

# INTRODUCTION TO ROBOTICS

(Kinematics, Dynamics, and Design)

## SESSION # 5: CONCEPTS & DEFINITIONS

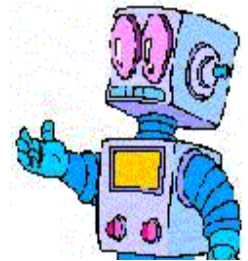
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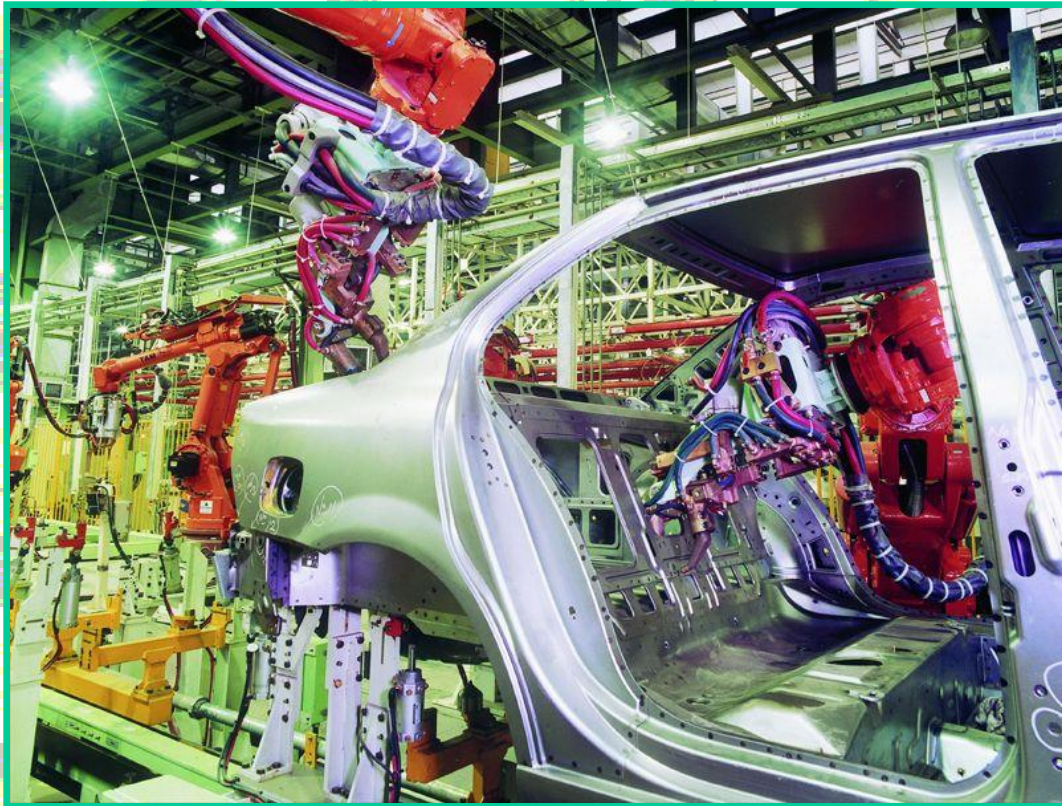
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# KUKA Robots Videos



AVSEQ01.DAT



AVSEQ04.DAT



# Foundations of Robotics

## Robotics Fundamentals

### Mechanical Manipulation

#### Mechanics

Mechanical Design

Direct Kinematics

Inverse Kinematics

Workspace/Trajectory Planning

Jacobians/Dynamics

Control Theory

Computer Science

Locomotion (Mobile Robots)

Computer Vision

Artificial Intelligence



# Important Definitions & Terminologies

- **Android:** A robot which resembles a human in physical appearance.
- **Artificial Intelligence:** The ability of a machine to respond to a new situation and to solve problems without human interference. (To learn from experience).
- **Manipulation:** Grasping, releasing, moving, transporting, or otherwise handling an object.
- **Manipulator:** A mechanism usually with several degrees-of-freedom which is designed for manipulation.
- **Master/Slave Manipulator:** A type of teleoperator consisting of a master arm held, moved, and positioned by a person, and a slave arm which simultaneously duplicates the operators motions (with a scale factor).



# Important Definitions & Terminologies

- **Prosthetic Robot:** A controlled mechanical device connected to the human body which provides a substitute for human arms or legs when their function is lost.
- **Intelligent/Adaptive Robot:** A category of robots that have sensory perception, making them capable of performing complex tasks which vary from cycle to cycle. (Automatically adjusts its task to the changing conditions in the environment).
- **End-Effector/Gripper:** A device connected to the end of a manipulator by which objects can be clamped, grabbed, or otherwise secured for movement.
- **Mobile Robot:** A robot mounted on a movable platform (base).
- **Payload:** The maximum weight that can be handled by a robot without failure.
- **Actuator:** An electrical, hydraulic, or pneumatic driver, such as a cylinder or electric motor, which delivers power for robot motion.



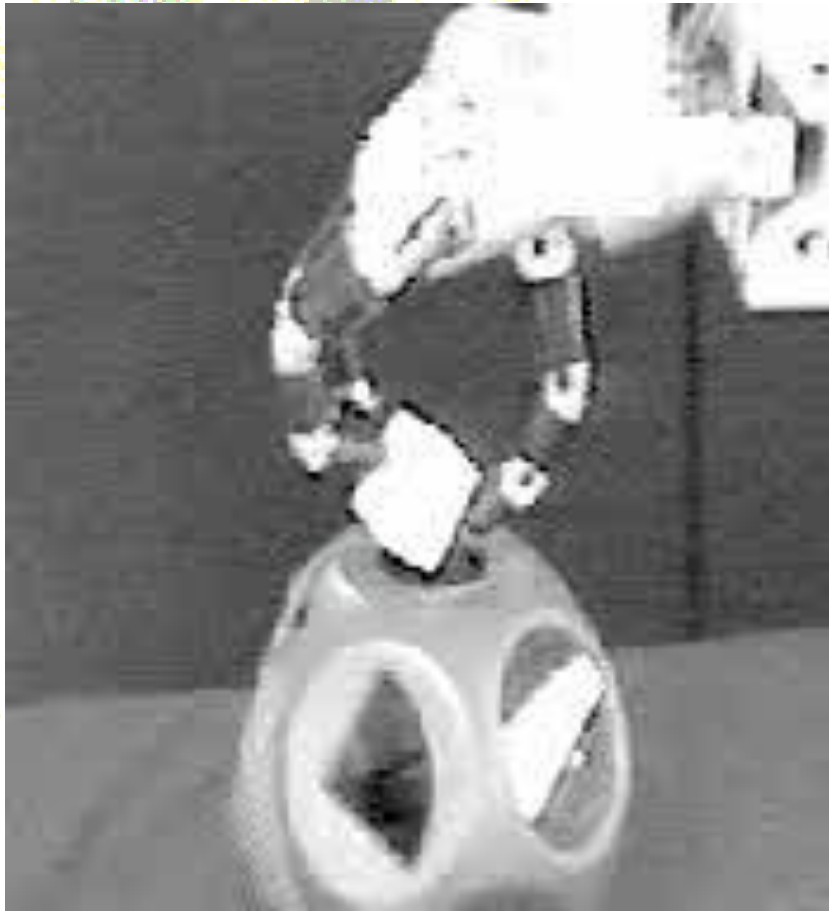


# Assembly and Manipulation at Different Scales

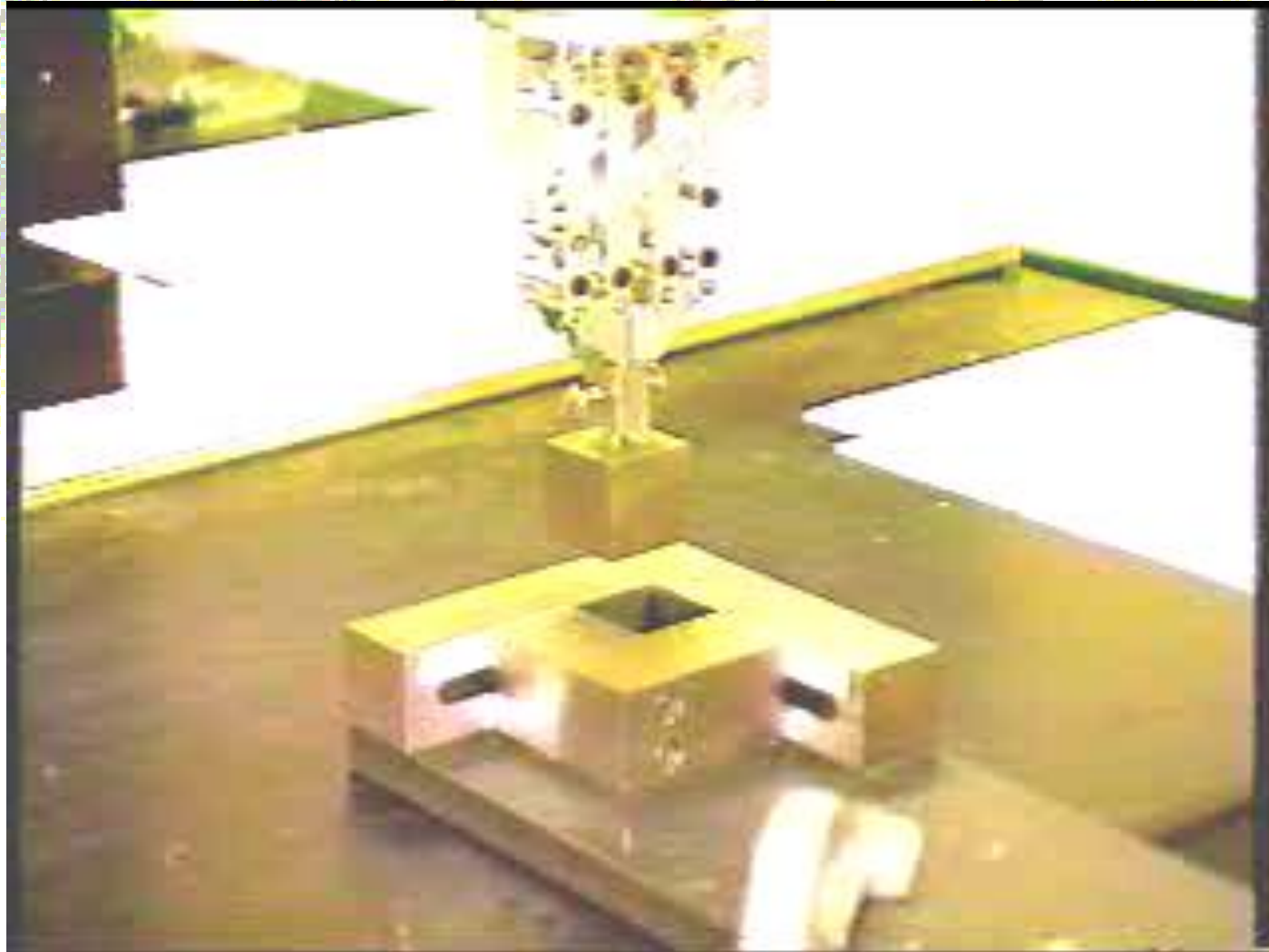
Assembly scale	Mesoscale	Microscale	Nanoscale
<b>Attribute</b>			
<b>Positioning</b>	Easy	Difficult	Very difficult
<b>Velocity</b>	Cm/s or m/s are not unusual	Slow ( $\mu\text{m/s}$ ), or (mm/s), vibration suppression	Very slow Nm/s, or $\mu\text{m/s}$
<b>Force Sensing and Control</b>	Easy / Necessary to avoid part damage and improve manipulability.	Difficult, The range of forces to be sensed could be as low as $\mu\text{N}$ .	Difficult, AFM (atomic force microscope) is used to measure force.
<b>Dominant forces</b>	Gravity, Friction	Friction, Surface forces (stiction, electrostatic, Van der Waals)	Molecular/Atomic forces
<b>Throughput</b>	Serial assembly provides adequate throughput.	Serial assembly is usually not sufficient. Parallel manipulation methods are preferred.	Parallel manipulation methods, or self-assembly are necessary.
<b>Gripper</b>	Mechanical, many examples, RCC, Utah/MIT hand, etc.	Micromechanical, gripper-free manipulation preferred.	Other, optical, proximity force, etc.
<b>Fixturing</b>	Mechanical	Micromechanical fixturing must be used	Chemical
<b>Compliance</b>	Gripper compliance is not necessary if force is measured.	Gripper compliance is usually necessary.	Mechanical compliance does not apply.
<b>Vision</b>	Easy	Difficult (expensive optics)	Impossible in visible wavelengths.



# Robot Gripper/End Effector

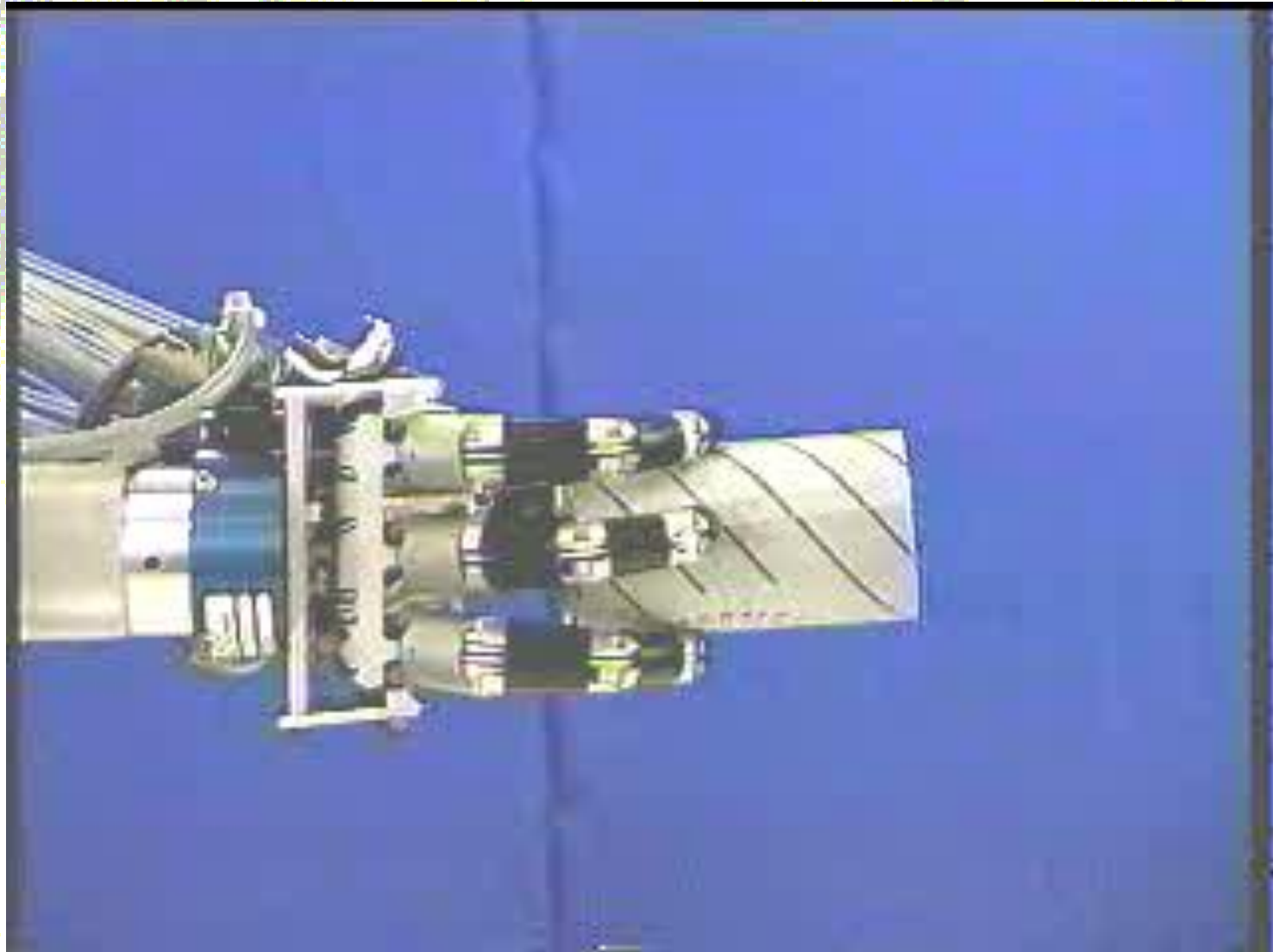


# Robot Gripper/End-Effector

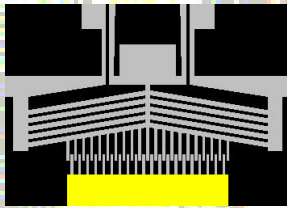




# Robot Grippers/End Effectors



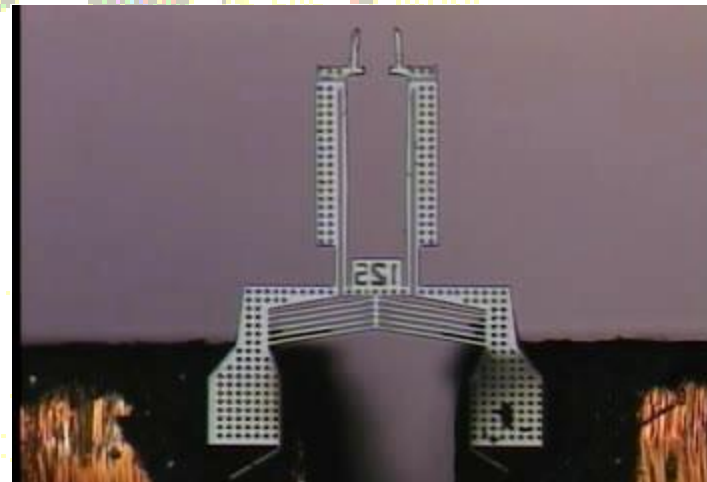
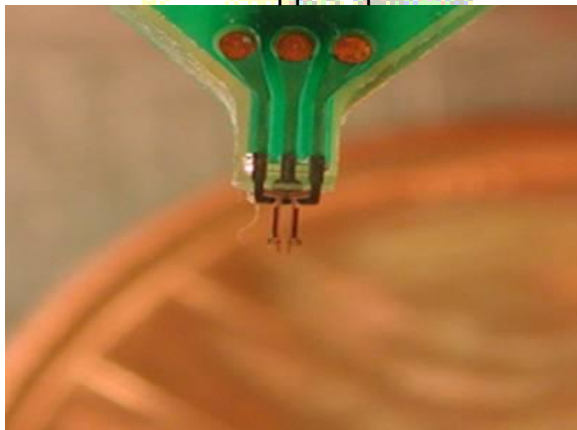
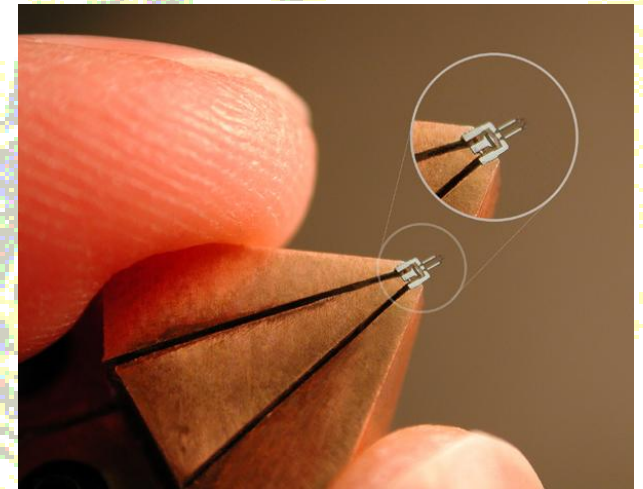
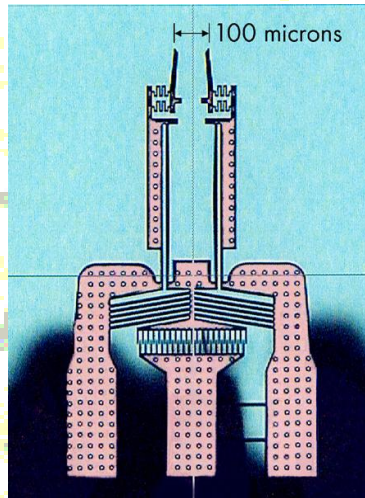
# Micro-Grippers for Micro-Assembly



Capacitive force sensor

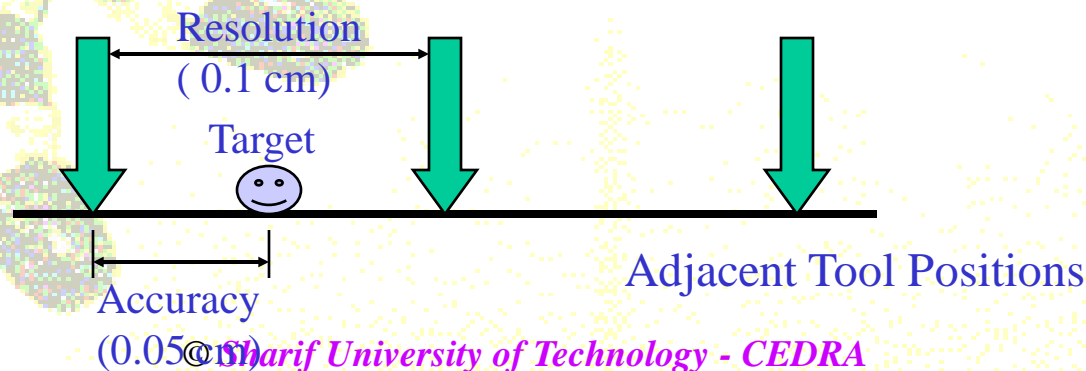


Gripper tips

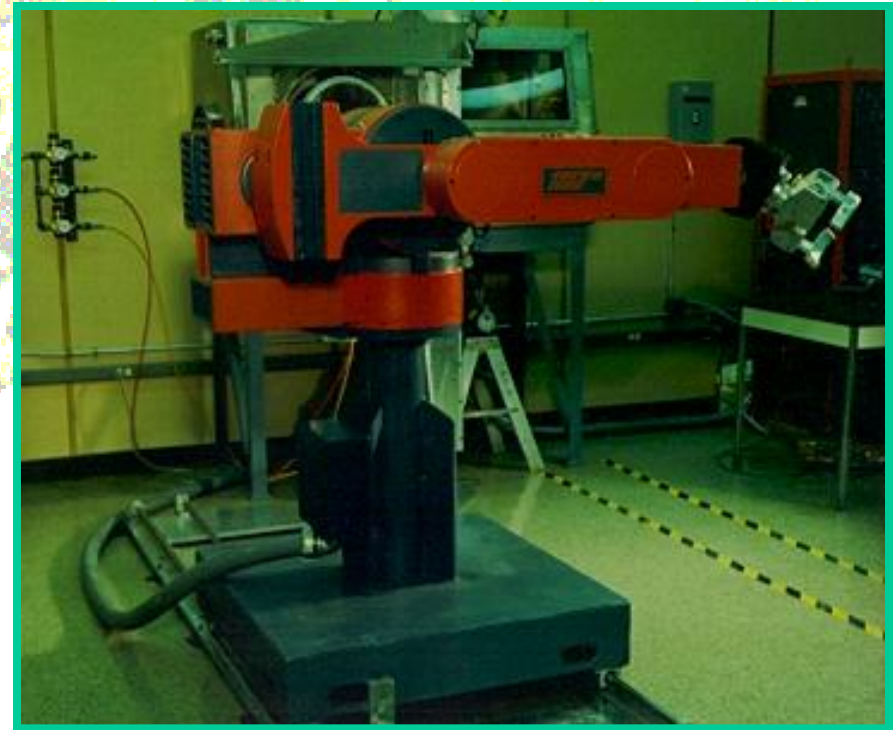
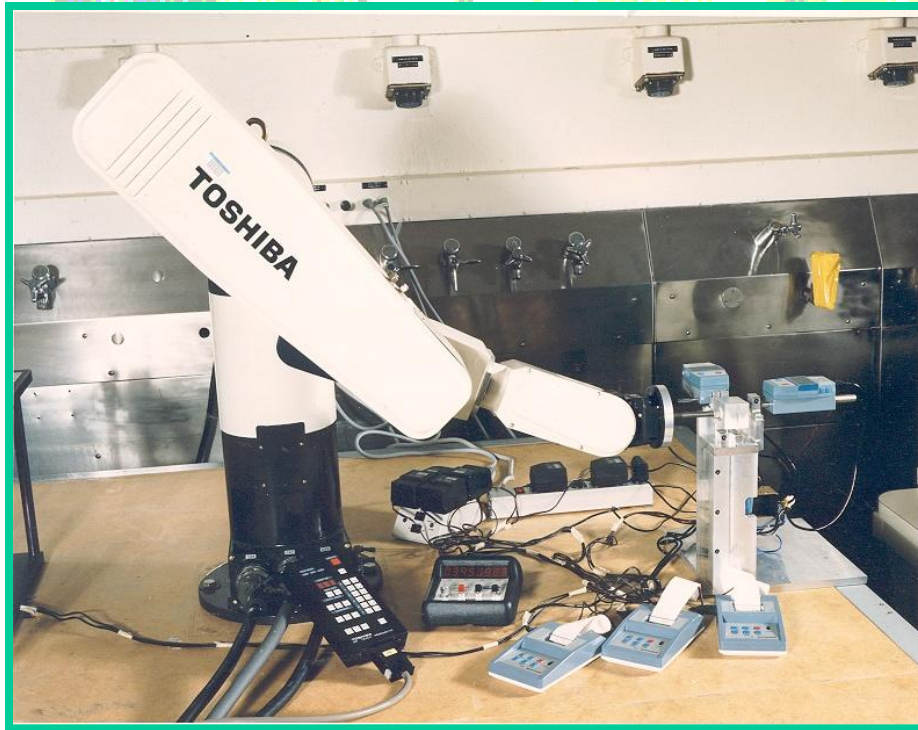


# Accuracy, Resolution, and Repeatability

- **Accuracy:** The difference between the point that a robot is trying to achieve and the actual resultant position  $\cong \frac{1}{2} \text{ Res.}$ , depends on backlash in gears and elastic deformations in links.
- **Resolution:** The smallest increment of motion or distance that can be detected or controlled by the control system of a mechanism/robot.
- **Repeatability:** The ability of a system or mechanism to repeat the same motion when presented with the same control signals. The cycle-to-cycle error of a system when trying to perform a specific task. (The precision of a robotic arm in returning to a previously taught position).

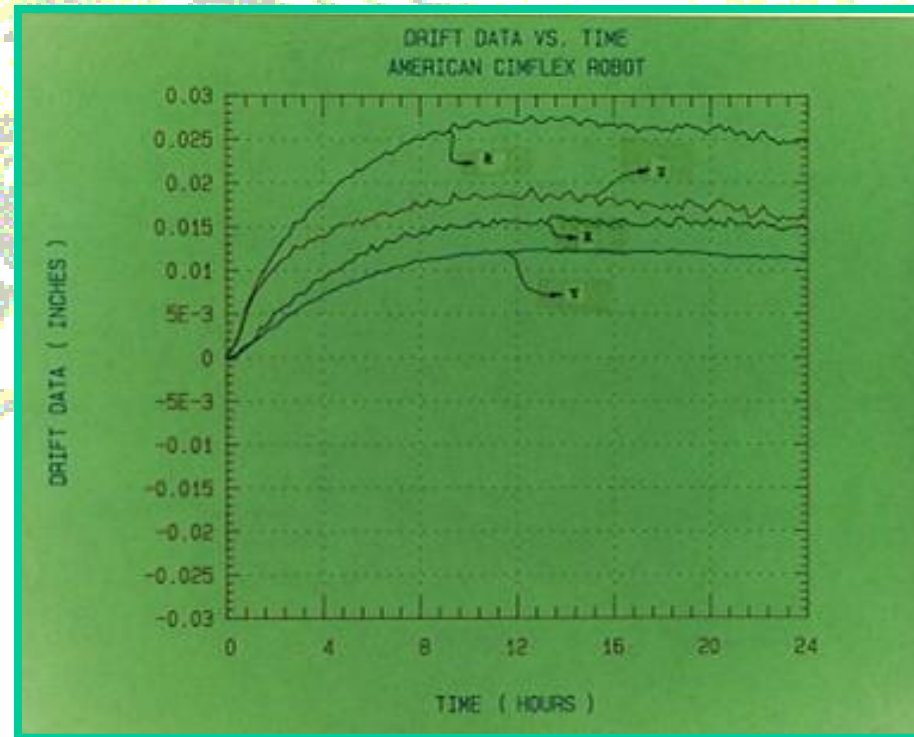
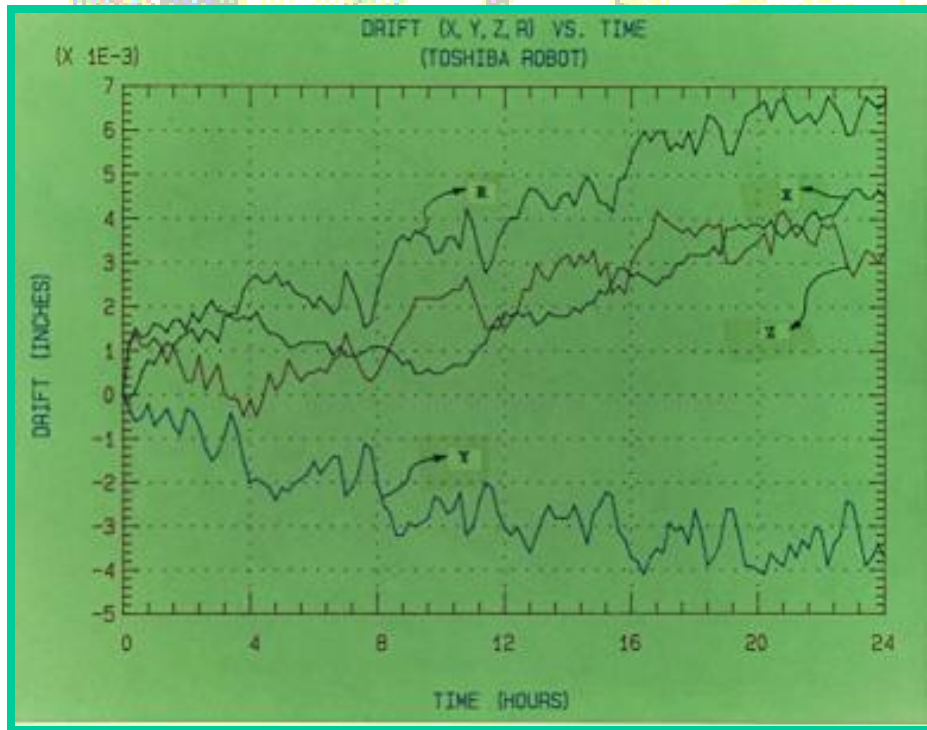


# Robotics Group: Los Alamos National Laboratory





# Robotics Accuracy and Repeatability (Drift) Measurement and Analysis



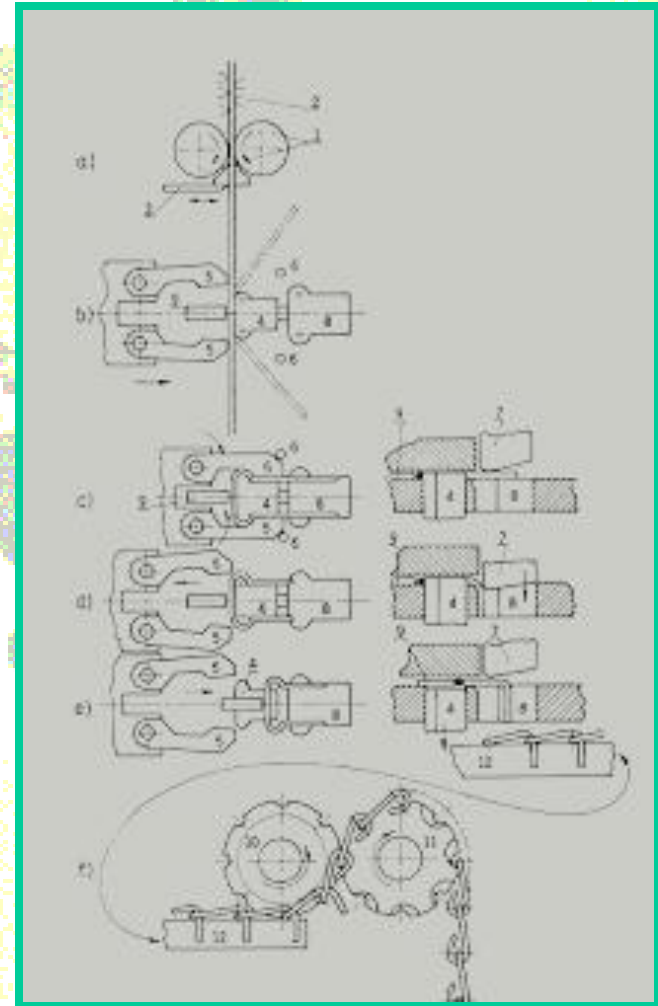
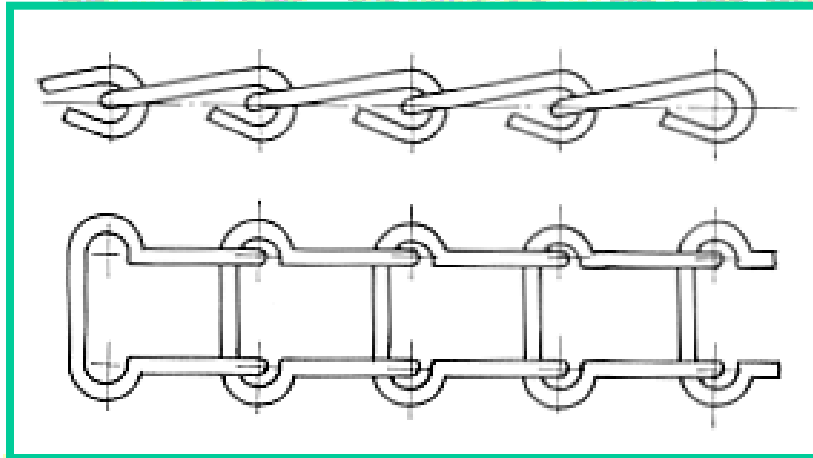


**Automation:** Technology concerned with the use of mechanical, electronic, and computer-based systems in the operation and control of production. (The technique of making a process automatic or self-controlling).

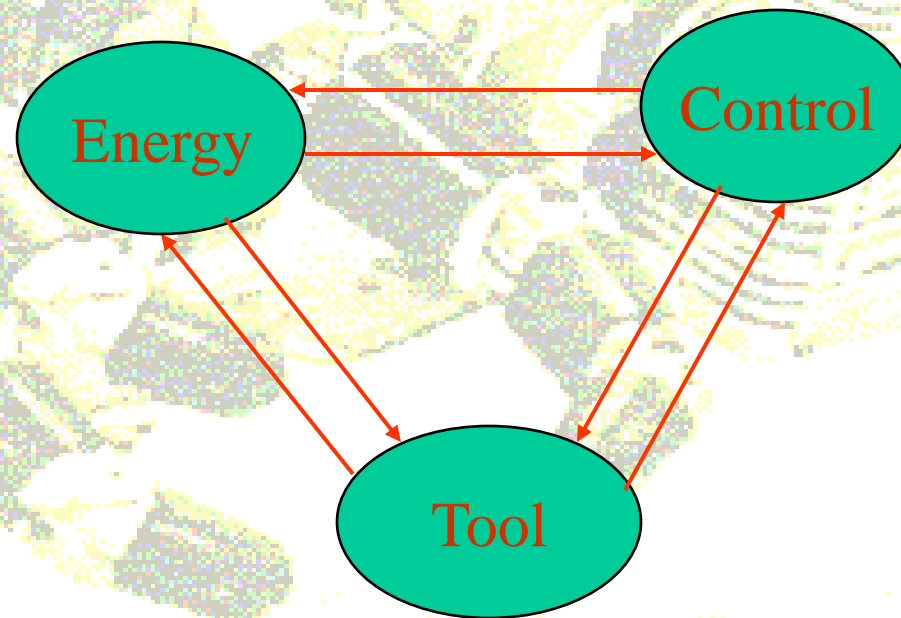
- **Fixed (Hard) Automation:** Specialized machines are designed for high-volume production of parts (i.e. mechanical, electrical, etc.). Can not be adapted (i.e. programmed) to perform variable-type work. (Efficient only when we have mass production  $\cong > 10000$ ).
- **Programmable Automation:** The production volume is rather low ( $<1000$ ), and various parts are needed to be produced. Hence, specialized devices are designed to be flexible and adaptable to variations in production. Parts are produced in a batch (group), and when the batch is completed, the system is reprogrammed to produce the next batch. Robots are occasionally used in the production of parts.
- **Flexible (Soft) Automation:** When the production volume is medium (1000 to 10000). Sometimes robots are applied for spot welding, spray painting, material handling, and component assembly. Variation of parts/products is more limited than the programmable automation.



# Processing Layout of an Automatic Machine for Manufacturing a Chain



Every instrument used by us can be described in a general form by an **Energy Source**, a **Control Unit**, and the **Tool** that are connected in some way.



# Layout of a Tracing System (i.e. key copy instrument)

