ME 599/699 Robot Modeling & Control

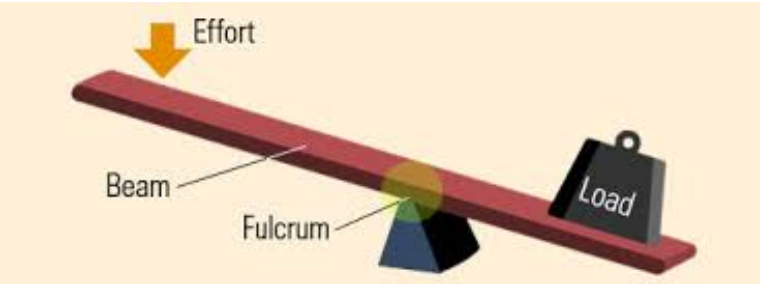
Robot Mechanisms

Spring 2020

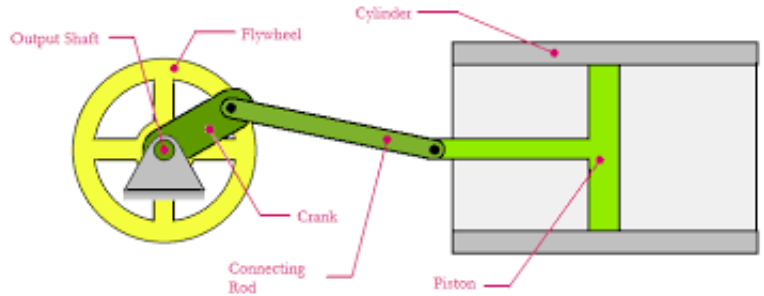
Hasan Poonawala

Robot Mechanisms

Mechanisms such as simple levers and crank-and-piston are widely used to transfer power/energy/force.



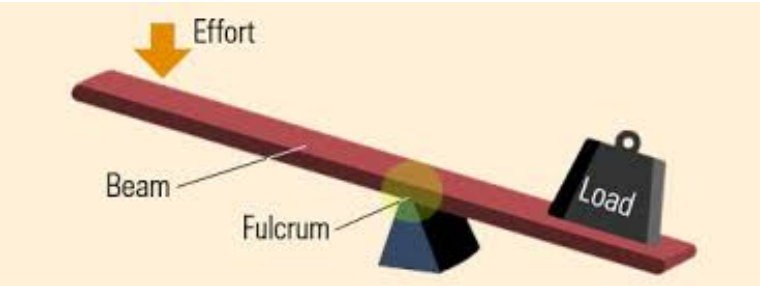
Simple lever



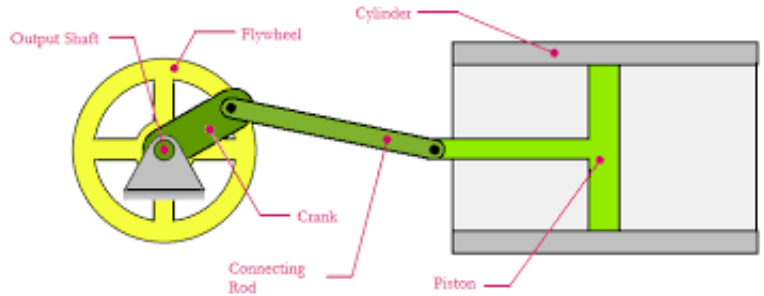
Crank and Piston

Robot Mechanisms

Mechanisms such as simple levers and crank-and-piston are widely used to transfer power/energy/force.



Simple lever

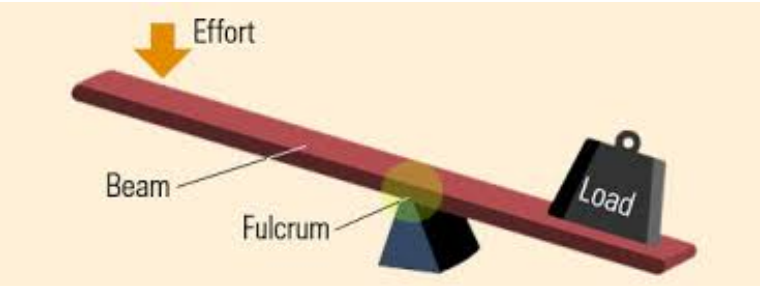


Crank and Piston

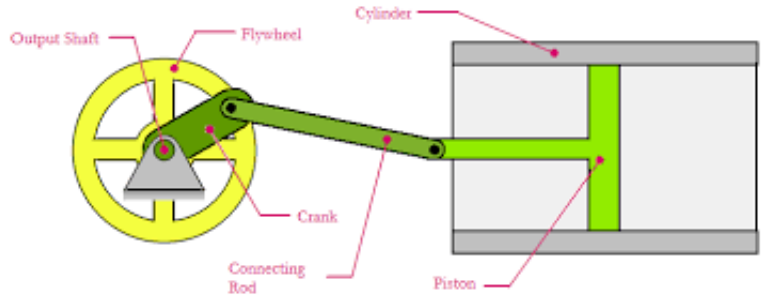
These mechanisms consist of (ideally) rigid bodies connected by joints that constrain relative motion.

Robot Mechanisms

Mechanisms such as simple levers and crank-and-piston are widely used to transfer power/energy/force.



Simple lever



Crank and Piston

These mechanisms consist of (ideally) rigid bodies connected by joints that constrain relative motion.

Examples of Joints

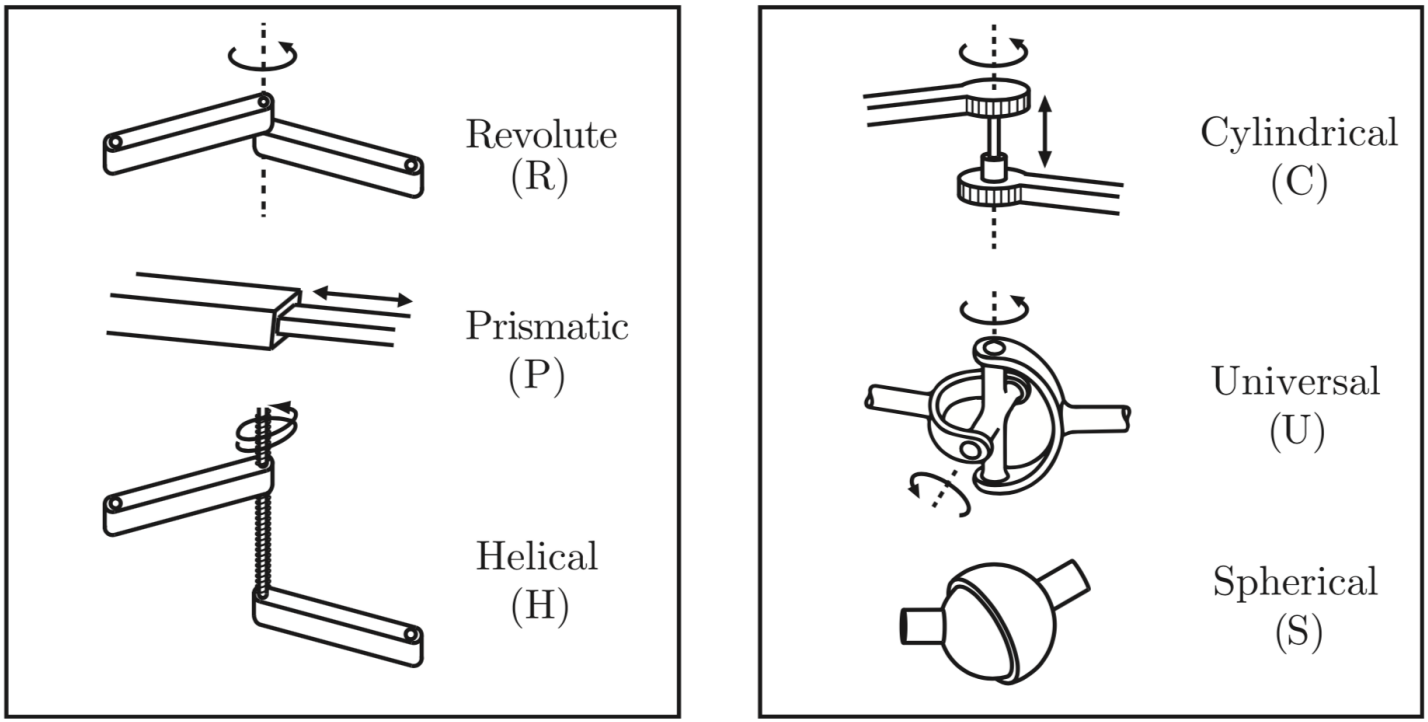


Figure 2.3: Typical robot joints.
source: Modern Robotics

Any joint can be abstractly replaced by multiple revolute (R) and/or prismatic (P) joints. Example: C= R+P

Joint Constraints

Joint type	dof f	Constraints c between two planar rigid bodies	Constraints c between two spatial rigid bodies
Revolute (R)	1	2	5
Prismatic (P)	1	2	5
Helical (H)	1	N/A	5
Cylindrical (C)	2	N/A	4
Universal (U)	2	N/A	4
Spherical (S)	3	N/A	3

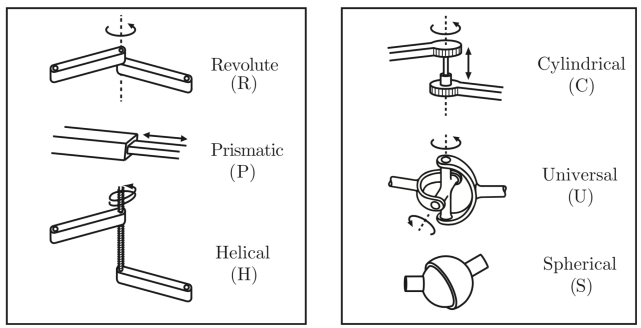
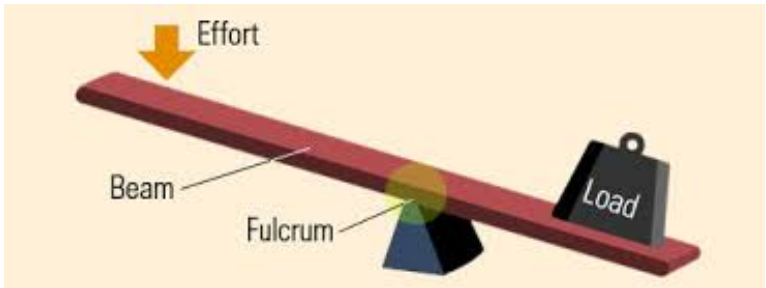


Figure 2.3: Typical robot joints.

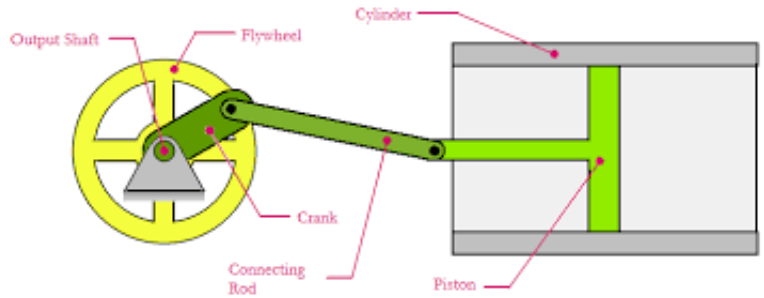
source: Modern Robotics

Exercise: Planar mechanisms

How many joints can you identify here? :



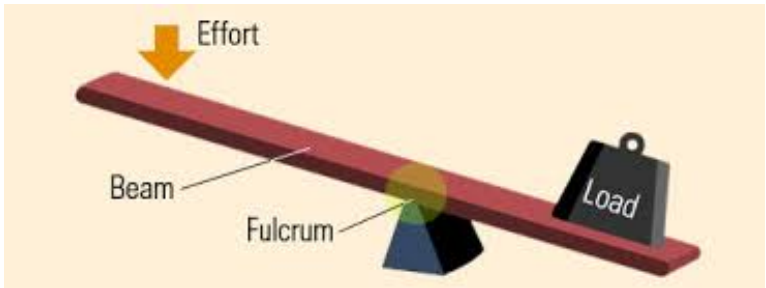
Simple lever



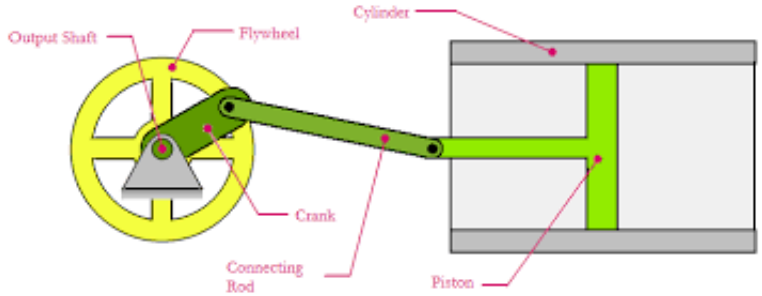
Crank and Piston

Exercise: Planar mechanisms

How many joints can you identify here? :



Simple lever

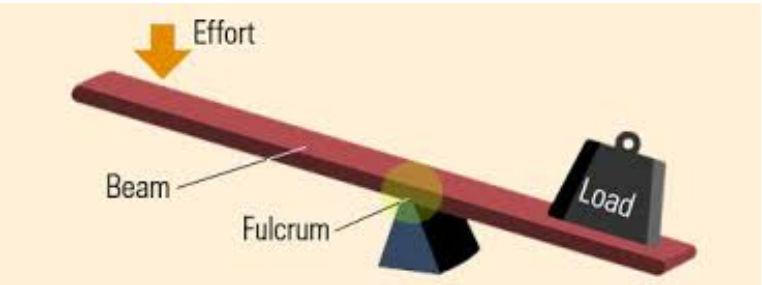


Crank and Piston

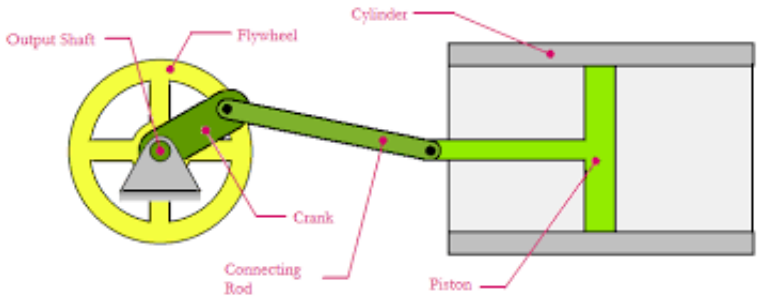
Lever: one revolute joint at the fulcrum.
Crank and Piston: Three revolute joints, one prismatic joint (formed by piston and cylinder)

Exercise: Planar mechanisms

What are the degrees of freedom of these mechanisms? :



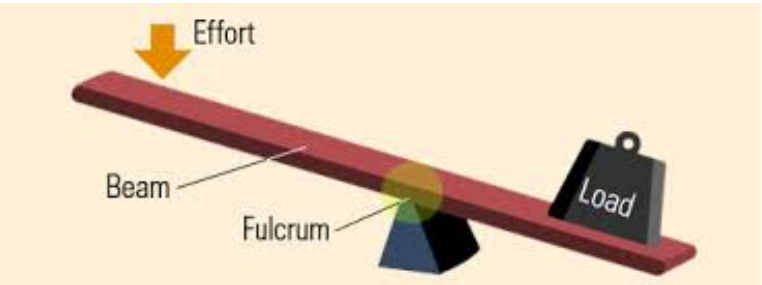
Simple lever



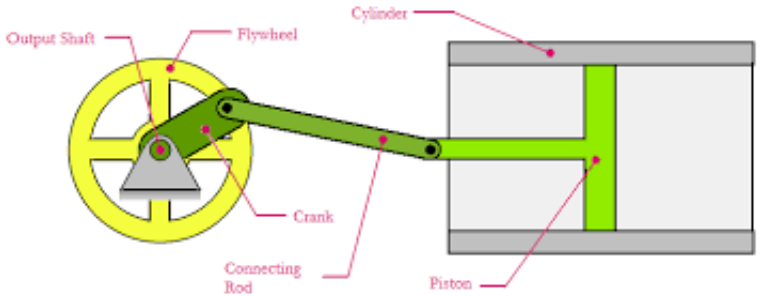
Crank and Piston

Exercise: Planar mechanisms

What are the degrees of freedom of these mechanisms? :



Simple lever



Crank and Piston

Lever: 1.
Why: the planar lever has 3DoF (two linear, one rotation). The revolute joint constrains 2DoF.

Crank and Piston: 1.
Why: Three moving links (green objects) = 9 DoF. The four joints restrict $4 \times 2 = 8$ DoF.

Kinematic Chains

We can combine links and joints in multiple ways:

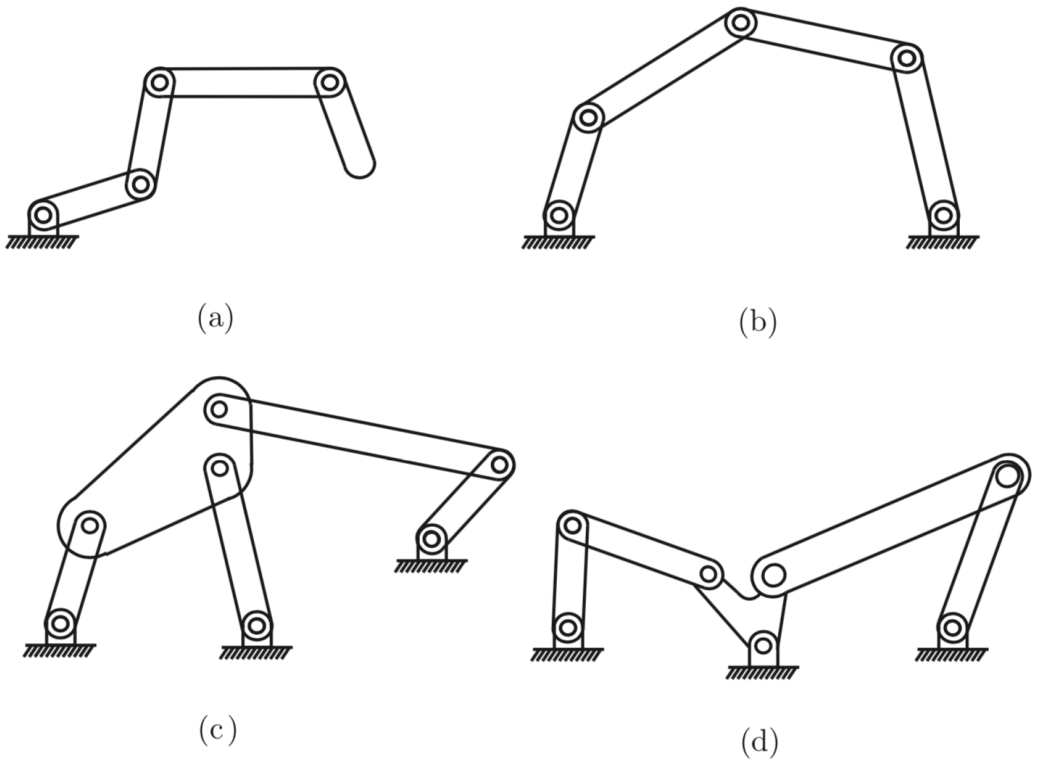


Figure 2.5: (a) k-link planar serial chain. (b) Five-bar planar linkage. (c) Stephenson six-bar linkage. (d) Watt six-bar linkage.

Kinematic Chains

Types of kinematic chains:

- Open / Closed
- Serial / Parallel

Idea: think of links forming a circuit including the non-moving fixed frame. Is it open/closed? Are links in series or parallel?

Kinematic Chains

Types of kinematic chains:

- Open / Closed
- Serial / Parallel

Idea: think of links forming a circuit including the non-moving fixed frame. Is it open/closed? Are links in series or parallel? Can you classify the mechanisms below?

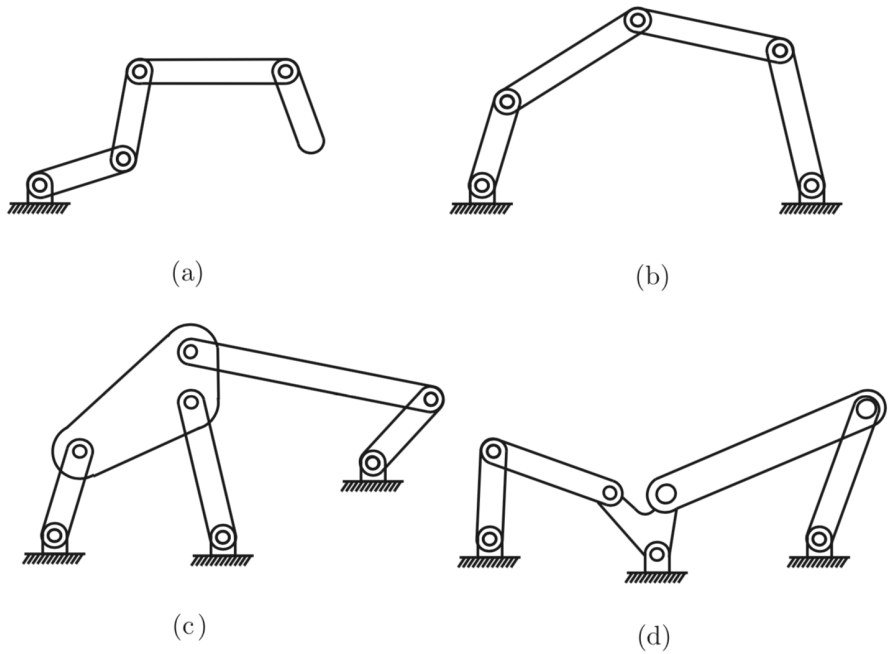
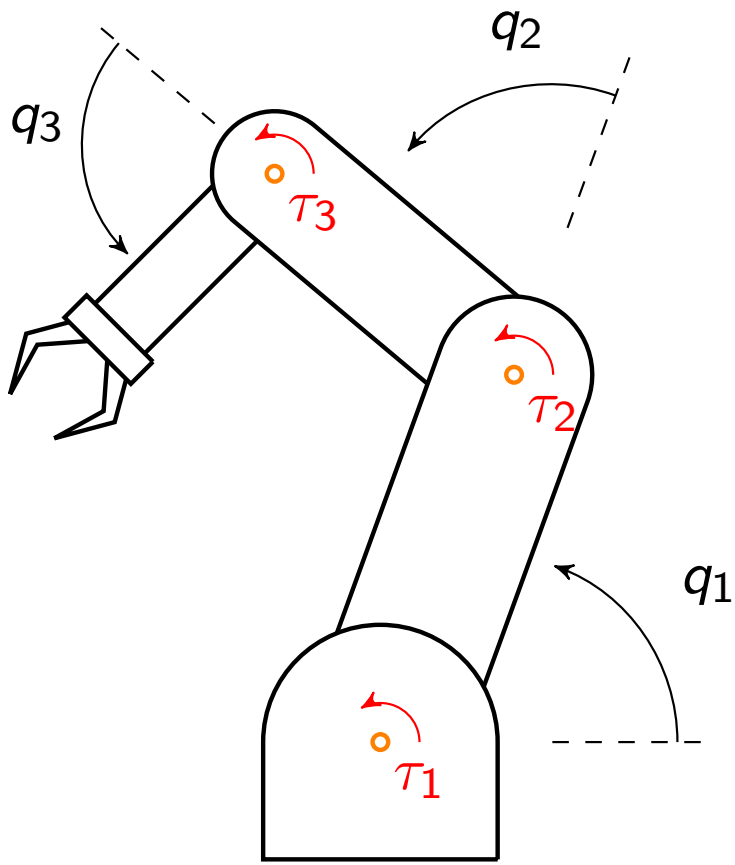


Figure 2.5: (a) k-link planar serial chain, (b) Five-bar planar linkage, (c) Stephenson

Robot Configurations: Joint Variables

The configuration q of such robots will depend on the joints between rigid parts that make up the robot

Robot Configurations: Joint Variables



The configuration q of such robots will depend on the joints between rigid parts that make up the robot

Powering Robots

The robot is usually powered at its joints, using servo **motors** or linear actuators.

Powering Robots

The robot is usually powered at its joints, using servo **motors** or linear actuators.

By attaching an **encoder** to the motor, we can measure the relative angles or translation between the two links at a joint.

Powering Robots

The robot is usually powered at its joints, using servo **motors** or linear actuators.

By attaching an **encoder** to the motor, we can measure the relative angles or translation between the two links at a joint.

In other words, we can change and measure the configuration q of a robot with revolute or prismatic joints in practice.

Powering Robots

The robot is usually powered at its joints, using servo **motors** or linear actuators.

By attaching an **encoder** to the motor, we can measure the relative angles or translation between the two links at a joint.

In other words, we can change and measure the configuration q of a robot with revolute or prismatic joints in practice.

This fact is responsible for the development of robot modeling and control as it occurred, which happened before computer vision was as powerful as it is today.