Introduction to Robotics for cognitive science

Dr. Andrej Lúčny

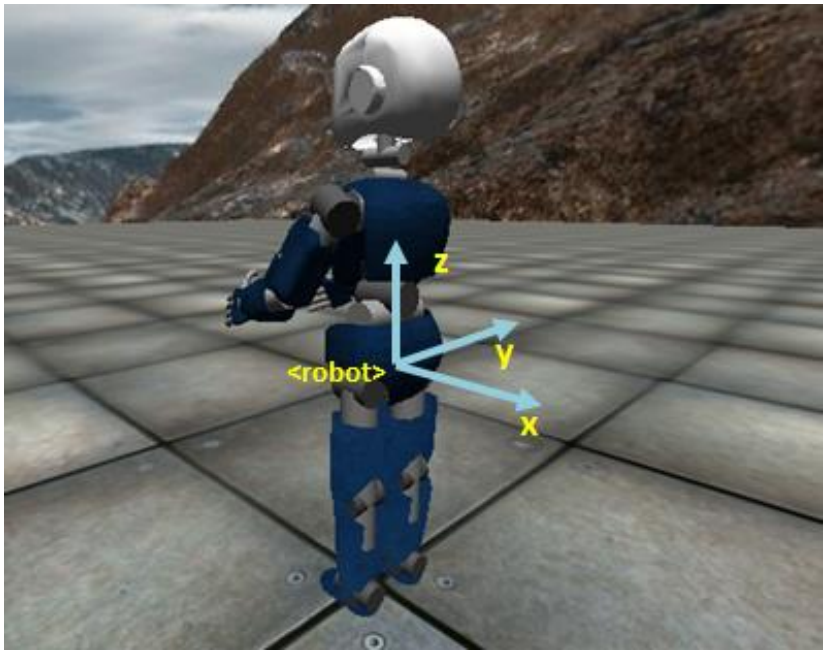
KAI FMFI UK

lucny@fmph.uniba.sk

www.agentspace.org/kv

Direct kinematics

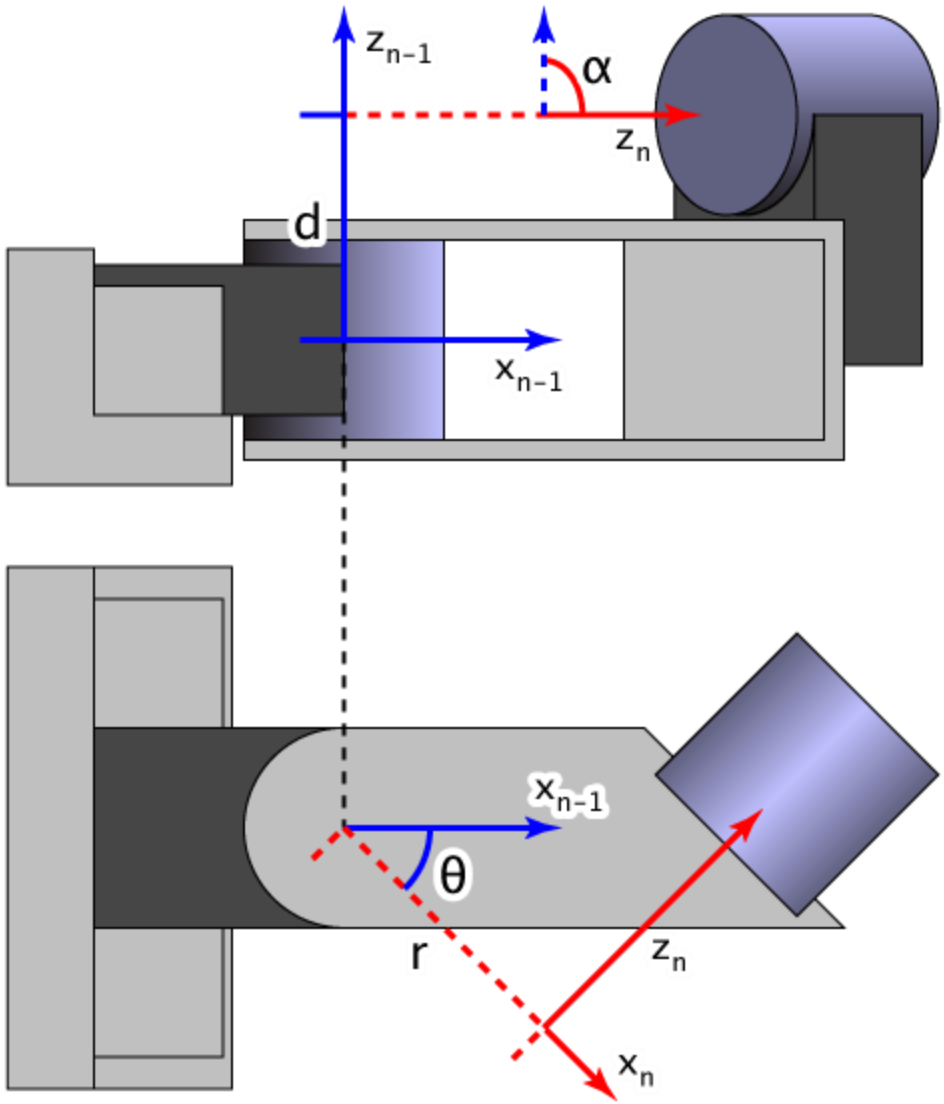
- Calculation of the robot position from the motors positions (coordinates from angles)



Robot body

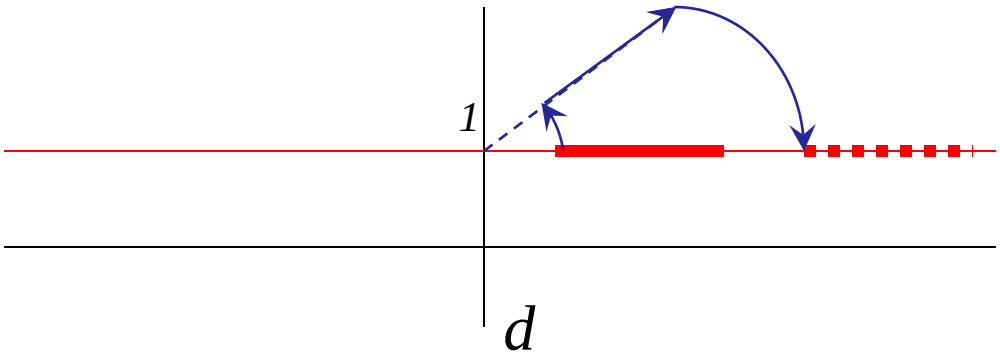
- For the calculation we need data about robot body
- Typically this data are expressed in form of Denavit-Hartenberg (D-H) convention which specify for each joint four parameters:
  - r(a), d, θ, α

(constants)



Math: projective geometry

- We need to calculate translations and rotations
- We have calculus of linear transformations which is good for scaling and rotations but cannot express translation. Therefore we extend space by one additional dimension *d* and we emulate translation as rotation, scaling and rotation on hyperplane $d = 1$



- Thus we have four coordinates (x,y,z,1)

- From *D-H* parameters of joints *1,2,…,n,* we can derive matrixes Z_i, X_i - linear transformations which mutual multiplication calculates the solicited trasformation T of (0,0,0,1) to (x,y,z,1)

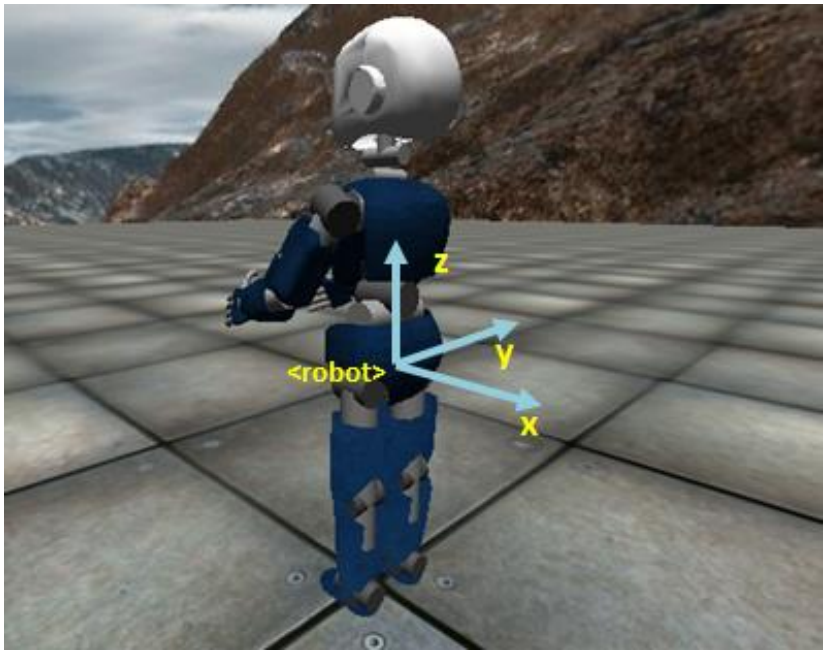
$$[T] = \underbrace{[Z_1][X_1]}_{\mathrm{DH}_1}[Z_2][X_2]\dots[X_{n-1}][Z_n][X_n],$$

$$[Z_i] = \begin{bmatrix} \cos\theta_i & -\sin\theta_i & 0 & 0 \\ \sin\theta_i & \cos\theta_i & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad [X_i] = \begin{bmatrix} 1 & 0 & 0 & r_i \\ 0 & \cos\alpha_i & -\sin\alpha_i & 0 \\ 0 & \sin\alpha_i & \cos\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

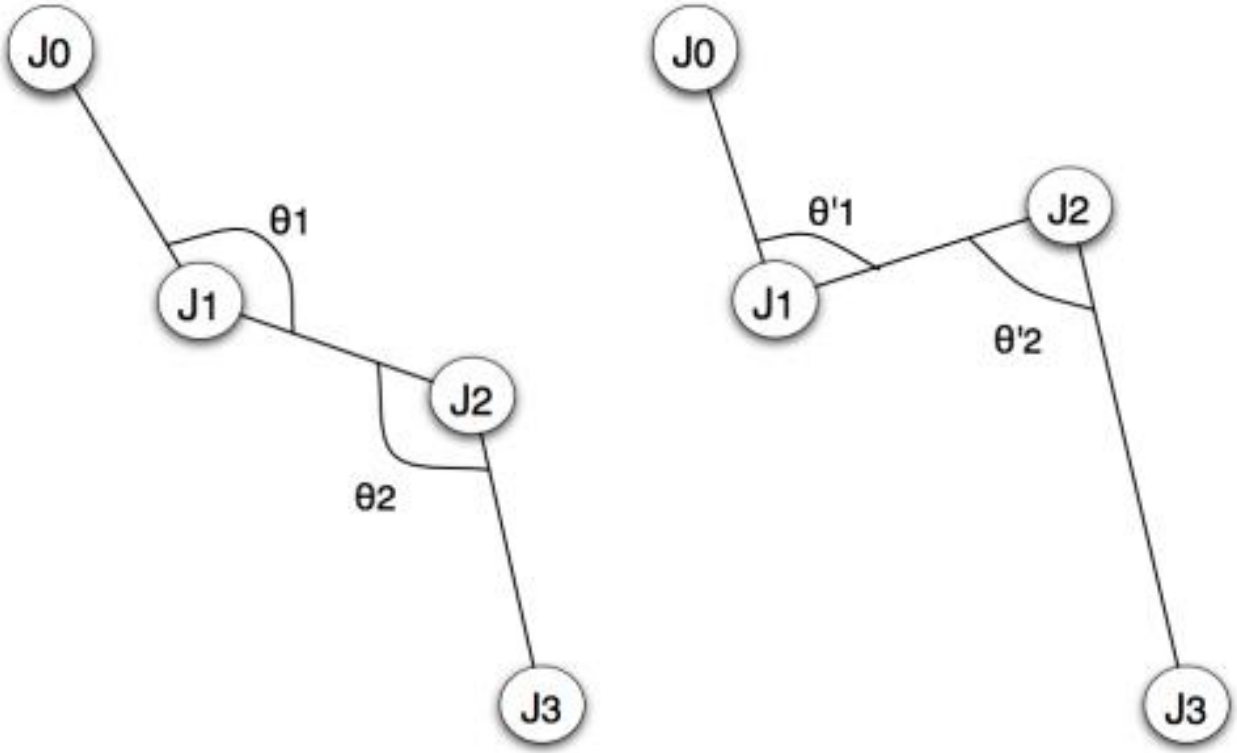
In this way we have solved direct kinematics

Inverse kinematics

- Calculation of the motors positions from the robot positions (angles from coordinates)



- Inverse kinematics can have more solutions or no solution



- Solution of inverse kinematics is more complicated. In analytic form it can be calculated only for specific cases.
- However we have heuristic iterative methods which can find solution, e.g. FARBRIK algorithm

FABRIK

forward and backward reaching inverse kinematics