Motion and Manipulation

Robotics

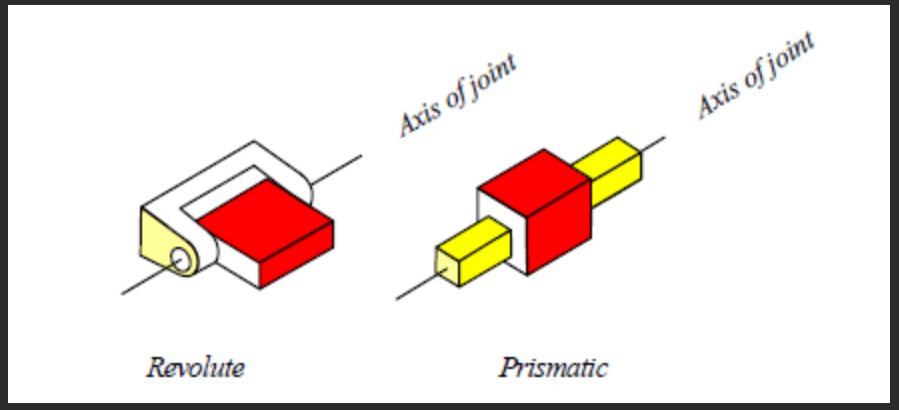
Robotic Manipulators

SCARA: Selective Compliant Assembly Robot Arm

PUMA: Programmable Universal Machine for Assembly

Robot Components

- Links: individual rigid bodies that make up the arm
- Joints: contact between two links allowing relative (single-coordinate) motion
  - revolute (R): rotation
  - prismatic (P): translation

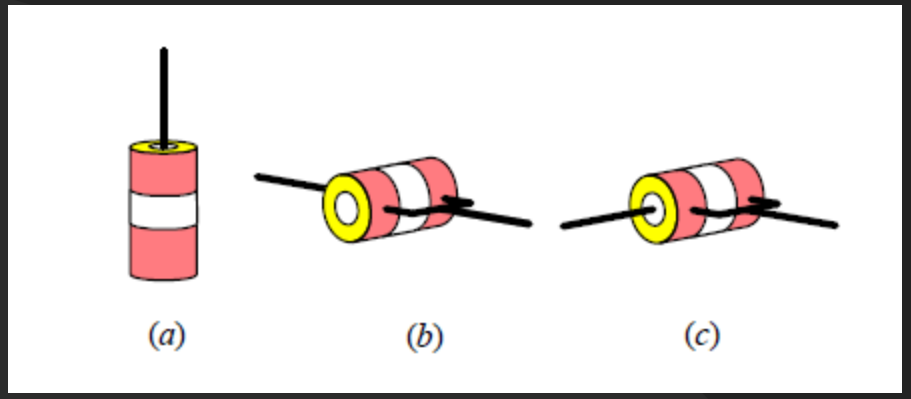


Joints

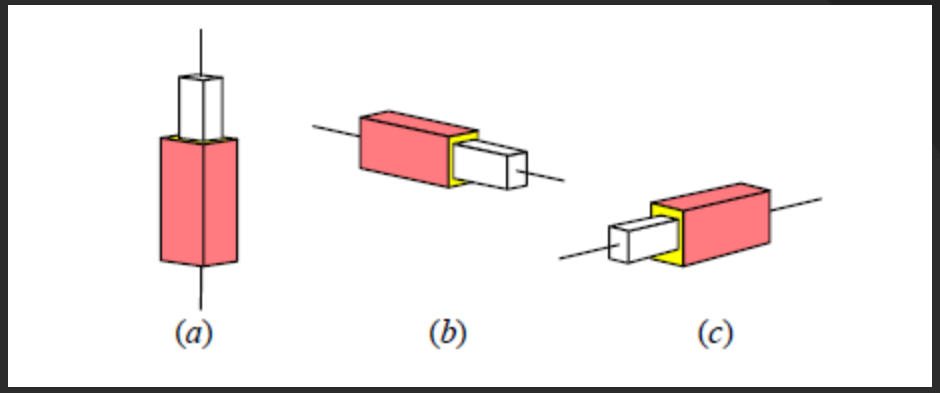
- Axis of joint or axis of motion: line about or along which the relative rotation or translation takes place.
- Joint variable or joint coordinate: describes the magnitude of the rotation about or translation along the axis of joint/motion.
- Joint can be
  - active: controlled by actuator
  - passive (inactive, free): determined by active joint coordinates

Joints

- Revolute joints



- Prismatic joints

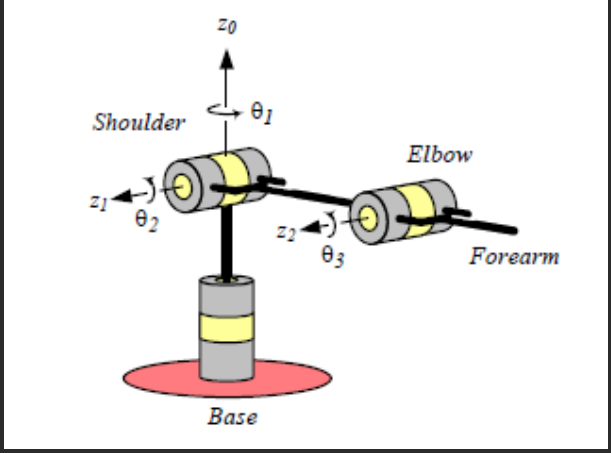


Joints

- Prismatic and revolute joints provide one degree of freedom; number of joints equals the number of degrees of freedom (DOF) of the manipulator.
- Manipulator in a 3D world should have six DOF: three for positioning, three for orientation.
- Manipulator with more than six DOF is kinematically redundant.

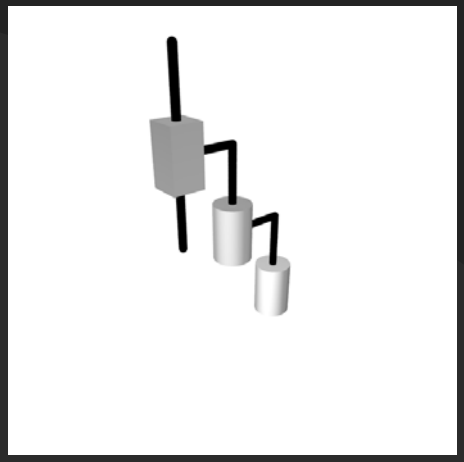
Robot Components

- Manipulator: main body consisting of links and joints

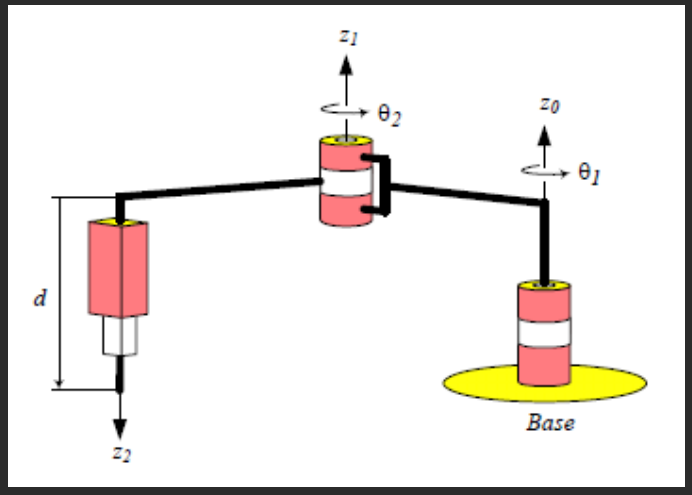


Example Manipulator

- SCARA

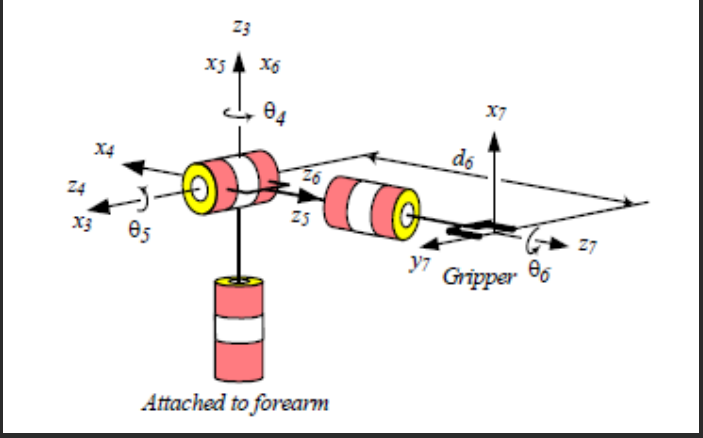


kinematic diagram



Robot Components

- Wrist: three revolute joint axes intersecting in a single point



Robot Components

- End-effector: part mounted on the last link to carry out the robot's task; example: gripper.
- Wrist and end-effector together sometimes referred to as a hand.
- Actuators: controllable electric/hydraulic/pneumatic drivers to change the robot's configuration

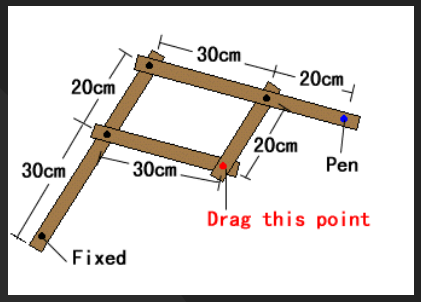
Robot Components

- Sensors: elements that detect and collect information about internal and environmental states, such as joint position, velocity, acceleration, force

- Controller: collects and processes sensor information, plans motions of the robot structure, and organizes information.

Robot Geometry

- Serial/open-loop manipulator: no cycles in geometry
- Parallel/closed-loop manipulator: geometry is cyclic
- Hybrid manipulator: both open-loop and closed-loop substructures



- Adjacent joints can be
  - parallel: ∥
  - orthogonal (intersecting at right angle): ⊢
  - perpendicular (right angle with respect to common normal: ⊥

Example

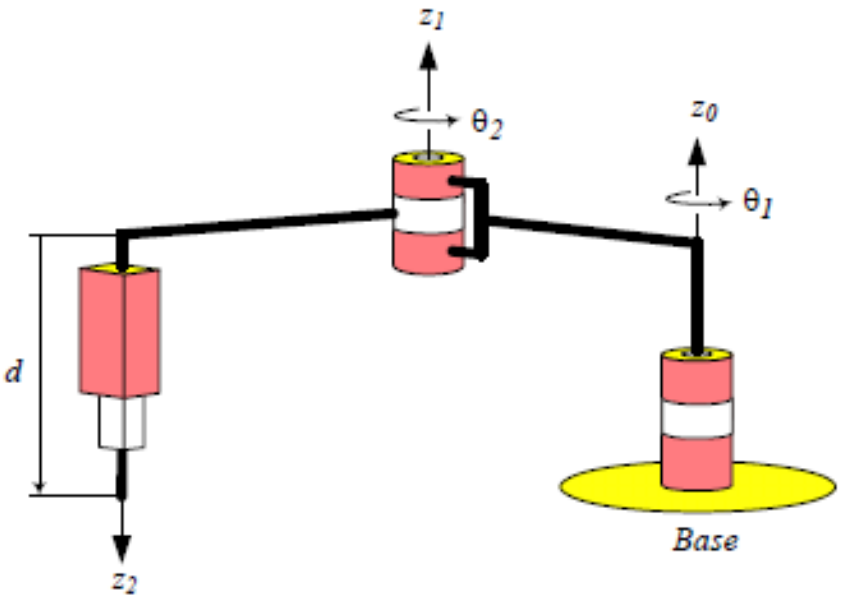


FIGURE 1.8. An R||R||P manipulator.

Example

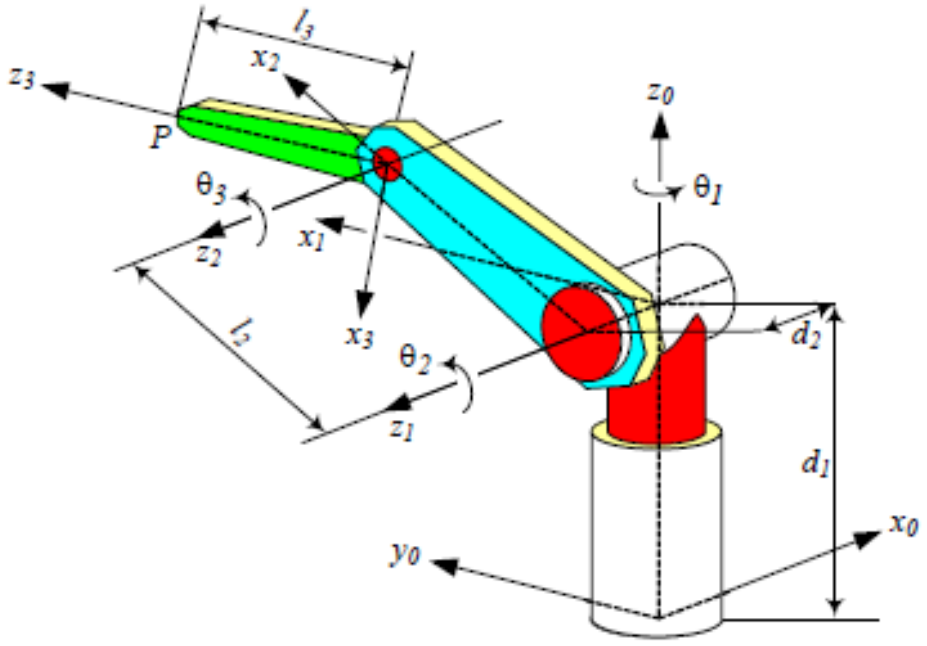


FIGURE 1.9. Structure and terminology of an R–R⊥R elbow manipulator.

Example

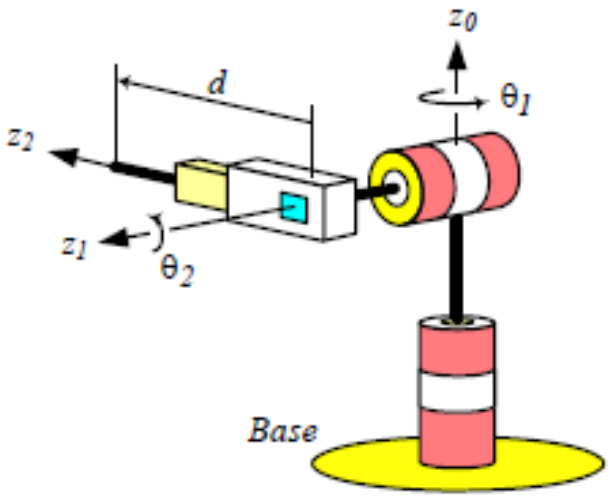


FIGURE 1.10. The R–R⊥P spherical configuration of robotic manipulators.

Example

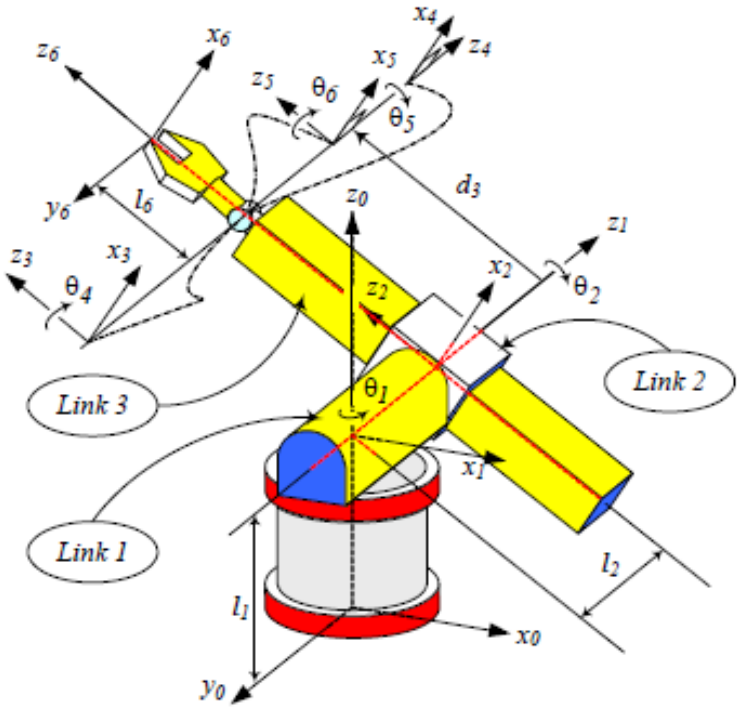


FIGURE 1.11. Illustration of Stanford arm; an R⊢R⊥P spherical manipulator.

Example

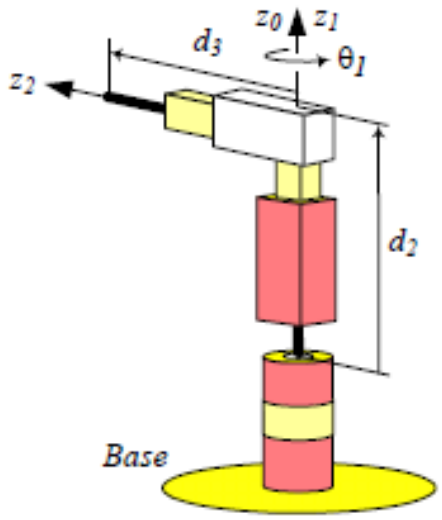


FIGURE 1.12. The R||P⊥P configuration of robotic manipulators.

Example

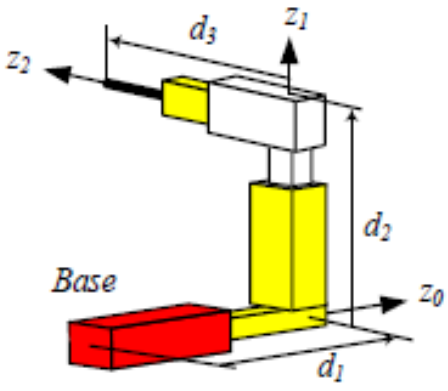


FIGURE 1.13. The P–P–P Cartesian configuration of robotic manipulators.

Classification

- Workspace: volume of space reachable by the end-effector
  - reachable workspace: reachable in at least one orientation of the end-effector
  - dexterous workspace: reachable in any orientation of the end-effector

Classification

- Actuator type
- Control method
  - servo or closed loop
  - non-servo or open loop
- Application type