1 intro to robotics

1.1 what is robotics

1.1.1 Accd. RIA 1979

- reprogramable device
- multifunctional manipulator
- to move material,part,tools or specialised device
- using various programing methods

1.1.2 Japanese Industrial robots association (JIRA)

- device with degrees of freedom that can be controlled

2 Laws of robotics

- robot may not injure human
- obey order given by humans
- must protect itself complying with 1st and 2nd law

2.1 capabilites of robots

- autonomy:perform task - based on current state - wihtout human intervention
- sense - plan - act

2.2 Types of robots

2.2.1 according to application

- Industrial robots - industrial use
- service robots - domestic use

2.2.2 based on useage and area

- manipulator
  - Industrial robots
  - collabrative robots (cobots)
- mobile robots
  - legged moblie robots
  - wheeled robots
- terrestrail robots - cheetah robots
- Aerial robots and underwater robtos
- Mobile manipulator

3 Robotics terminology

workspace - volume in which end effector can reach (oreientation and position)
Degeree of freedom - minimum no of co ordinates needed to describe a system

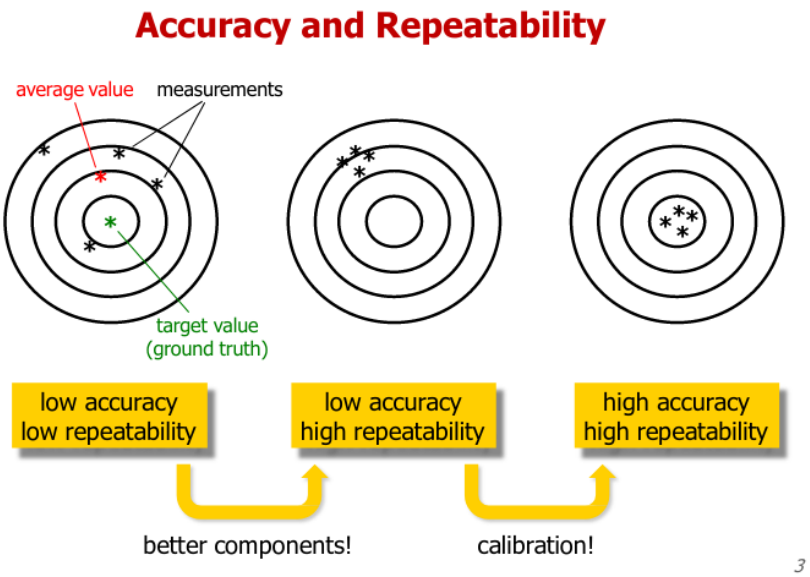
- **redundant manipulator**- spatial manipulator more than 6 DOF / planar with more than 3 DOF
- **underactuated manipulator**- spatial with less than 6 DOF / planar with less than 3 DOF

postion - tranlational location of something
oreientation - rotational location of something (roll, pitch,yaw)
kinematics - study of motion without regards of forces
dynamcis - study of foreces with regard of forces
actuator - provide the force for robots motion
sensor - estimate robots condition in robot's condidtion and environment
Accuracy - ability to position itself to the desired loaction with minimum error

- **accuracy** - depends on machine accuracy in construction
- can be improve by kinamatic calibiration

Repeatebility - ability to do a task repeateadly

- depends on robot controller and mesaurement resolution



Spatial Resolution

- smallest increment of movement in which robot can divide its work
- depends on control resolution and mechanical inaccuracies

stability - maintaining output over time/temperature

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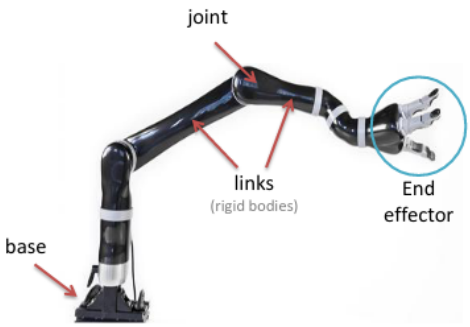
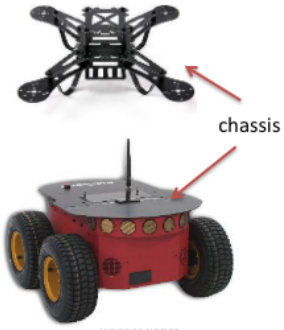
4 Elements of robots

4.1 Mechanical systems

- **links** - connects the joints
- **Parts** - supporting structure,end effector , chasis, wheels etc



JACO Robot (Kinova)



Pioneer Robot

4.2 Sensing systems

- **proprioceptive sensors**
  - Internal state of robot
  - position,velocity,torque of joint
- **exteroceptive**
  - external environment
  - camera,proximity

4.3 Actuation systems

- Motors - electric,hydraulilc,pneumatic
- Algos for moot control
- Transmissions

4.4 Control system

- Brain of the robots
- 2 levels
  - **Low level** - Motor control
  - **High level** - Planning,task control, Learining

5 Rigid Bodies

Set of particle with constant realtive distance distance between any 2 particles

$$\| \mathbf{p}_A(0) - \mathbf{p}_B(0) \| = \| \mathbf{p}_A(t) - \mathbf{p}_B(t) \|$$

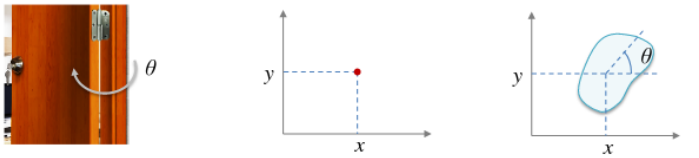
Whatever the motion of the rigid body, the relative distance (between any 2 points in the body) remains fixed

Spatial rigid bodies - it moves in 3D **Planar rigid bodies** - it moves in 2d

6 Configuration of rigid bodies

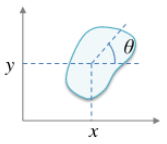
6.1 Configuration

- complete specification of all points of rigigd body
- complete specification of all points of postion and oreientation
- **Examples**
  - configuration of hinge θ
  - configuration of a point in plane (x, y)
  - confiuration of rigid body in plane (x, y, θ)

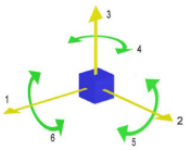


6.2 Degrees of freedom

- minimum no of co-ordinates needed to represent the config of rigid body
- no of independant co-ordinates required to represent configuration



Rigid body in the plane: 3 *dof*



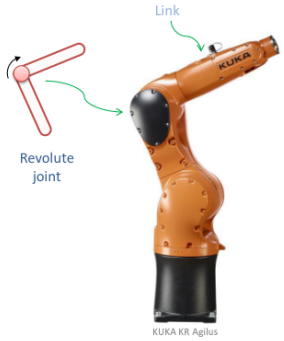
Rigid body in the space: 6 *dof*

- *Dof* of a person walking on the surface of a sphere: 2

6.3 Mecahnisms

- Closed chain mechanism
  - the have closed loop
  - Examples
    - 4 bar linkage
    - Parallel robots
- open chain mecahnism
  - No loops
  - series of link and joints

7 How to represent a robot

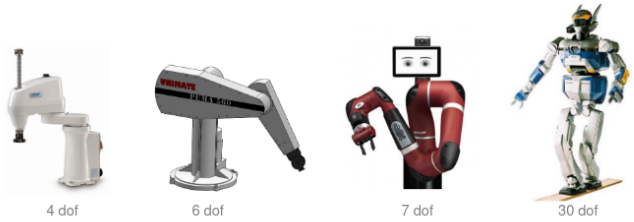


7.1 Robot configuration

- complete specification of every points in robots (position and orientation)
- configuration of every free link - 6 parameters
- every joint - 5 parameters
- every link - 1 parameters
- configuration of a complete robtot - 2 parameters

7.2 Degrees of freedom

- minimum no of independent co-ordinates to represent a robot
- $dof = (\sum freedomofeverylink) - (independantconstrains)$



8 Joints

- they are th connection between two links
- **Function**
  - constrain motion of a link with respect to each other (reduce DOF)
  - provide freedom for motion of link
- **DOF of joint**
  - every independant motion that a joint allows
- In general, DOF of robot depends on number of link and joints (grubler formula)

8.1 Most used joints in robotics

8.1.1 Prismatic joint

- allows tranlational movement on a fixed axis
- 1 doffor motion
- 5 constrains to spatial motion

Figure 1:

8.1.2 Revolute joint

- allows rotational movement on fixed axis
- 1 dof
- 5 constrains

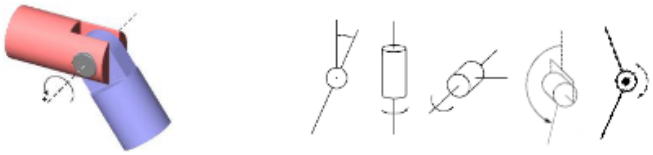


Figure 2: revolutejoint

8.1.3 Helical joint

- Also known as screw
- allow simulataneous but dependant movement in rotational and translational axis
- 1 dof
- 5 constrains

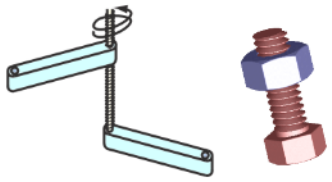


Figure 3: helical-joint

8.1.4 Cylinderical joint

- independant rotation and translational movement
- 2 dof
- 4 constrains

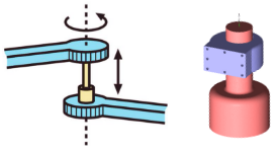


Figure 4: cylinderical-joint

8.1.5 Universal joint

- 2 revolute joints with their axis are orthagonal
- 2 dof
- 4 constrains

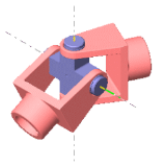


Figure 5: universal-joint

8.1.6 Spherical joint

- ball and socket joint
- 3 dof
- 3 constrains

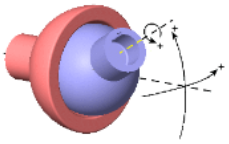


Figure 6: spherical-joint

9 robots based on physical configuration

- Cartesian configuration
- Cylinderical configuration
- Polar configuration
- Joint-arm configuration

9.1 Cartesian configuration

- Links are connected with linear joints
- example gantry robots
- 3 Prismatic joints
- commonly used for
  - pick and place
  - assembly operations
  - handling machine tools
  - arc weldings

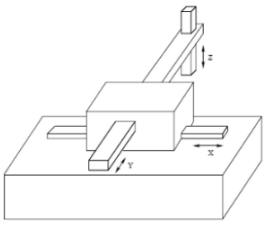


Figure 7:

9.1.1 advantages

- ablity to do straight line insertions
- easy computation and programming
- most rigid structure for given length

9.1.2 disadvantages

- require large operating volume
- exoposed guiding surface leads to corrosion
- can only reach front itself
- axes hard to seal

10 Cylinderical configuration

- one rotational joint and two linear joint
- example versatran 600
- commonly used for
  - handling die casting
  - assembly operations
  - machine tools
  - spot welding

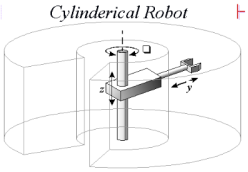


Figure 8:

10.1 Advantages

- can reach around itself
- rotaitonal axis easy to seal
- easy programming
- rigid to handle heavy loads

10.2 Disadvantages

- cant reach above itself
- linear axes hard to seal
- wont reach around obstacles

11 Polar/Speherical robots

- have work space of spheraical robots
- 2 rotary joints and one prismatics joint
- example Unimate 2000B

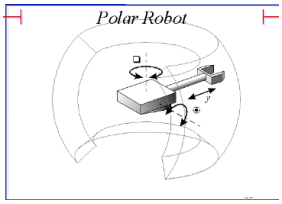


Figure 9:

- commonly used for
  - die casting and fettling
  - handling machine tools
  - arc/spot welding

11.1 Advantages

- large working envelope
- two rotational drive are sealed easily

11.2 Disadvantages

- Complex co ordinates difficult program and visualise
- exposed linear drive
- Low accuracy

12 Joint-arm configuration

- Combination of cylinderical and articulated joints
- base connected with twisting joint
- arm joint are rotatory
- Many commericial robots use this

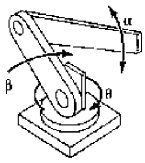


Figure 10:

13 Articulated Robots

- Robots with 3 rotatory joints
- example T3,PUMA
- Commonly used for
  - assembly operation
  - Welding
  - Weld sealing
  - Spray painting
  - die casting

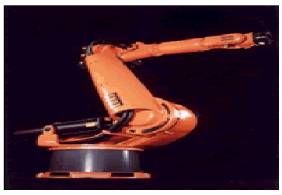


Figure 11:

13.1 Advantages

- maximum flexibility
- any point total volume can be reached
- all joints can be sealed

13.2 Disadvantages

- Extremely difficult to program visualise and controll
- restricted volume coverage
- low accuracy

14 SCARA

- selective compliance Articulated robot arm
- 2 parallel robots arm
- commonly used for pick and place

14.1 Advantages

- High speed
- Height axis is rigid
- large work area in floor space
- moderately easy to program

14.2 Disadvantages

- Limited application
- 2 ways to rach a point
- difficult to program off line
- highly complex arm