Denavit Hartenberg parameters (convention) Standardize the choice and description of robotic arms kinematic chains

https://www.youtube.com/watch?v=rA9tm0gTln8

Robotic arm joints are mostly of two types

→ Revolute joint

→ Prismatic joint

Ball and socket joint

(1) Axis of rotation of revolute joints $= Z_i$
$= Z_{i-1}$

(2) Find the common normal between Z_i and Z_{i-1}
$= x_i$

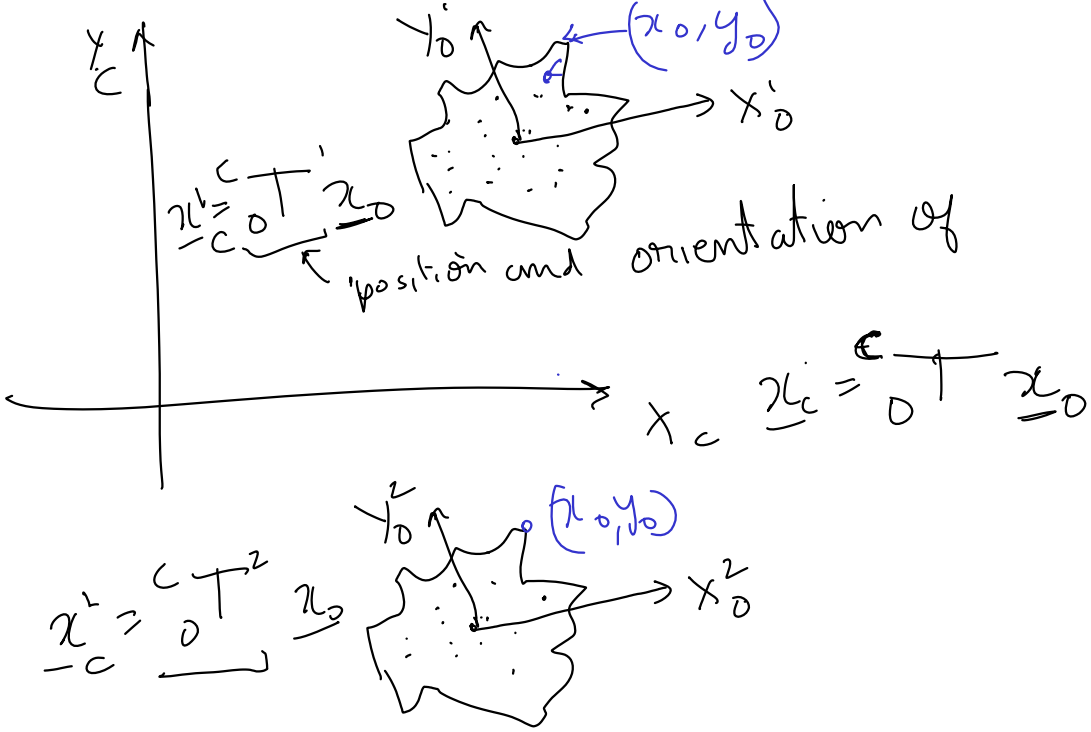
(3) x_{i-1} depends upon the previous link or is arbitrary

$$\underline{y}_{i-1} = \underline{Z}_{i-1} \times \underline{x}_{i-1} \quad , \quad \underline{y}_i = Z_i - \underline{x}_i$$

(5) Rotation and translation along the X-axis $= \alpha_i, r_i$ (x_i-axis)
" " " " " Z-axis $= \theta_i, d_i$ (Z_{i-1} axis)

$$^{i-1}_{i}R_{x_i}(\alpha_i) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\alpha_i) & -\sin(\alpha_i) \\ 0 & \sin(\alpha_i) & \cos(\alpha_i) \end{bmatrix}_{3\times3} \Rightarrow {}^{i-1}_{i}T^{R}_{x_i}(\alpha_i) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & c\alpha_i & -s\alpha_i & 0 \\ 0 & s\alpha_i & c\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Why Transformation matrices also describe position + orientation



321 Kinematic Structure

rotation orientation

$$ {}^0_3T = {}^0_1T(\theta_1)\,{}^1_2T(\theta_2)\,{}^2_3T(\theta_3) $$

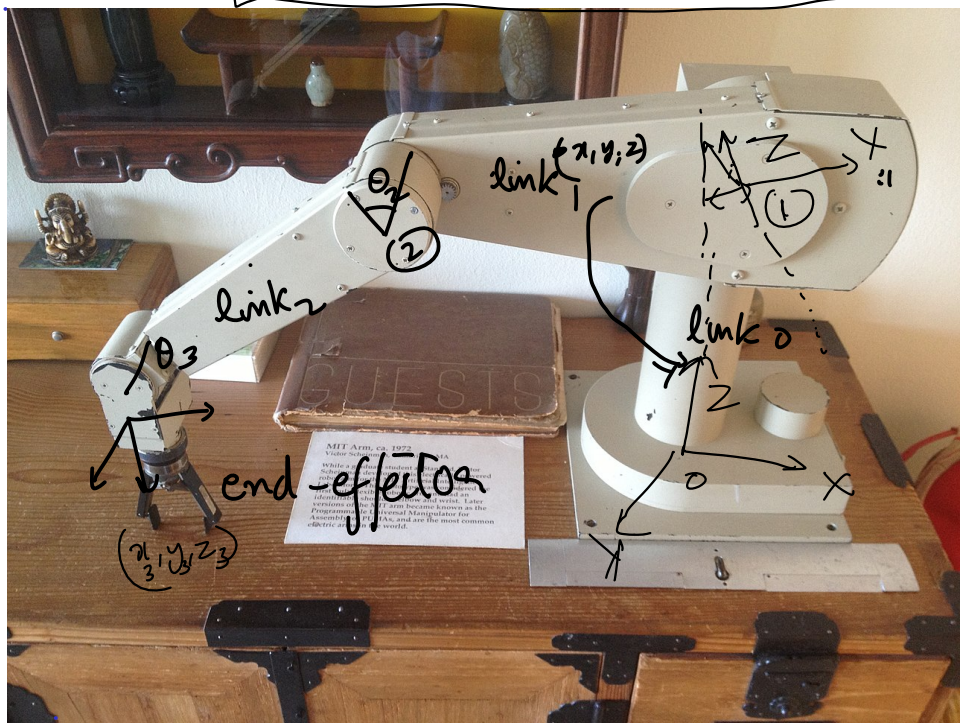
$$ \underline{x}_0 = {}^0_3T\,\underline{x}_3 $$

static

9 Rot 3 trans

12

4x4



description of robotic arm

dst

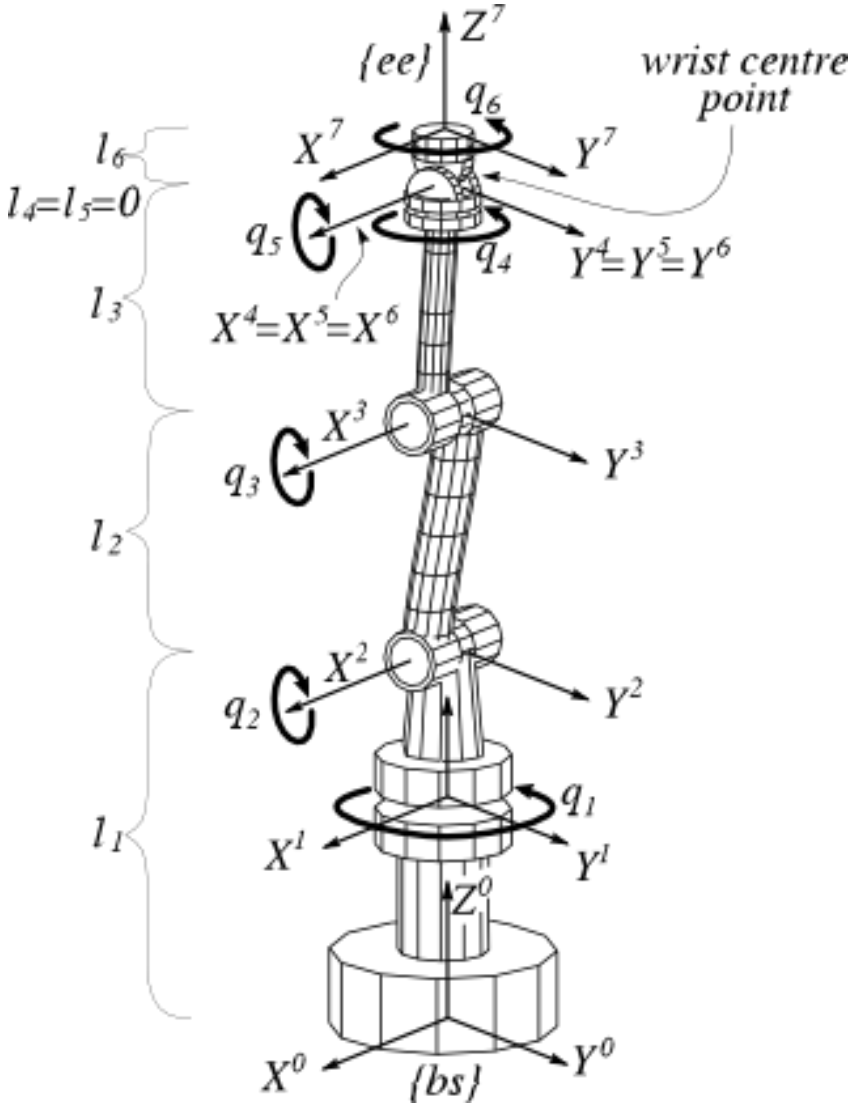
$$ \underline{x}_0 = {}^0_1T(\theta_1)\,{}^1_2T(\theta_2)\,{}^2_3T(\theta_3)\,\underline{x}_3 $$

src

Forward kinematics

is the problem of finding the end-effector pose in the base coordinate system when the joint angles (joint states) are given.

pose: pos + orientation



Numerical solutions to IK problems: Jacobian inverse technique