Introduction to Robotics

Lecture 4

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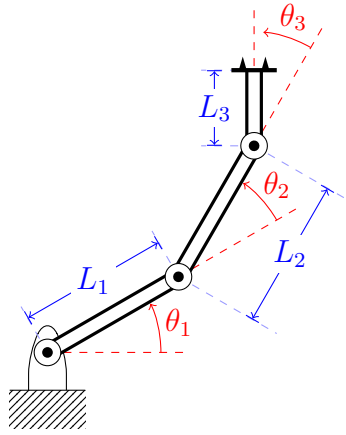
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Contents

1 Forward kinematics

Let's recapitulate the naming conventions for a exemplary manipulator:

2 Denavit-Hartenberg (1955) solution

Jacques Denavit and Richard Hartenberg introduced this convention in 1955 in order to standardize the coordinate frames for spatial linkages. They came up with an universal algorithm for describing the motion (or in other words: attaching a reference frames to the links) of a manipulator.

2.1 Preliminary assumptions

1. motion allowed only along z-axis
2. rigid body assumed

2.2 Algorithm:

1. Step: assign axes of rotation $z_0 \ldots z_{n-1}$
2. Step: describe base frame $O_0 x_0 y_0 z_0$[1]
3. Step: create a loop $i = 1, \ldots, n-1$ (repeat steps 4-6)
4. Step: determine O_i (the origin of next frame), consider 3 cases:

    (a) case: $O_i = z_{i-1} \bigcap z_i$

    (b) case: a point where normal line passing through O_{i0-1} crosses Z_i

    (c) case: a point where normal line to both Z_{i-1} and Z_i crosses Z_i

5. Step: determine x_i axis, for each case:

    (a) $x_i = z_{i-1} \times Z_i$

    (b) b and c: x_i along normal line selected previously

6. Step: calculate missing axis y_i such the $x_i y_i z_i$ is a right-handed frame
7. Step: end-effector frame:

    (a) origin O_n – between fingers of a grabbing, two fingered effector

    (b) $z_n \parallel z_{n-1}$ – inherited from the last joint

    (c) y_n – finger motion direction

    (d) $x_n \rightarrow x_n y_n z_n \rightarrow$ right-handed

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[1]Axis should be chosen wisely, in respect to the surroundings, context, and the use case.

8. Step: determine D-H parameters described in table below:

	θ_i	d_i	a_i	α_i
1				
2				
n				

This is the procedure that is using th D-H parameters

$$Rot(z, \theta_i) \rightarrow Tran(z, d_i) \rightarrow Tran(x, a_i) \rightarrow Rot(x, \alpha_i) \tag{1}$$

note-1 with pictures