

Robotics: An Introduction

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Definition

- **A Robot is a Programmable, multi-function manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.**
- **Key points:**
 - machine
 - repeated tasks
 - programmability
 - intelligence (e.g., decision making capabilities)
 - articulated motion
 - adapt to environment
 - senses the environment

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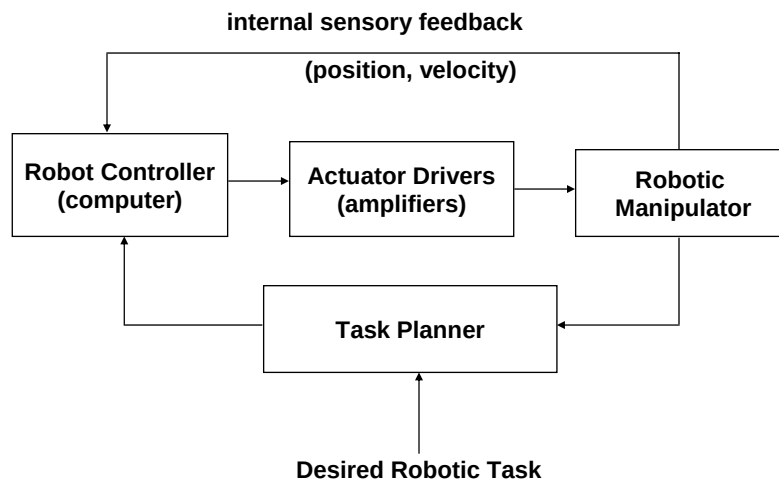
What is the ultimate robot?

A Humanoid!

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System Components



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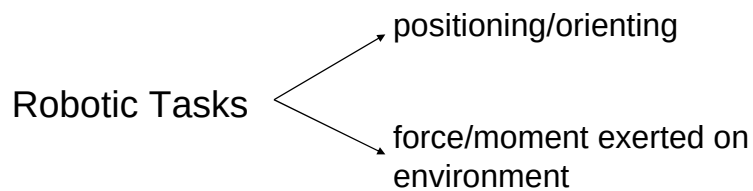
Robotic Manipulator Configurations

- Cartesian
- Cylindrical
- Spherical
- SCARA
- Articulated
 - PUMA
 - Intellelex

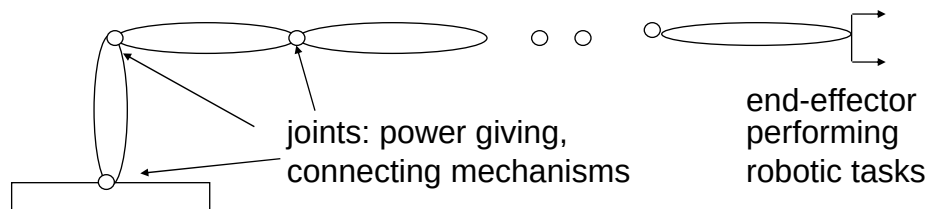
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Tasks and Mechanism



Connected Kinematic Chain



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Robot Joints and Degrees-of-Freedom

3D Space = 6 DOF ↗ 3 position
↘ 3 orientation

In robotics,

DOF = number of independently driven joints

As DOF ↑

positioning accuracy ↓

computational complexity ↑

cost ↑

flexibility ↑

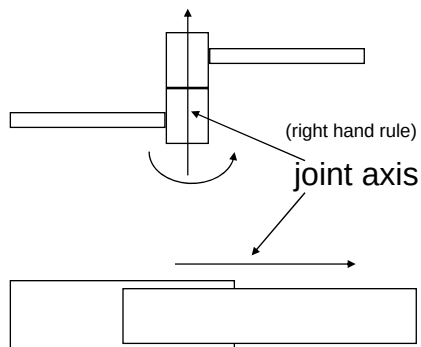
power transmission is more difficult

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Robot Joints

Two Basic Types:



Rotational

Translational
(Prismatic)

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Robot Joints

	<i>Rotational</i>	<i>Translational</i>
Accuracy	Non-Uniform	Consistent
Kinematics	Complex	Simple
Control	Coupled, Difficult	Decoupled, Easy
Link Design	Simple	Complex
Dexterity	Good	Bad

As the number of rotational joints increase,

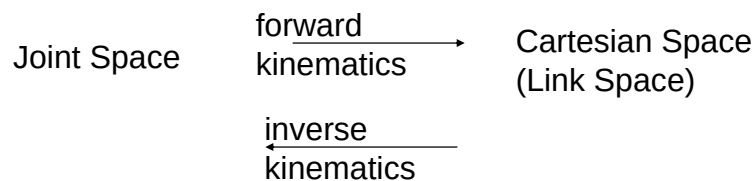
- task planning complexity ↑
- control algorithm complexity ↑
- dexterity ↑
- accuracy ↓

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Robot Kinematics

- kinematic modeling of robotic manipulator
- position, velocities, accelerations, etc. of each link
- relationship to joint position, velocity, etc.
- pure geometry - no regard to forces

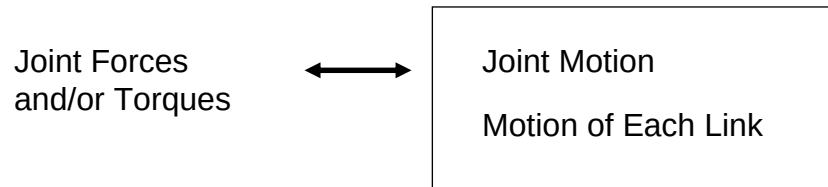


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Robot Dynamics

- **Equations of Motion of the Robotic Manipulator**



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Robot Control

- **What is it?**
 - What should the joint actuations be, so the robot does the task
 - » **Motion**
 - » **Force**
 - » **Both**
- We know kinematics and dynamics, why do we need control?

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Robot Control

- **Motion Control**
 - design of a stable and robust algorithm to coordinate joint motion and enable the robot to follow a specified trajectory, described in a Cartesian coordinate frame
 - Point-to-Point
 - Trajectory Following
 - Independent Joint Control
 - Inverse Dynamics Control (Computed Torque)
- **Force Control**
- **Compliance Control**
- **Hybrid Position/Force Control**
- **Impedance Control**

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Task Planning

- **Robotic task is broken down into**
 - motion commands
 - force/torque commands
 - strategies to react to forces/torques
- **Trajectory Generation**
 - joint trajectories
 - » position of each joint as a function of time
 - » coordinated motion of joints to provide desired end-effector motion

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Manipulator Design

- **Dexterity Considerations (Geometry, Workspace)**
- **Control Considerations**
- **Rigid Vs Flexible**
- **End-Effector Toolings**
- **Actuators and power transmission**
- **Sensors**
- **Depending on task (e.g., number of DOF?)**

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Robot Programming

- **Robot Operating System and Robot Programming Language**
 - VALII, Karel, Robot-Basic, etc
- **User Interface**
 - AdeptMotionWare
- **Walk-Through Programming**
- **Telerobotics**

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