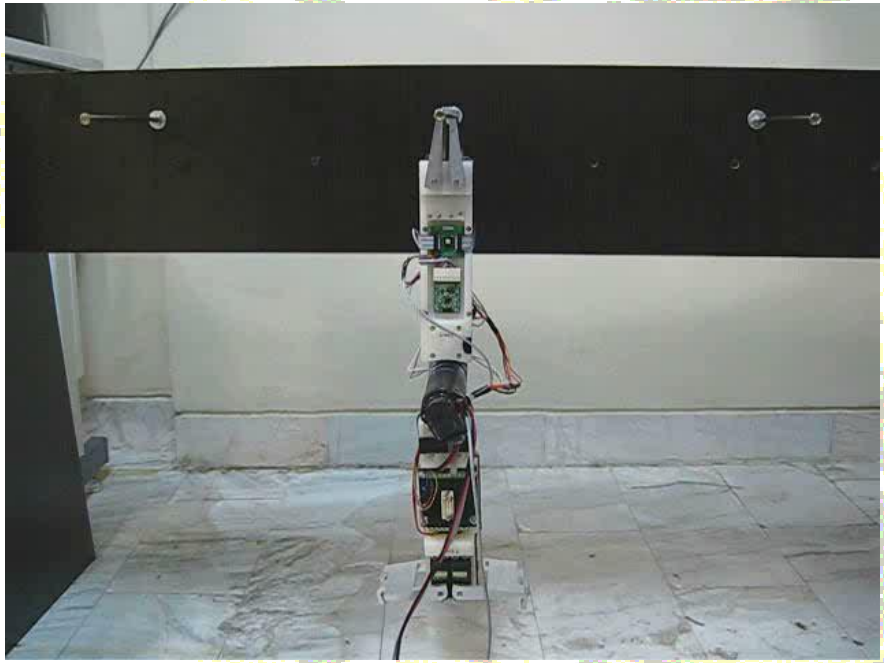
Mobile Manipulators





The Brachiation Robots

Robot Brachiation (Modified)

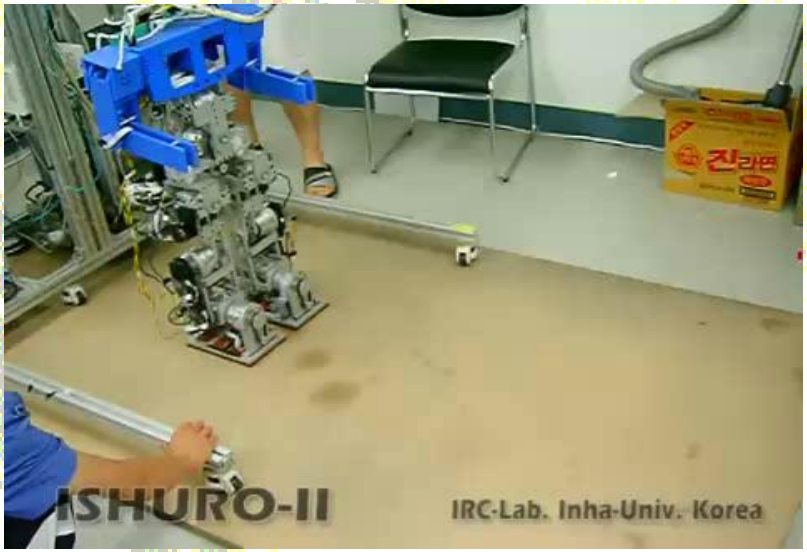


The Modular Self-Reconfigurable Robots

Robots Geometrical Configurations

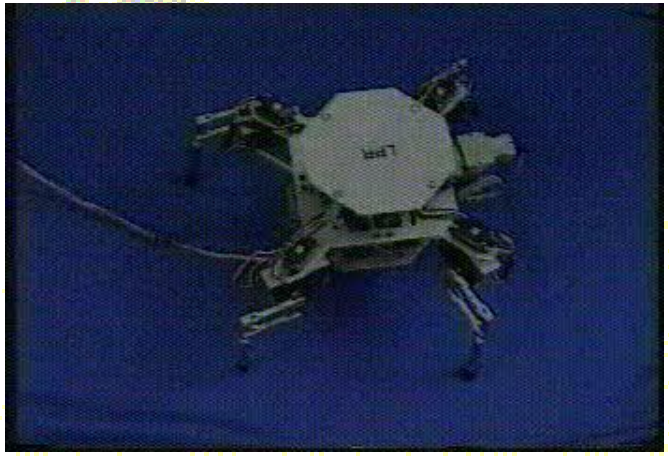
Walking/Climbing Robots

(Robotic Insects, etc.)



Advantages:

- Extended workspace.
- Applicable for various tracks.

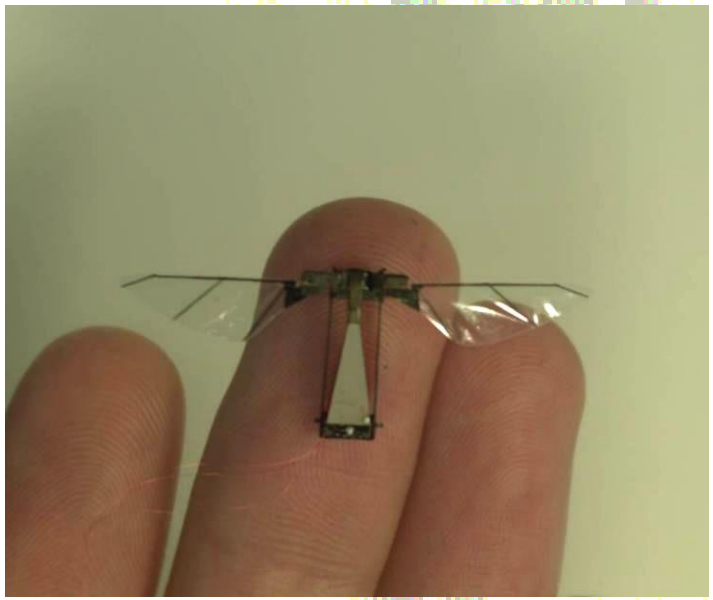


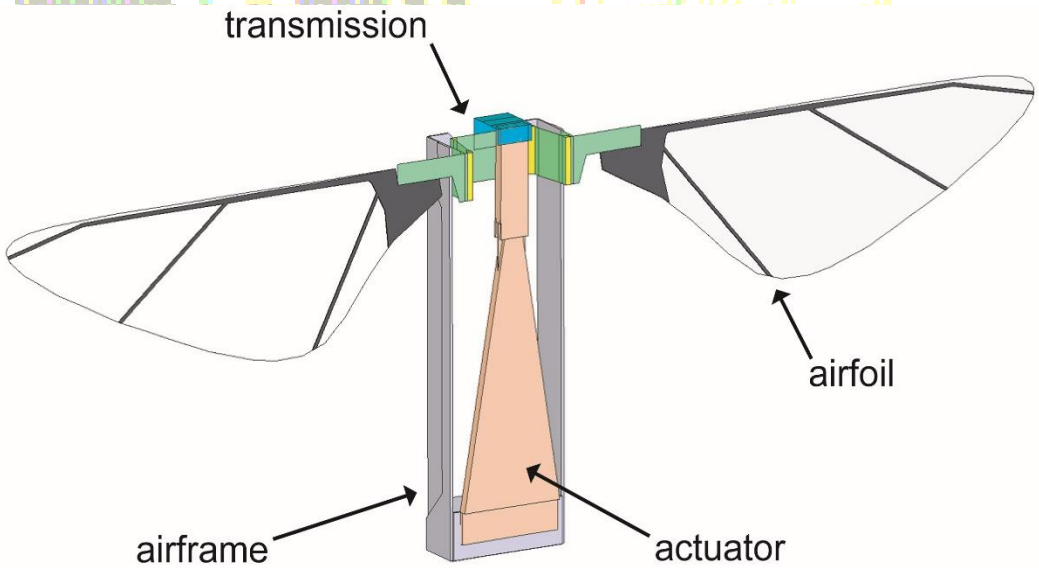
Disadvantages:

- Complex mechanical design.
- Complex dynamics and control.

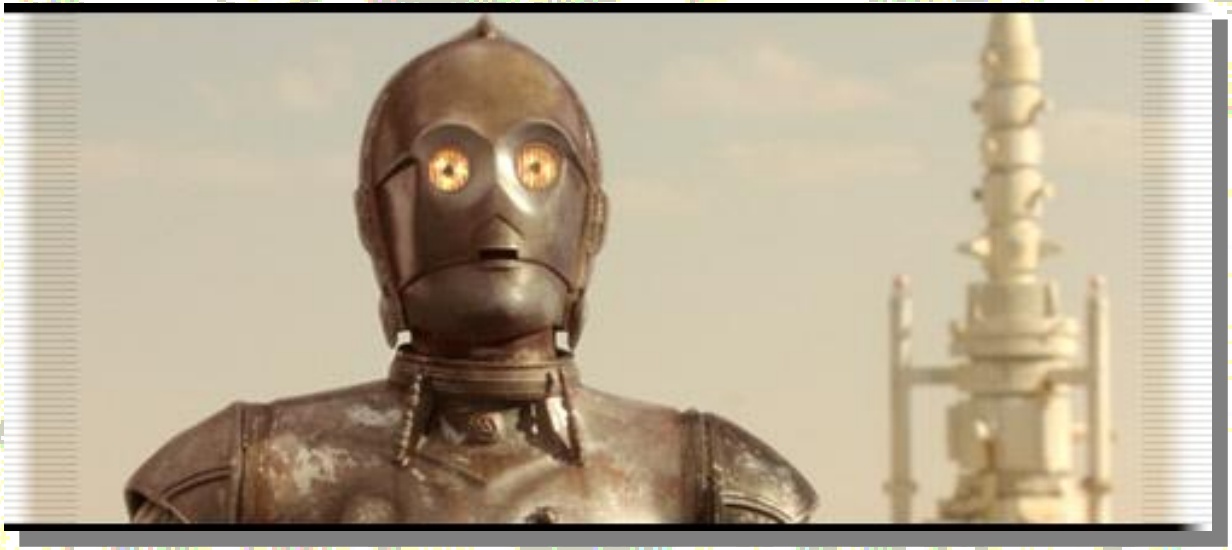
The Harvard Microrobotic Fly

- Goal: create a robotic insect capable of sustained autonomous flight
- Key Specs.: 3cm wingspan, 60mg, 2 wings





Humanoid Robot



دانشگاه صنعتی شریف

سازمان گسترش و نوسازی صنایع ایران

پژوهشکده سیستمهای پیشرفته صنعتی

Advanced Manufacturing Research Center (AMRC)

طراحی و ساخت یک سیستم گیرپیرهای روباتیکی چند منظوره

Design and Fabrication of a System of Modular Robotic Grippers

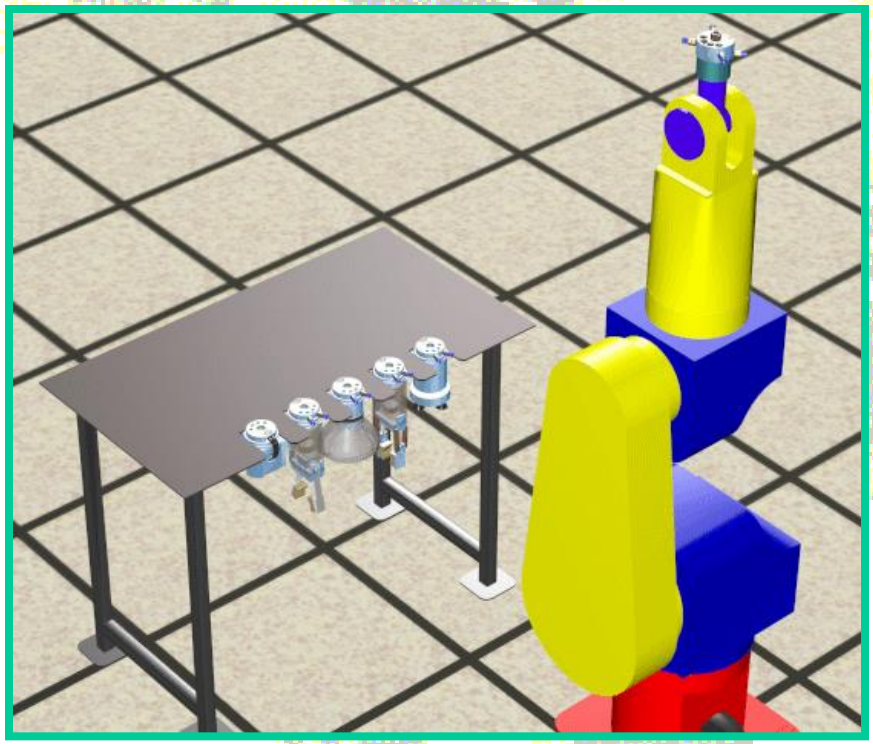
مجری طرح :

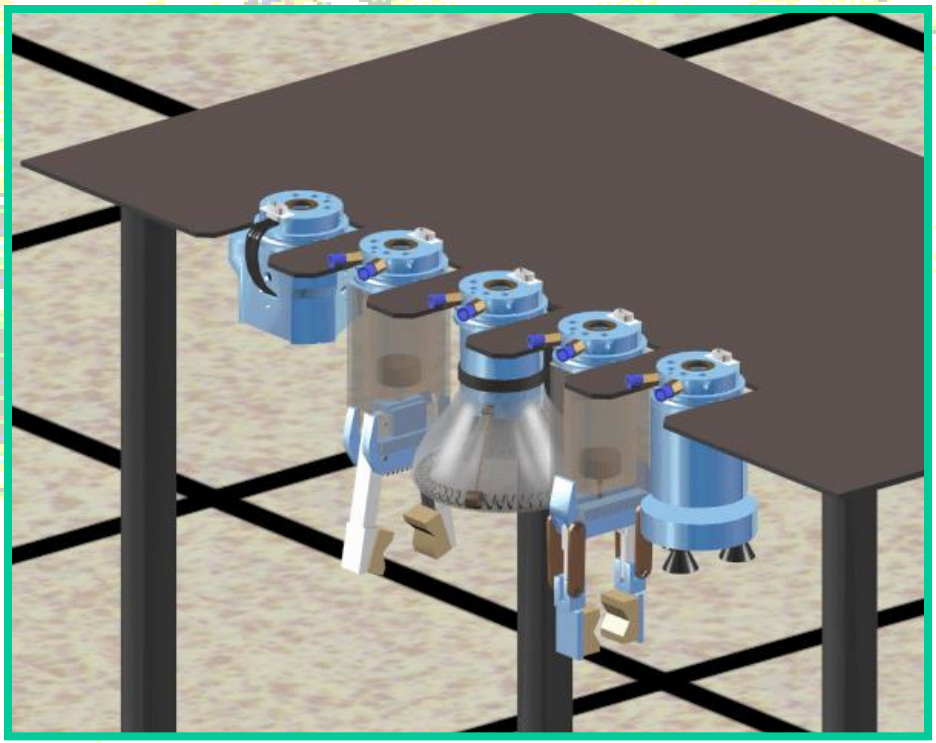
دکتر علی مقداری، دانشیار دانشکده مهندسی مکانیک - دانشگاه صنعتی شریف

Principal Investigator :

Prof. Ali Meghdari, Sharif University of Technology, School of Mechanical Engineering, Tehran, IRAN

The Animated Robotic Work Station

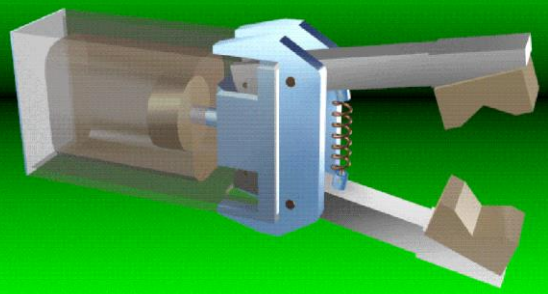


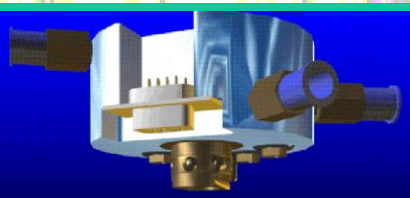


Animated Models of Robotic Grippers & The AMRC Quick Change System

گیرپیر لولایی با بادامک گوه‌ای

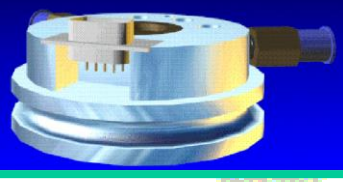
Pivoting End Effector With Wedge Cam



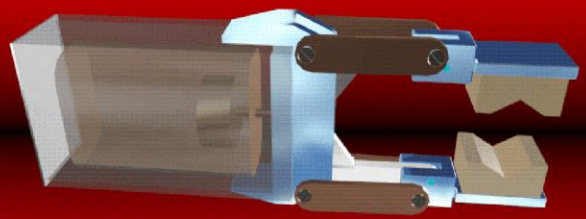


Quick Change System

سیستم تعویض سریع



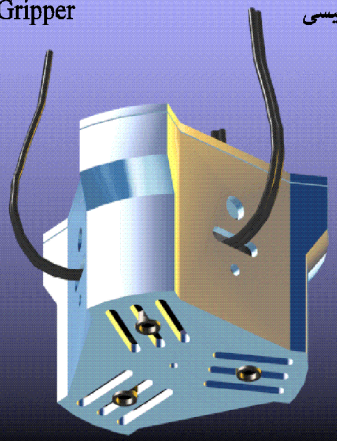
گیرپیر چهار میله‌ای موازی



Parallel Four-bar Linkage Gripper

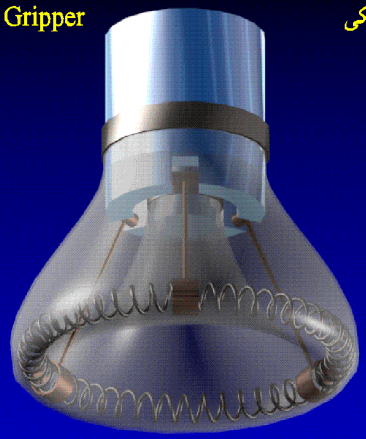
Magnetic Gripper

گیرپیر مغناطیسی

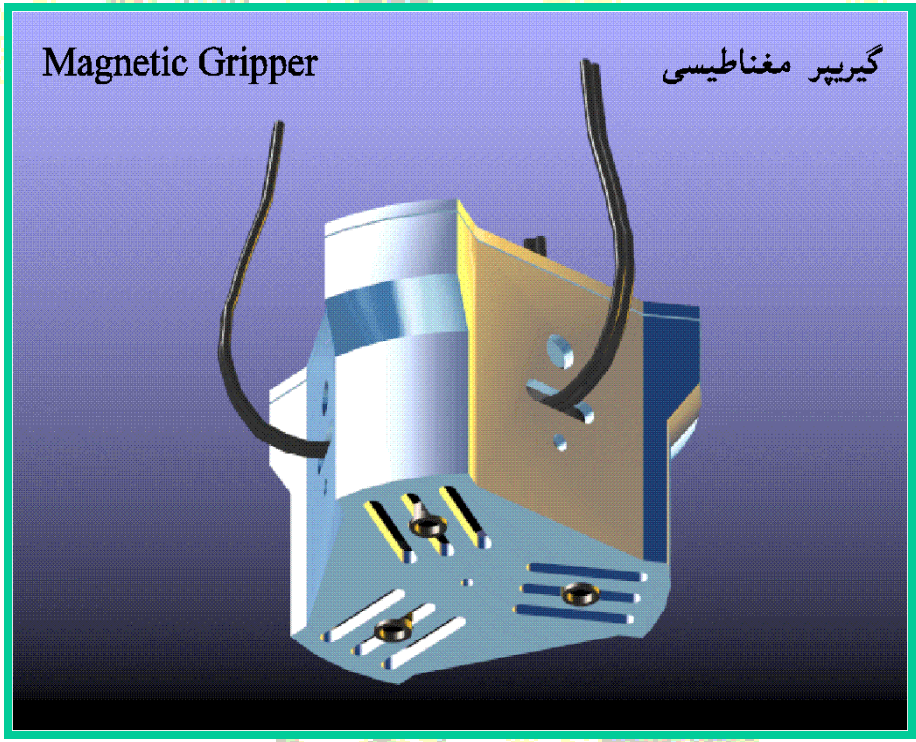


Inflatable Gripper

گیرپیر بادکنکی

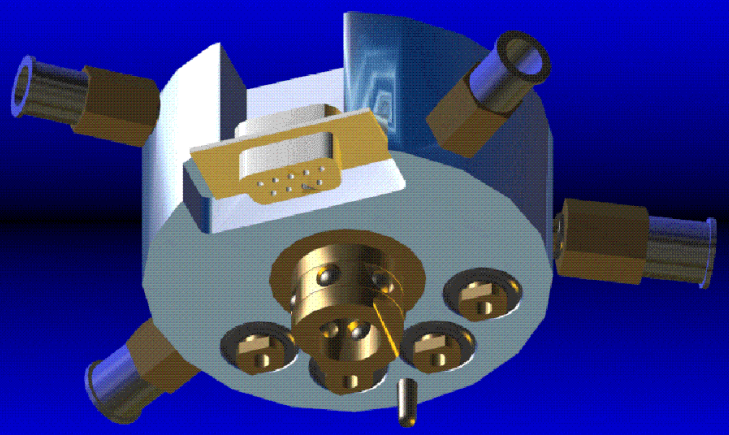


Animated Models of Robotic Grippers



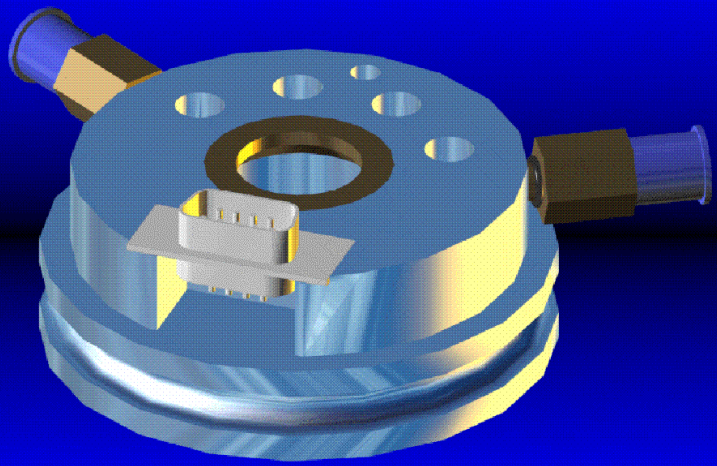
Animated Model of AMRC Quick Change System

قسمتی از سیستم تعویض سریع که به روبات وصل می‌شود.

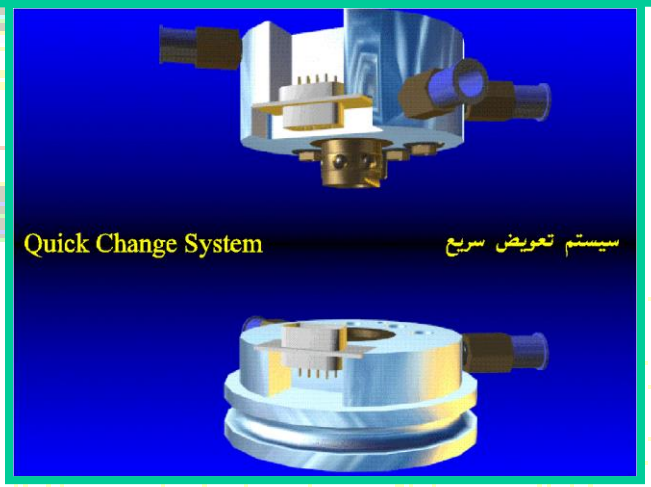


Part of Quick Change System attached to robot.

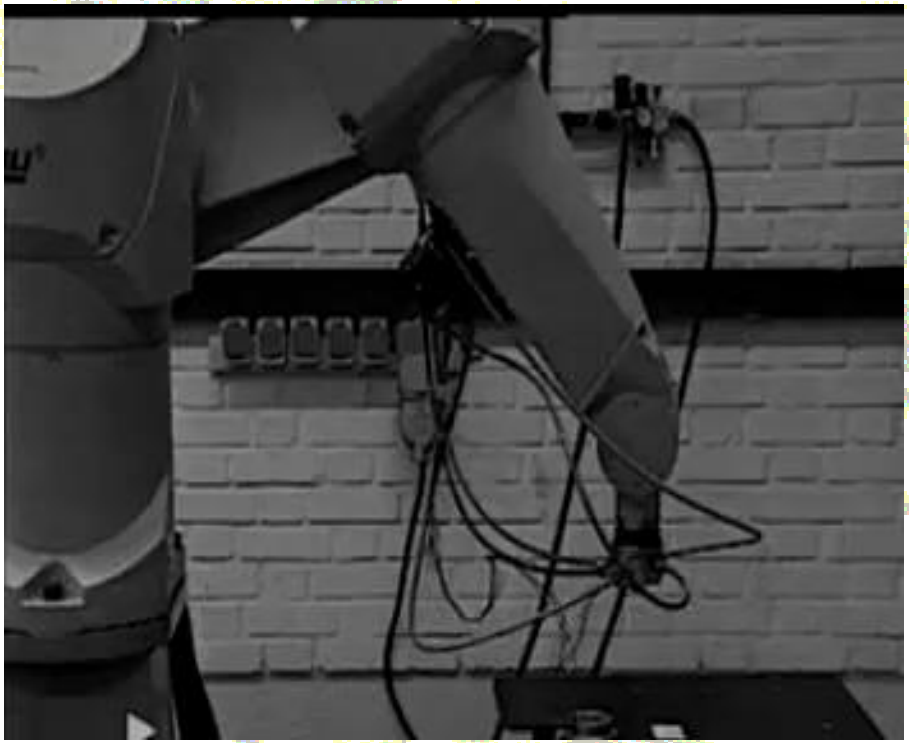
قسمتی از سیستم تعویض سریع که به گیریپر وصل می‌شود.



Part of Quick Change System attached to gripper.

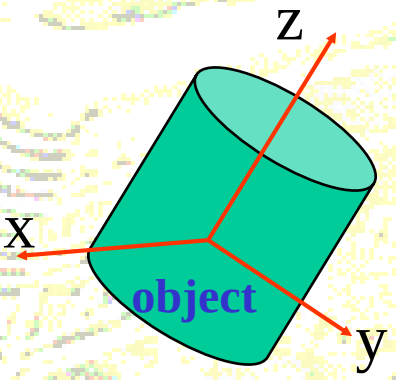


Advanced Manufacturing Research Center

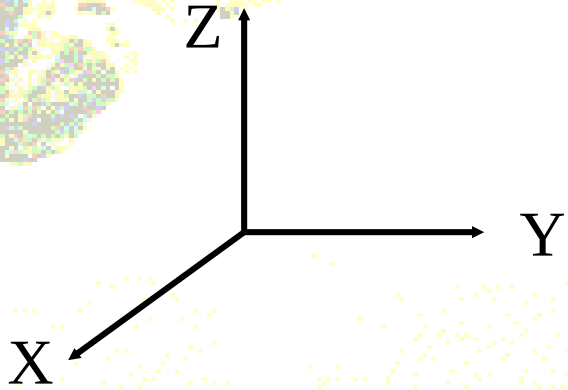


Mechanics of Mechanical Manipulators

To describe the **Position** and **Orientation** of a body in space:



- Rigidly attach a coordinate system (frame {x, y, z}) to the object, then
- Describe the Pos. & Orien. of this frame with respect to a reference frame {X, Y, Z}

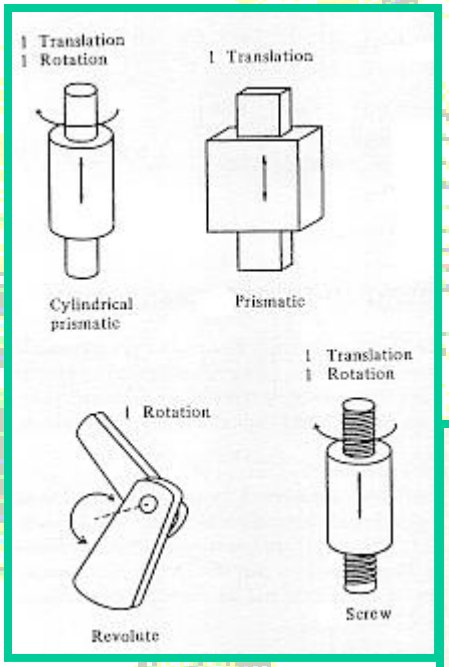


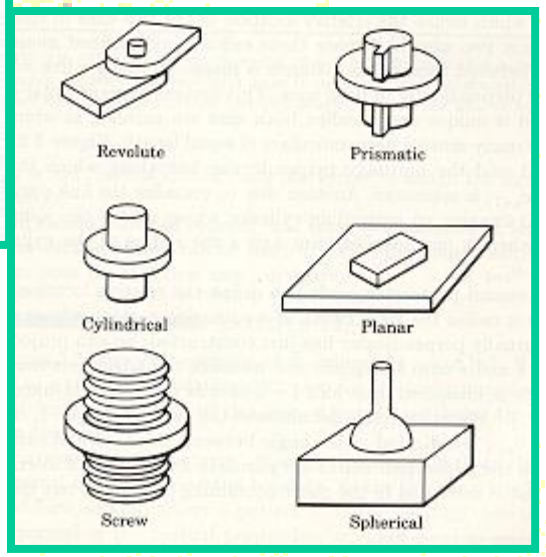
{Reference Coordinate System}

Basic Elements of Manipulator Arms

Manipulators consist of:

- Links (nearly rigid), and
- Joints:
  - Revolute (Displacement = Joint Angle)
  - Prismatic/Sliding (Translation = Joint Offset)





The Six Possible Lower-Pair Joints

Degrees-of-Freedom (Mobility) of a Robot

- An object is said to have "***n***" **degrees of freedom *(DOF)*,** if its configuration can be minimally specified by "***n*" *parameters***.
- For a robot manipulator, the number of joints determine the number of DOF.
- To reach any point in the space with an arbitrary orientation: ***6 DOF* (*3 DOF* for positioning and *3 DOF* for orientation**)

Degrees-of-Freedom (Mobility) of a Robot

- **Less than 6 DOF**: the arm cant reach any point in the space with an arbitrary orientation.
- **More than 6 DOF**: Kinematically **Redundant Manipulator.** A redundant joint is one that is unnecessary because other joints provide the needed position and/or orientation.
- Certain applications may require more than 6-DOF, for example:
  - Obstacle Avoidance.

Degrees-of-Freedom (Mobility) of a Robot

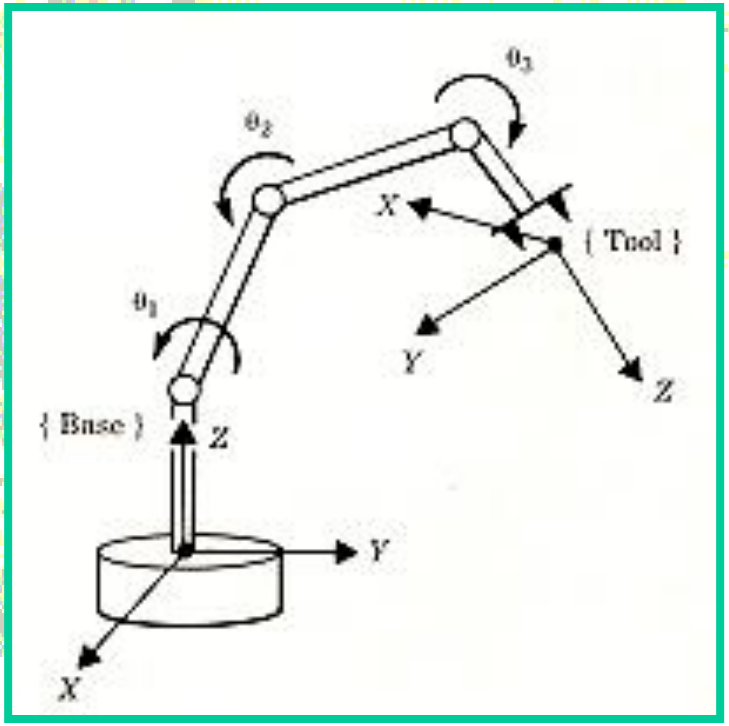
The number of input parameters (i.e. joint variables) which must be independently controlled in order to bring the robotic arm into a particular position/orientation.

- In **open kinematics chains** (i.e. Industrial Manipulators):

  {# of D.O.F. = # of Joints}

  3R = An Arm with 3 successive Revolute Joints.

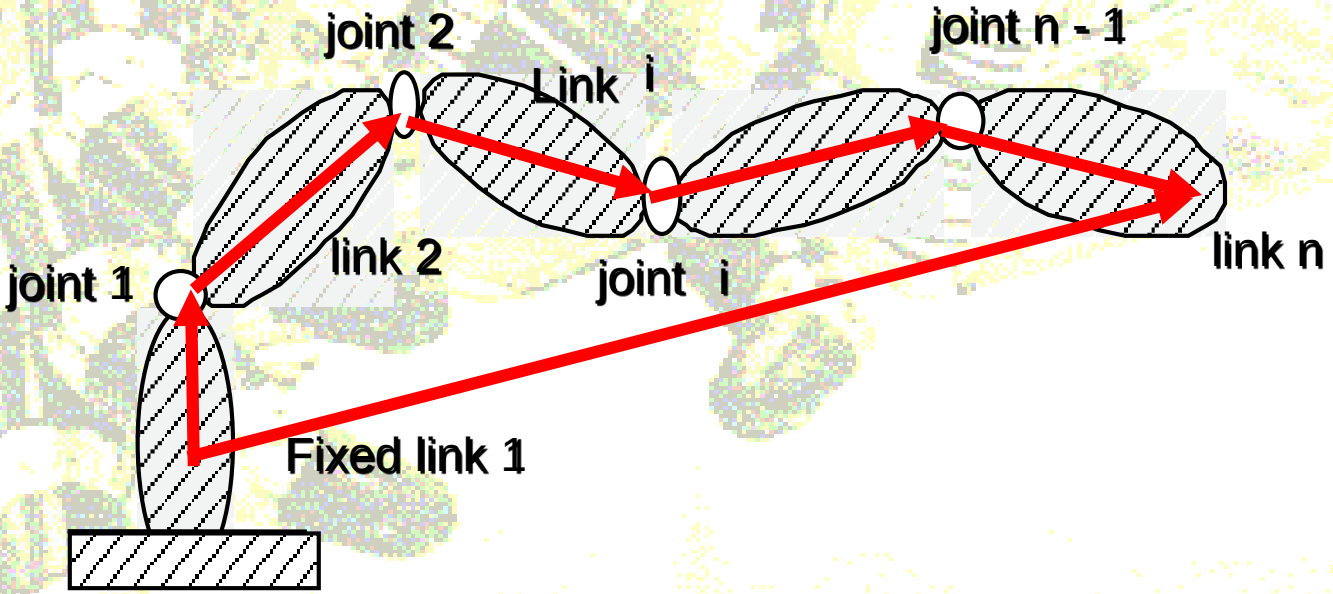
  3P = An Arm with 3 successive Sliding/Prismatic Joints.



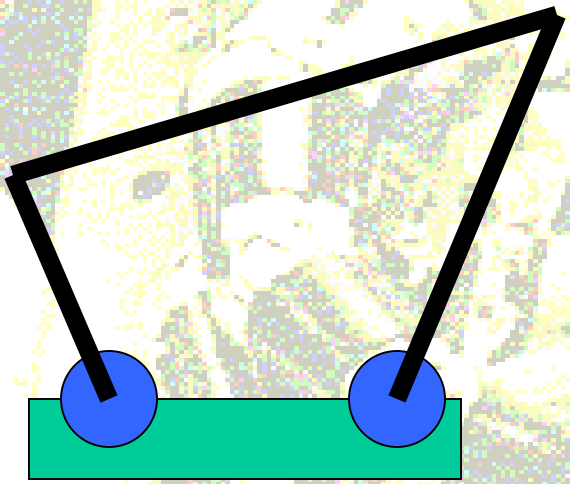
A 3-DOF Manipulator Arm

Kinematics chain

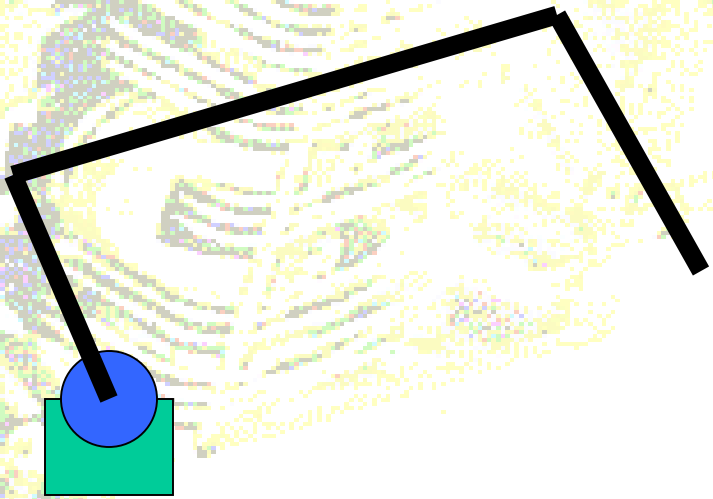
Mechanisms can be configured as kinematics chains. The chain is closed when the ground link begins and ends the chain; otherwise, it is open.



Simple Examples



A one degree-of-freedom closed-loop mechanism

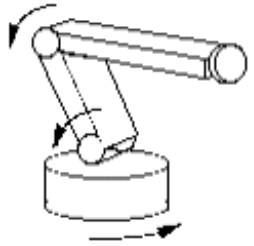


A three degree-of-freedom open-loop mechanism

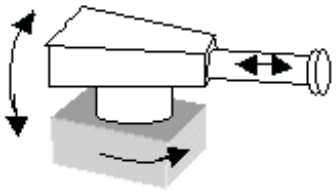
Serial Robot Types

Serial robots can be classified as revolute, spherical, cylindrical, or rectangular (translational, prismatic, or Cartesian).

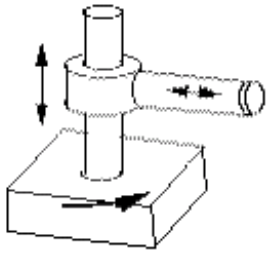
These classifications describe the primary DOF (degrees-of-freedom) which accomplish the global motion as opposed to the distal (final) joints that accomplish the local orientation.



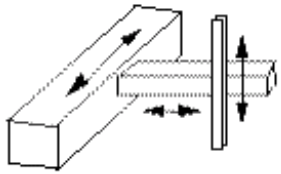
Revolute



Spherical¶



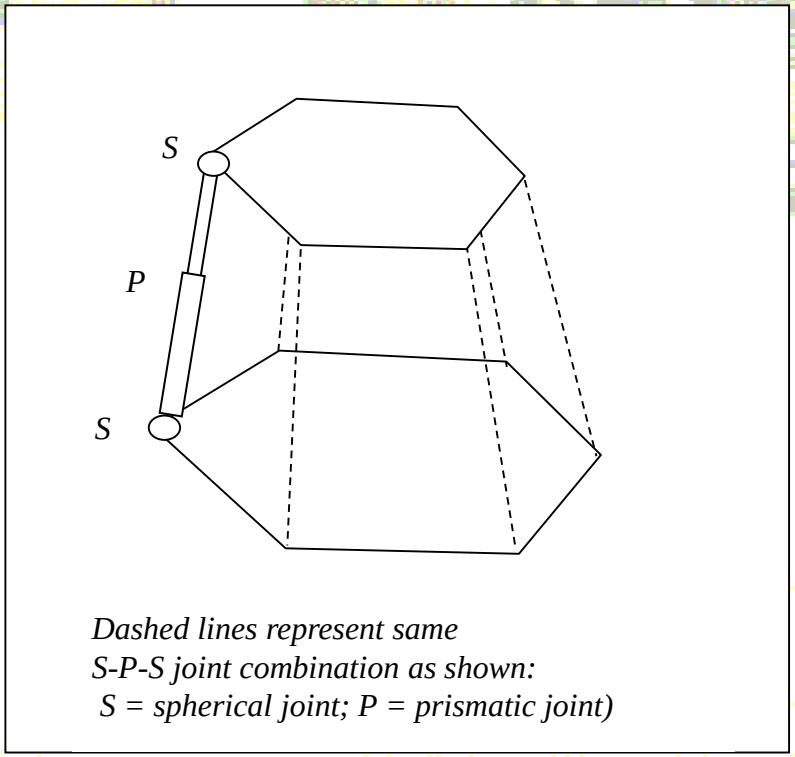
Cylindrical¶



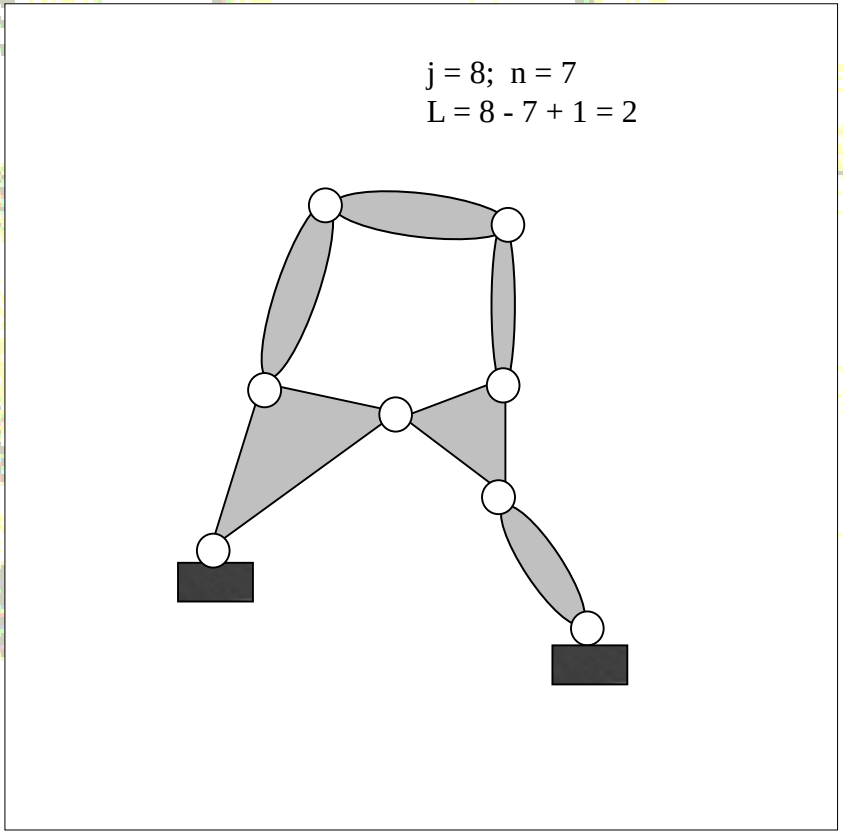
Rectangular¶

Closed Loop Robot Types

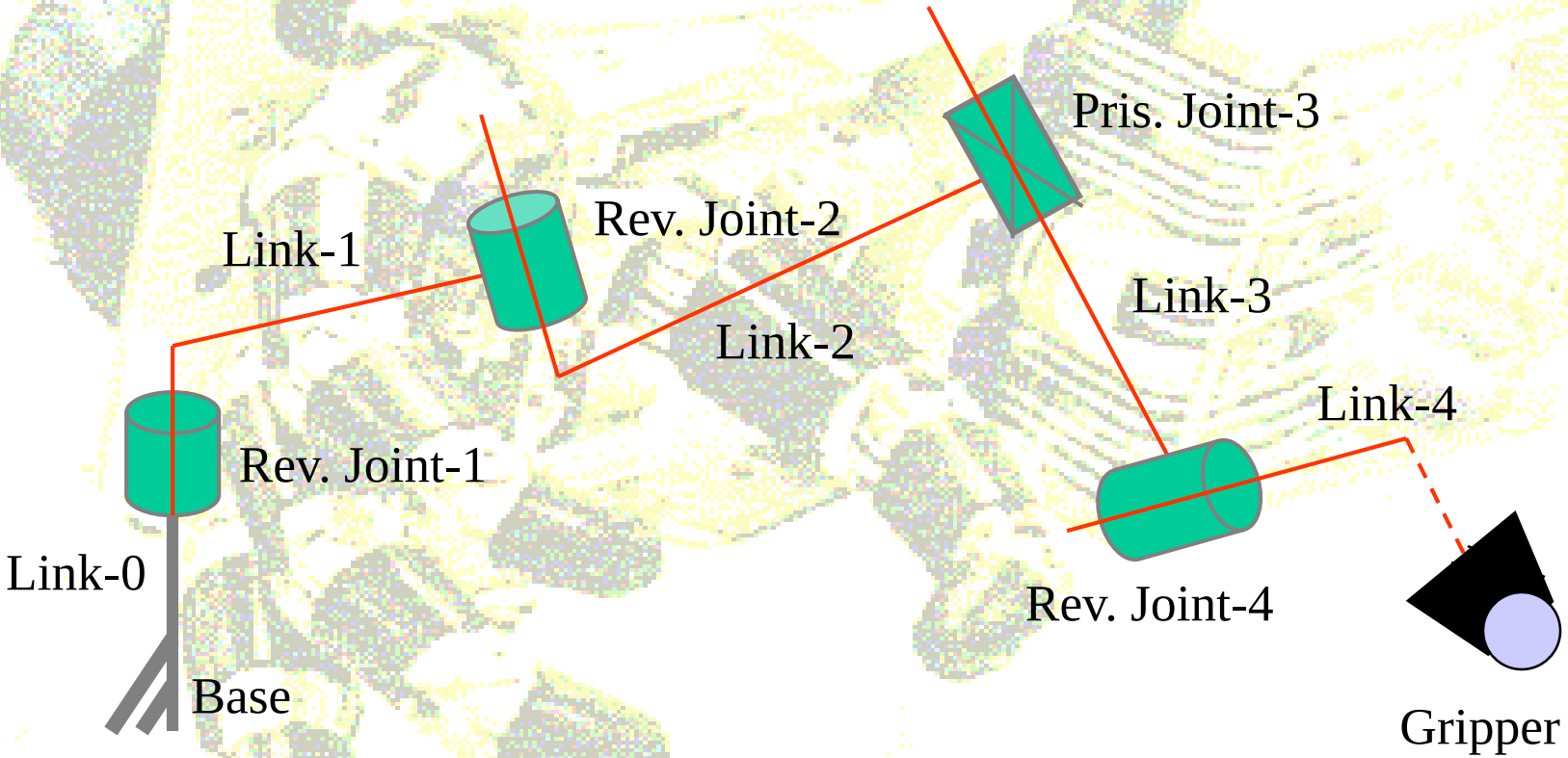
Closed loop robots/mechanisms like: Stewart Platform/Parallel Robots, and Multiple-Loop Mechanism/Robots).



Dashed lines represent same S-P-S joint combination as shown: S = spherical joint; P = prismatic joint)



Degrees-of-Freedom (Mobility) of a Robot



A **2R1P1R** Robot Manipulator