Robotics

CSE4316

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Lecture 2: **Robot Morphology**
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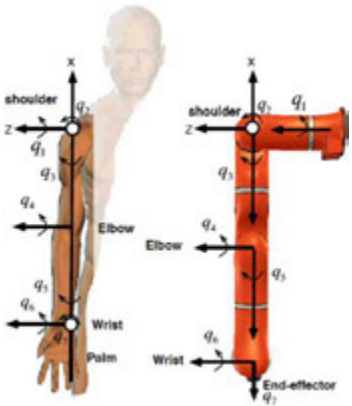
Lecture: 2

Robot Morphology

- Robot Components, Joints, Degrees of Freedom.
- Coordinates, Reference Frames.
- Configurations,Workspace.
- Advantages and Disadvantages of Robots.

Manipulator Joints and Links

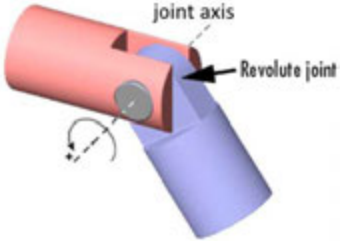
- A robot joint is similar to a human body joint
  - It provides relative movement between two parts of the body
- It constrains the motions of the connected links. Typical industrial robots have five or six joints
  - Coordinated movement of joints enables robot to move, position, and orient objects
- A joint can be classified as: One, Two, or Three degrees of freedom (**DOF**).



One-DOF Joint

Revolute Joint

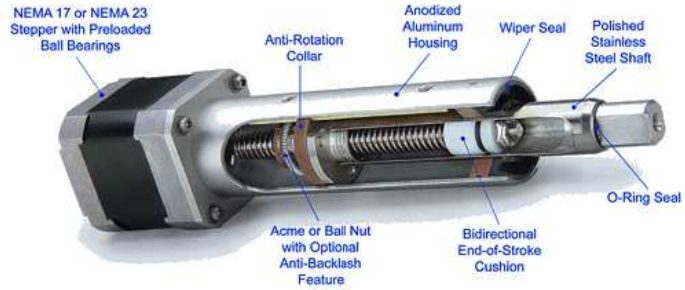
- Imposes a **rotational** motion
- Rotary, (electrically driven with motor: stepper, servo, $\cdots$)
- Symbol: **R**



One-DOF Joint

Prismatic Joint

- Imposes a **translational** motion
- Linear, No rotation involved (electric, hydraulic or pneumatic)
- Symbol: **P**



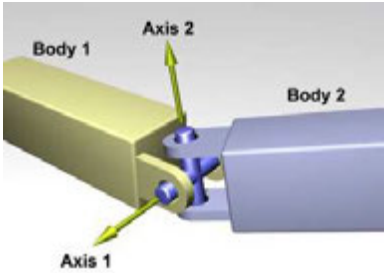
[http://www.ultramotion.com]

Joints

Less common types

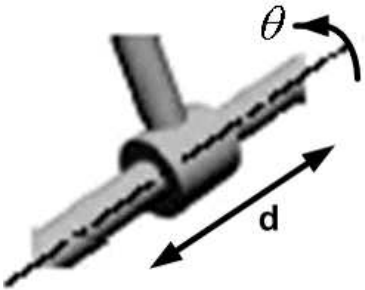
Universal joint

- 2DOF
- Symbol: U



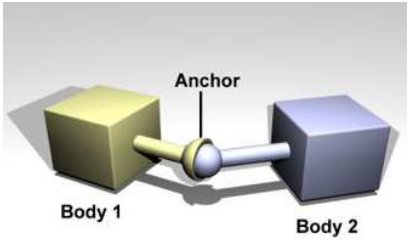
Cylindrical joint

- 2DOF
- Symbol C



Spherical joint (Ball-and-socket)

- 3DOF
- Symbol S



Manipulator Joints and Links

Degrees of Freedom

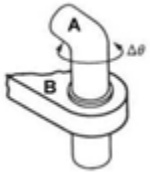
Number of **independent** **position variables** that have to be specified to locate all parts of a mechanism.

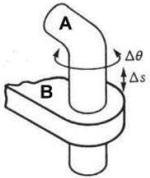
- An object is said to have a n degrees of freedom (DOF), if its **configuration** can be **minimally** specified by n parameters.
- In most manipulators this is usually the **number of joints**.

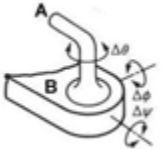
Manipulator Joints and Links

DoF Examples

- How many degrees of freedom does each joint have?
- How many DOF does the robot ABB IRB 6620LX have? [4 DOF]





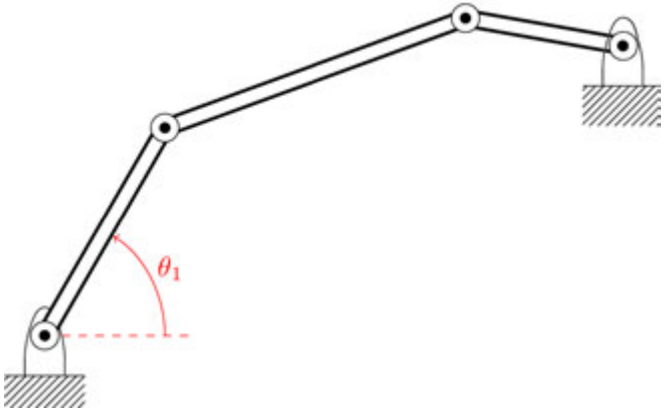


- How many degrees of freedom does your arm have? [30 DOF]

Manipulator Joints and Links

DoF Examples

- How many degrees of freedom does this robot have? (note: it has one **actuated** joint)



- Answer: this robot has **one** DOF as all other joints are **passive** and **dependent**

Parallel Manipulators

Parallel Manipulator

two or more series chains connect the end–effector to the base (closed-chain)

- DOF for a parallel manipulator determined by taking the total DOFs for all links and subtracting the number of constraints imposed by the closed-chain configuration

Gruebler's Formula

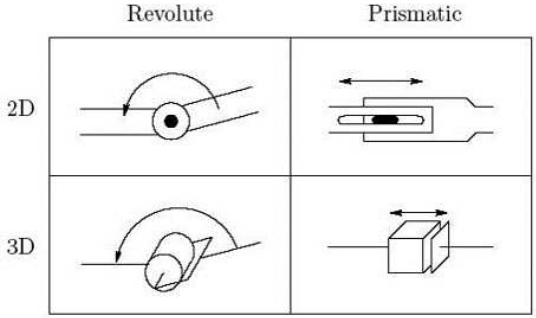
$$DoF = 3(n_L - n_J) + \sum_{i=1}^{n_J} f_i \qquad \textbf{2D}$$

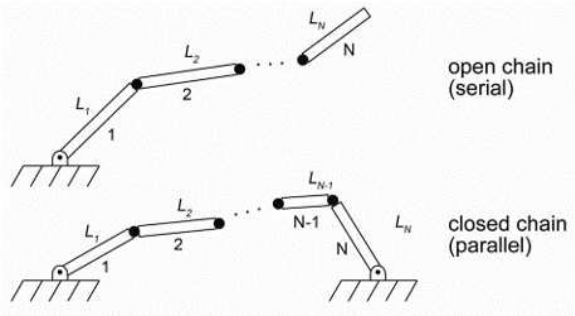
$$DoF = 6(n_L - n_J) + \sum_{i=1}^{n_J} f_i \qquad \textbf{3D}$$

n_L	number of links (excluding ground)
n_J	number of joints
f_i	DOF for joint i

Joint Representations

- For the majority of this course, we will consider robotic manipulators as **open** or closed **chains** of links and joints





Manipulator Joints and Links

- To reach any point in space with arbitrary orientation: 6 DOF
  - 3 DOF for **positioning** and 3 DOF for **orientation**
- Less than 6 DOF: **Under Actuated** manipulator
  - the arm can not reach any point in the space with an arbitrary orientation.
- More than 6 DOF: Kinematically **redundant** manipulator.
  - Certain applications may require more than 6 DOF
  - for example: Obstacle Avoidance.

Robot Configuration

Manipulator Configuration

a complete specification of the location of every point on the manipulator.

joint variable

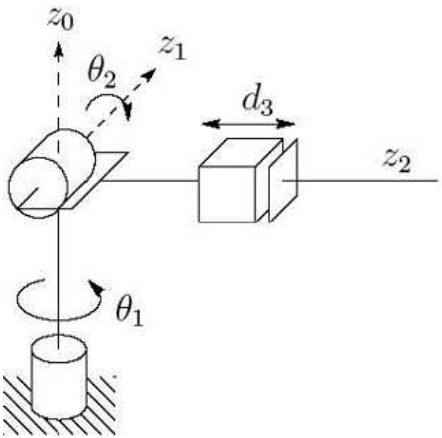
joint angle for revolute joints or joint offset for prismatic joints

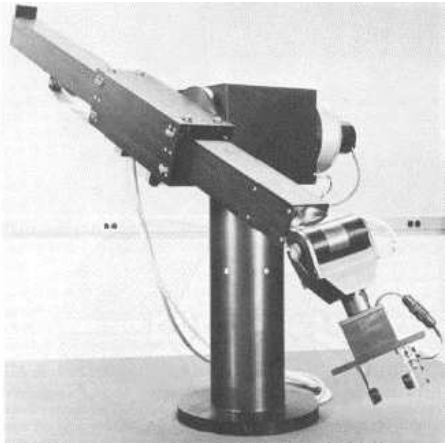
- If you know the values for joint variables, it is straightforward to infer the position of any point on the manipulator.
- set of all possible configurations is the **configuration space**
- For **rigid** links, it is sufficient to specify the configuration space by the joint angles

Robot Configuration

Common configurations: Stanford arm (RRP)

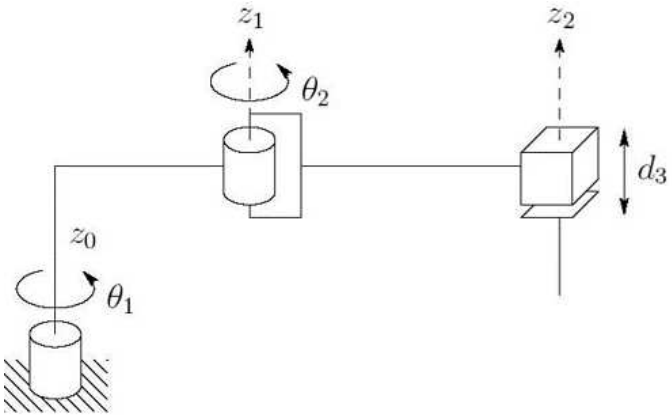
- Spherical manipulator (workspace forms a set of concentric spheres)





Robot Configuration

Common configurations: Selective Compliance Assembly Robot Arm (SCARA) (RRP)

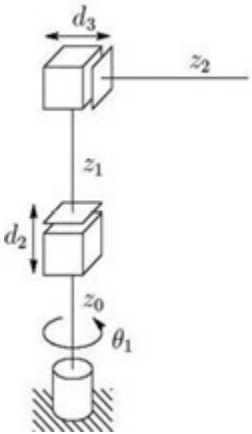


Adept Cobra Smart600

Robot Configuration

Common configurations: Cylindrical Robot (RPP)

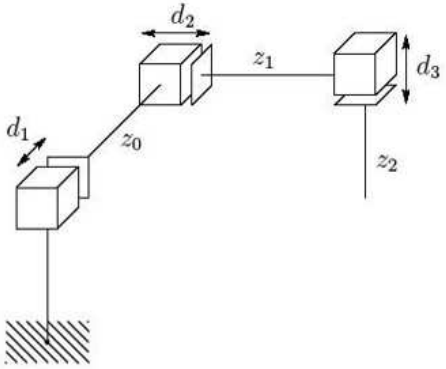
- workspace forms a cylinder



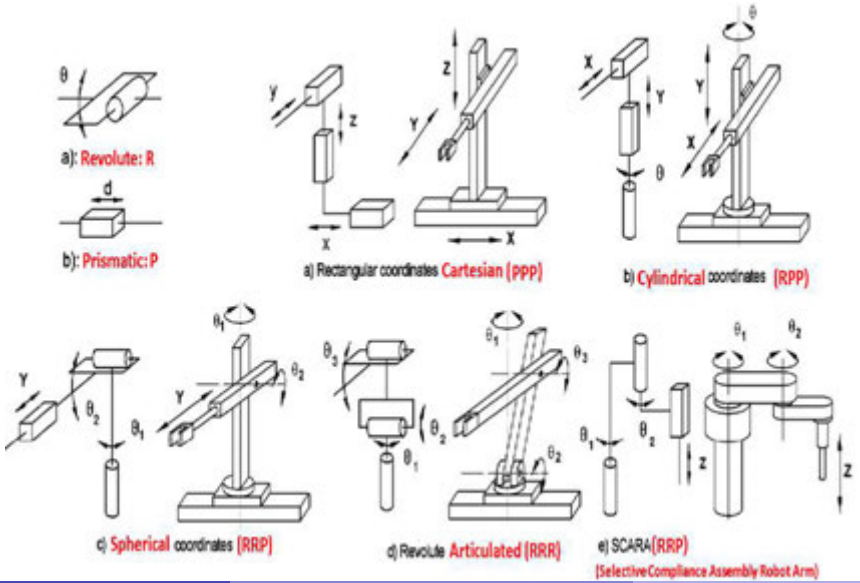
Robot Configuration

Common configurations: Cartesian Robot (PPP)

- Increased structural rigidity, higher precision
- Pick and place operations



Robot Configuration



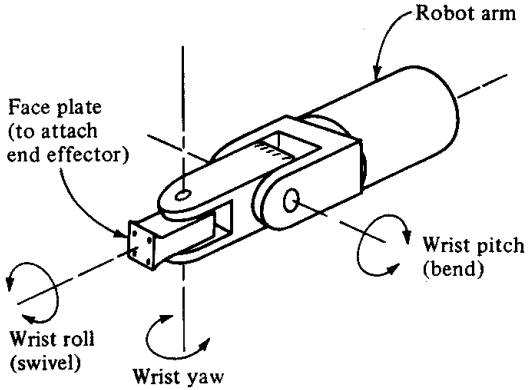
Manipulator Design

Robot manipulators can usually be divided into two sections:

- **Arm-and-body assembly**: to position an object or tool
  - 3 joints are typical for arm-and-body
- **Wrist assembly**: to properly orient the object or tool
  - 2 or 3 joints are associated with wrist

Wrist

- The wrist is assembled to the last link of the arm-and-body
- A typical wrist would have 3 DOF described as:
  - **Roll**: rotation around arm axis (rotational movement)
  - **Pitch**: up and down movement (up and down movement in vert. plane)
  - **Yaw**: right to left rotation (sideways movement in a horiz. plane)



End Effector

Gripper Examples

- Anthropomorphic or task–specific
- Force control vs. position control

Administrative Instructions

(mini)– projects

This semester you have to select **one** of the following projects:

1. 6DoF Robot Arm Manipulator
2. Robotics Software Utilities
3. Wheeled Mobile Robot

- use the project datasheet (template is soon available on course website).
  - must be submitted in hard and soft form **by the end of this week**.
- more organizational instructions to be announced in the next days.

Thanks for your attention.

Questions?

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