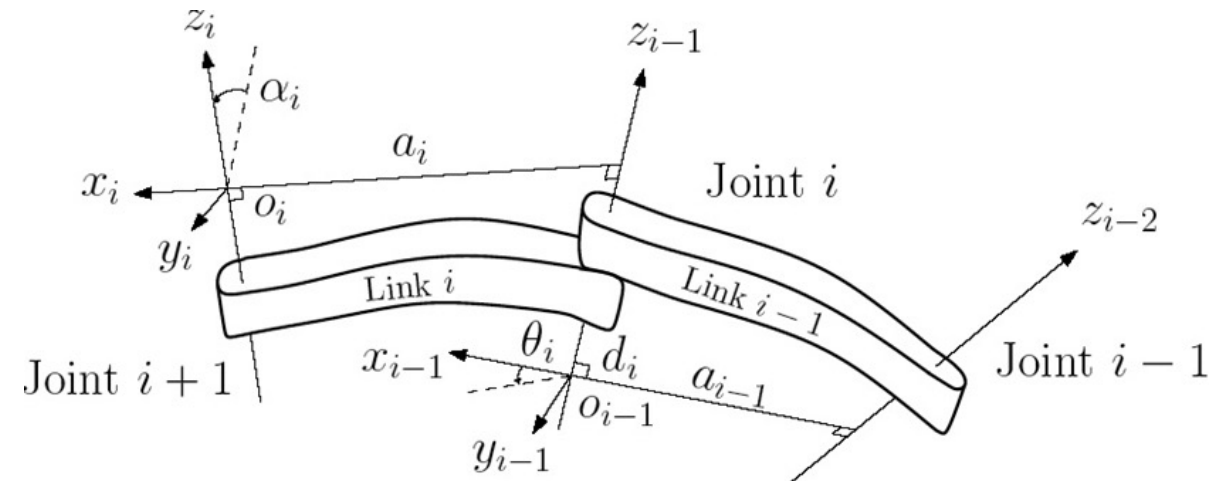
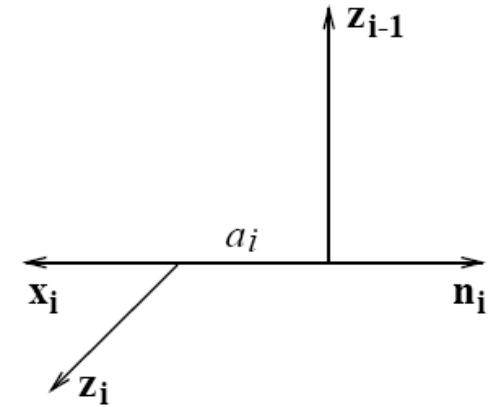


Intro to Robotics

Lecture 5

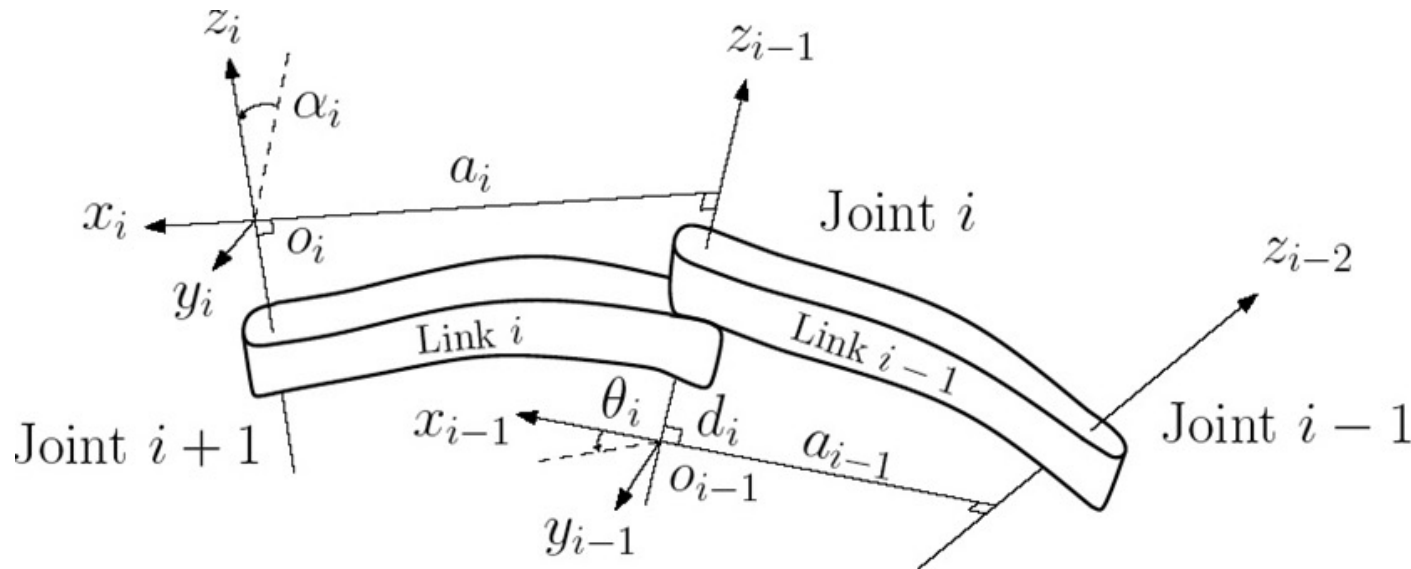
Denavit-Hartenberg Convention

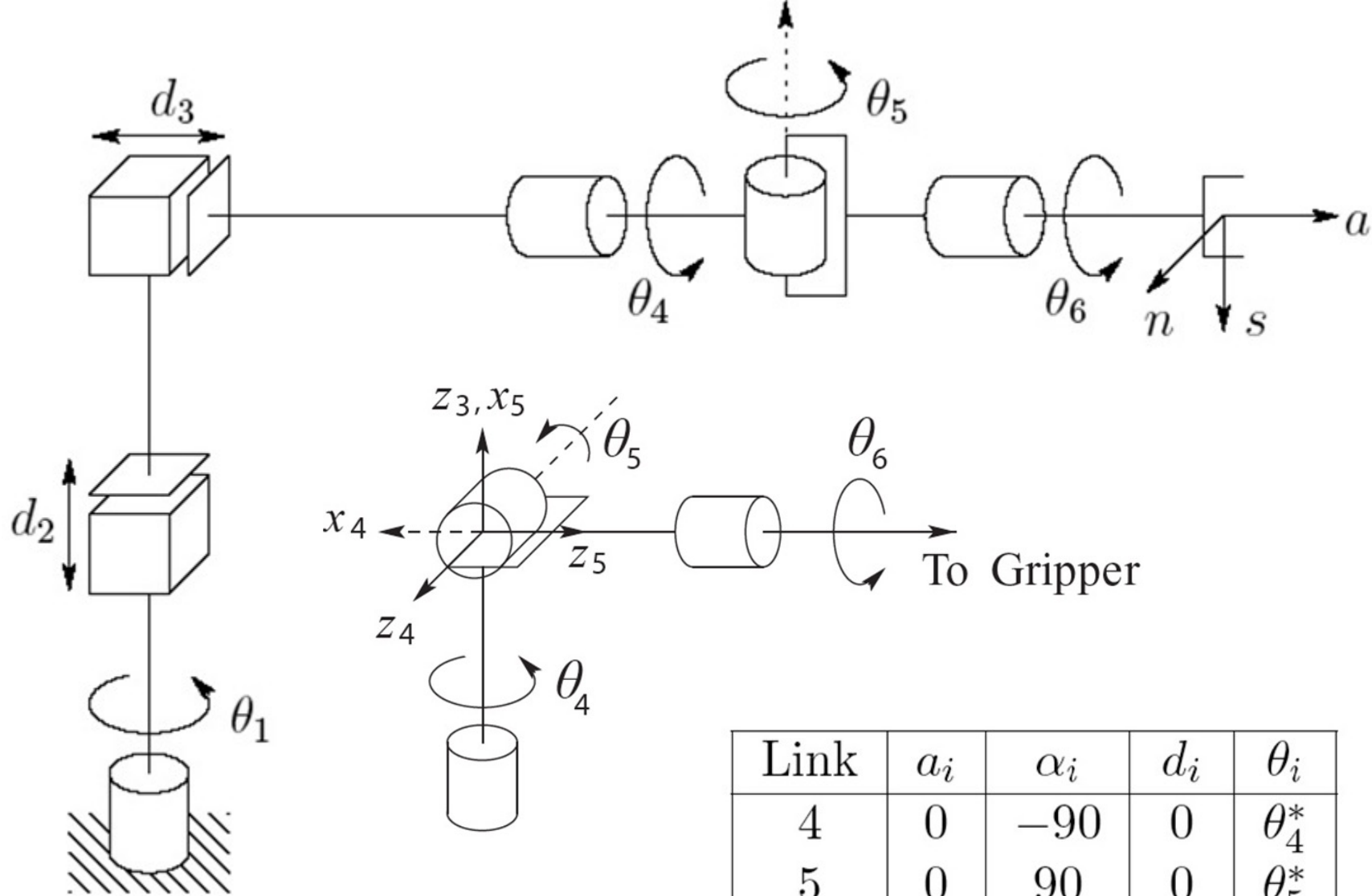
- Joint counts up from 1 at the base; axis counts up from 0
- Joint i connects link $i - 1$ to link i
- Align the Z_i with joint $i+1$
- **Base coordinate system:** Z_0 axis align with joint 1, origin is at the base
- **Origin of the coordinate system i :**
 - intersection of the Z_i & Z_{i-1} or
 - the intersection of common normal between the Z_i & Z_{i-1} axes and the Z_i axis
- **X_i axis:**
 - $X_i = \pm(Z_{i-1} \times Z_i) / \|Z_{i-1} \times Z_i\|$ pointing from Z_{i-1} to Z_i , or
 - along the common normal between the Z_{i-1} & Z_i axes when they are parallel
- **Y_i axis:** $Y_i = +(Z_i \times X_i) / \|Z_i \times X_i\|$



Link and Joint Parameters

- *Joint angle* θ_i : the angle from X_{i-1} to X_i about the Z_{i-1}
- *Joint distance* d_i : the distance from X_{i-1} to X_i , as measured along Z_{i-1} . It could be negative
- *Link length* a_i : the distance from Z_{i-1} to Z_i , along X_i . It is always positive
- *Link twist angle* α_i : the angle from Z_{i-1} to Z_i about the X_i axis

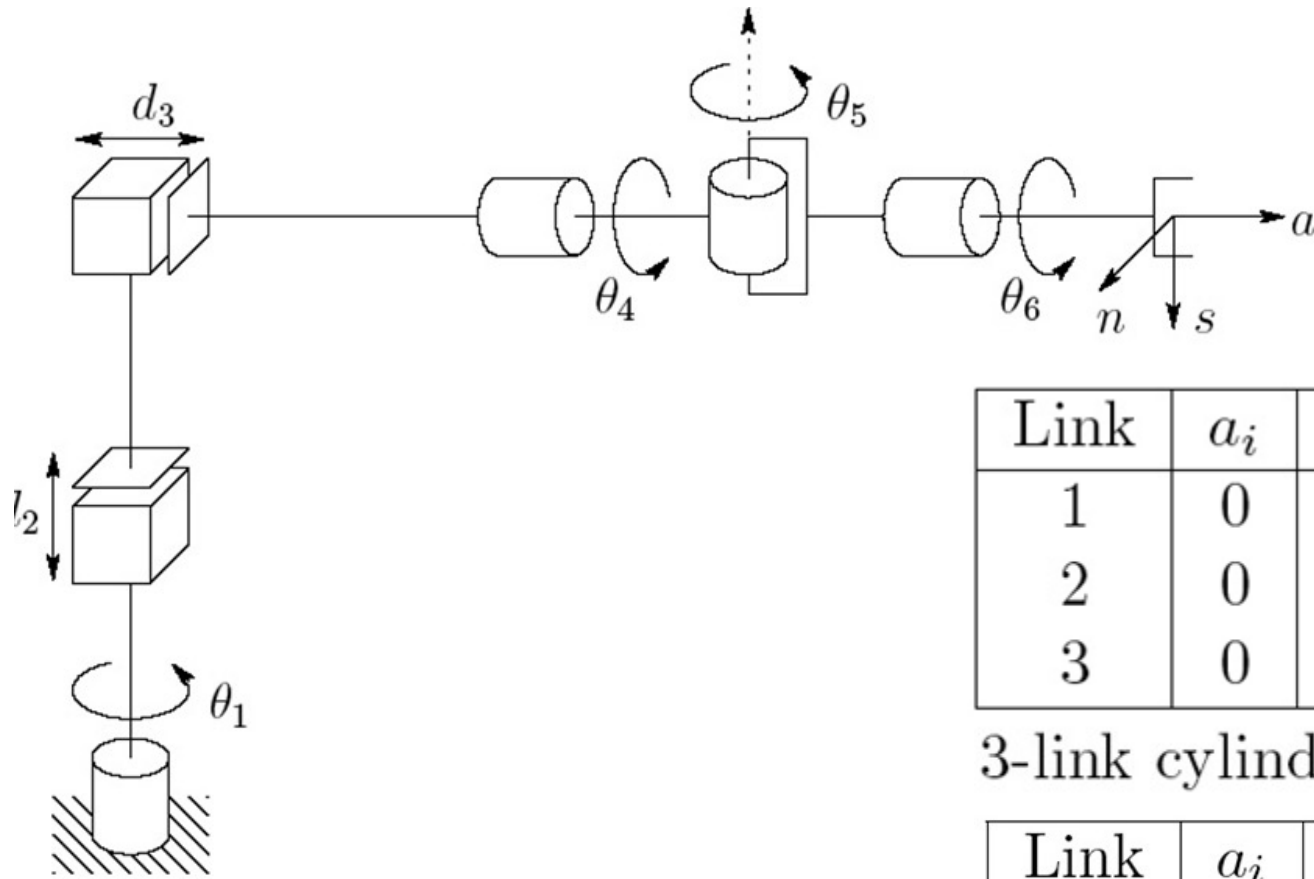




The spherical wrist

Link	a_i	α_i	d_i	θ_i
4	0	-90	0	θ_4^*
5	0	90	0	θ_5^*
6	0	0	d_6	θ_6^*

* variable



Cylindrical robot with spherical wrist

Link	a_i	α_i	d_i	θ_i
1	0	0	d_1	θ_1^*
2	0	-90	d_2^*	0
3	0	0	d_3^*	0

3-link cylindrical manipulator

Link	a_i	α_i	d_i	θ_i
4	0	-90	0	θ_4^*
5	0	90	0	θ_5^*
6	0	0	d_6	θ_6^*

* variable
spherical wrist