Modeling the iCub with a kinematic and dynamic library

Semester project intermediary presentation

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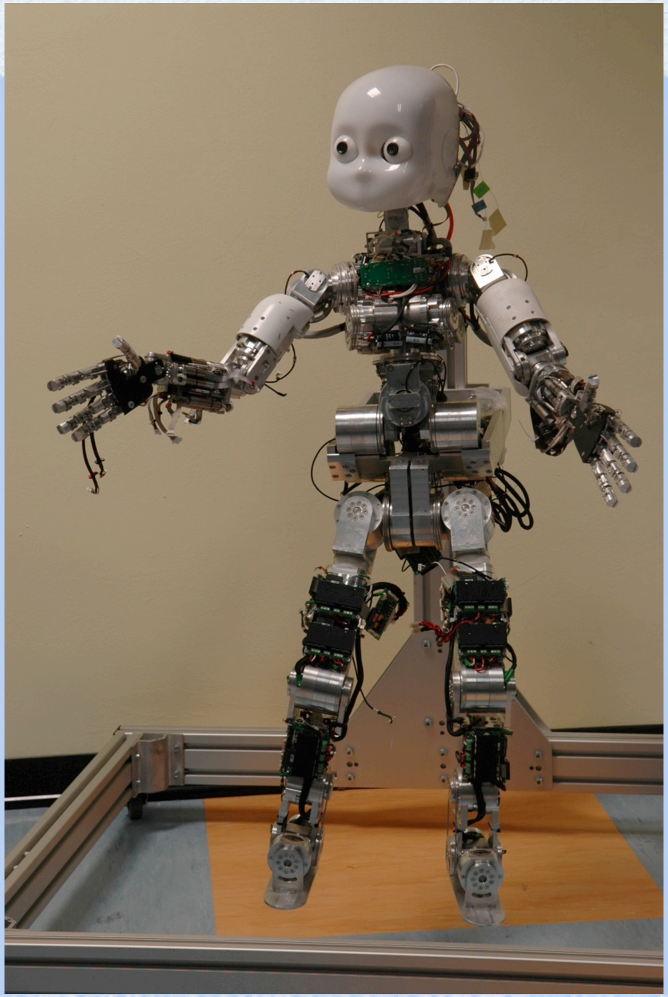
INTRODUCTION

- **The iCub robot :**
- small sized humanoid robot
- European project among several universities, which aims to study cognition

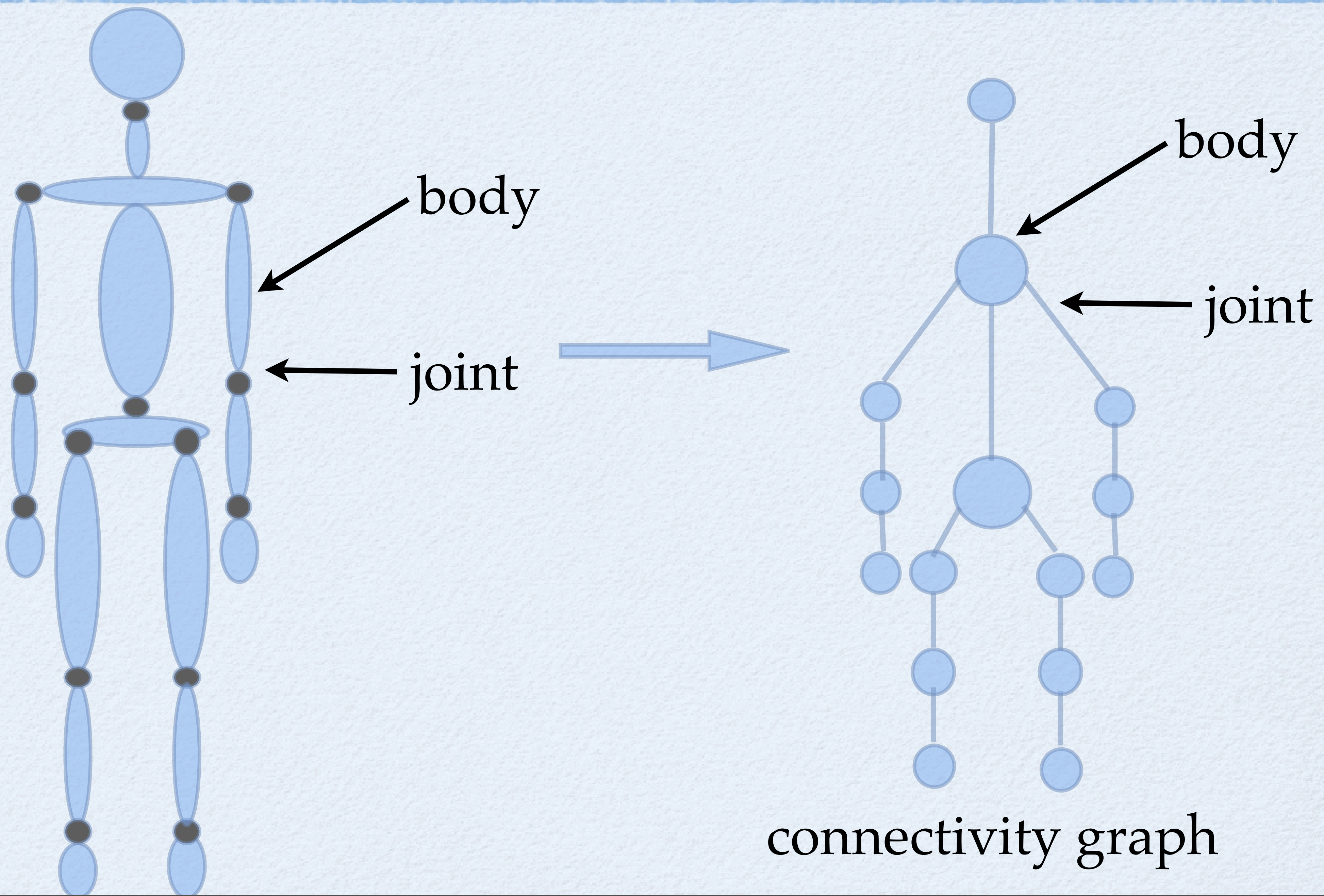


http://robotcub.org

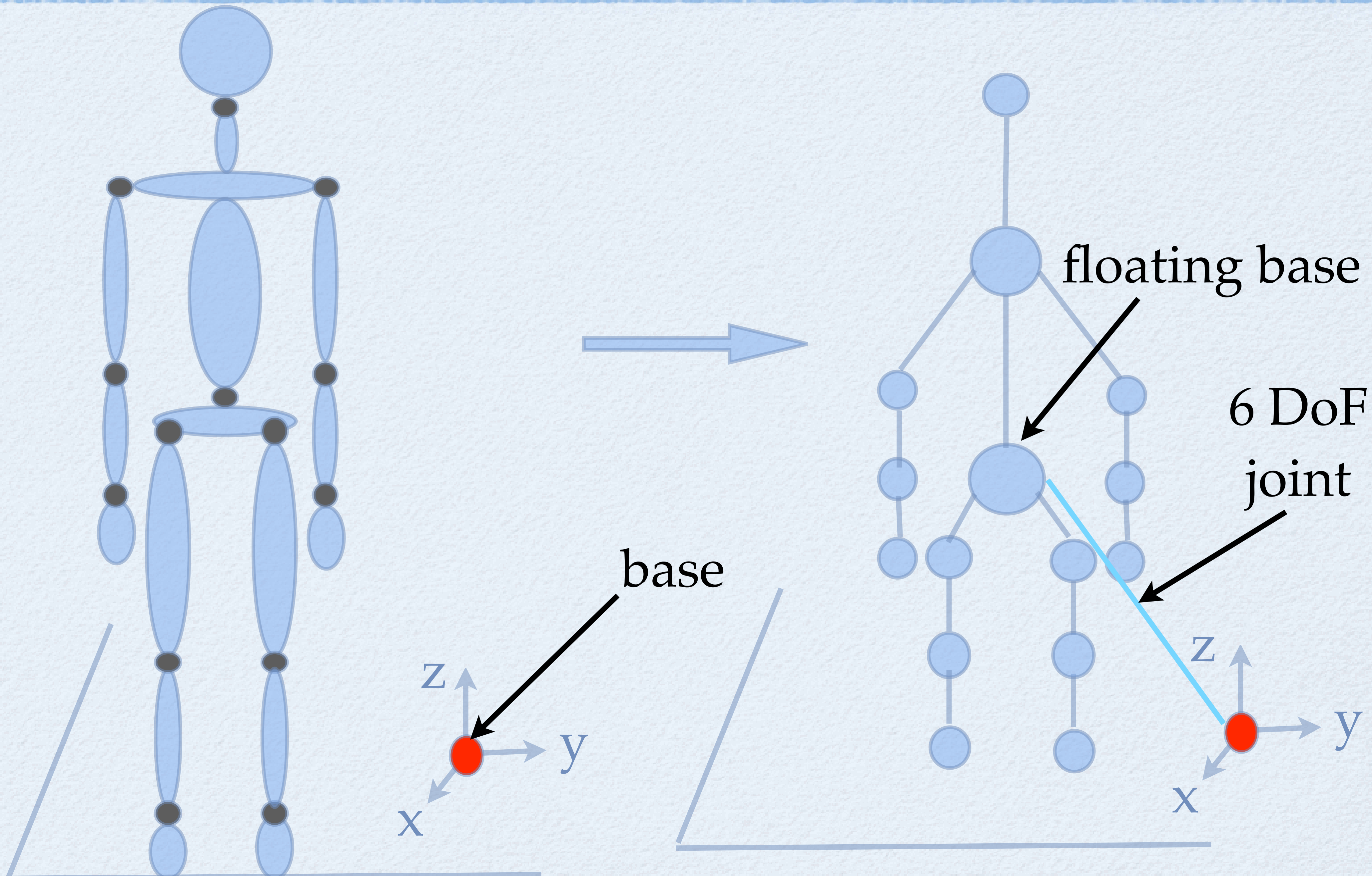
INTRODUCTION

- **Goal of the project** : biped gait stability.
- **Need:**
    - Model of the robot
        - Denavit-Hartenberg's parameters
    - Description of the movements
        - Forward vs. Inverse kinematic
        - KDL (Kinematic and Dynamic Library)

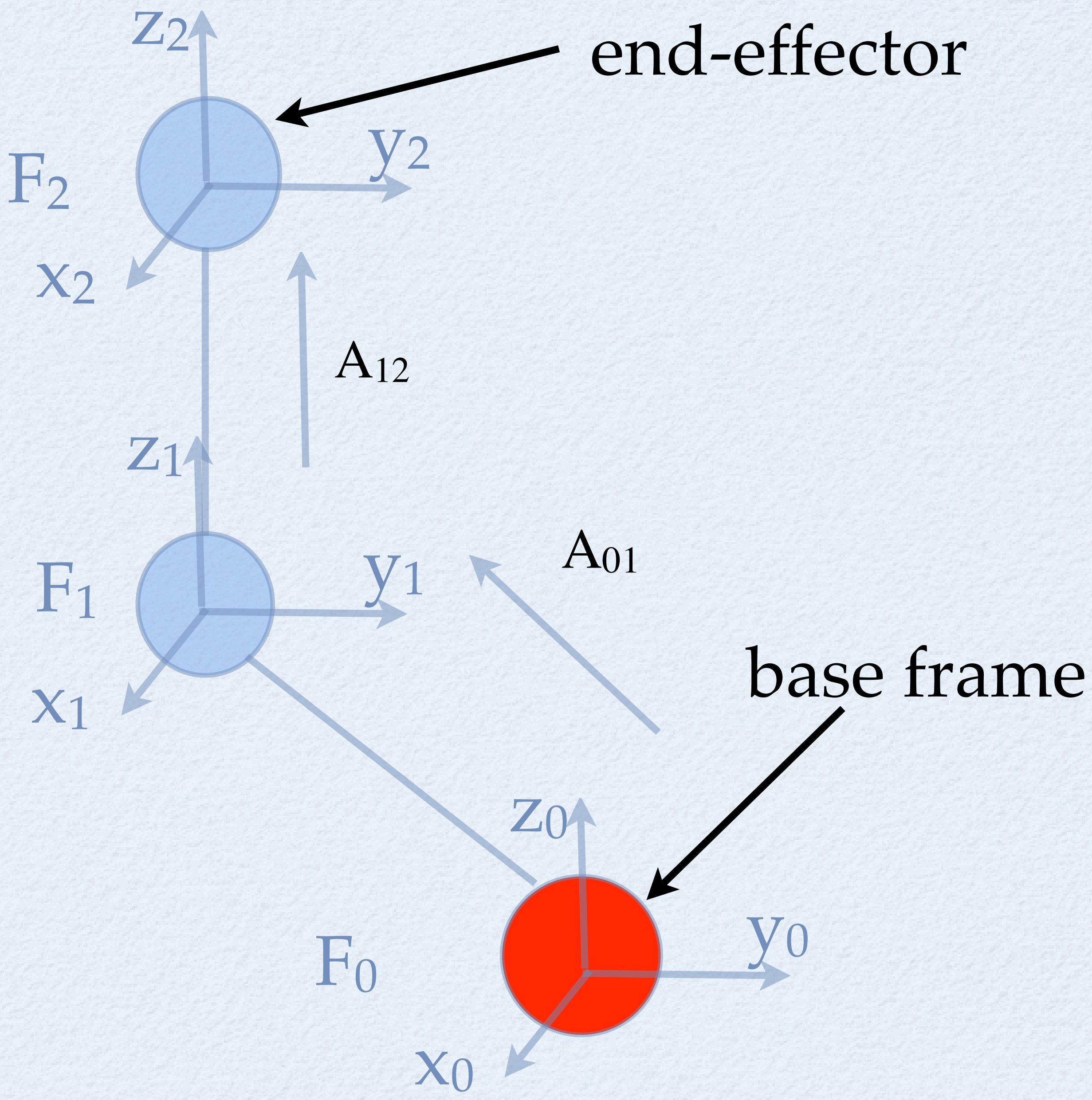
Modeling



Floating Base



Geometric Model



Denavit-Hartenberg Parameters

- Idea : most common joint types can be characterized by a line in space
- Need only four parameters to locate a line:
  - a_i : link (body) length
  - α_i : link twist
  - d_i : link offset
  - θ_i : joint angle
- Usually for revolute joints a_i, α_i, d_i are constants, θ_i is the only variable

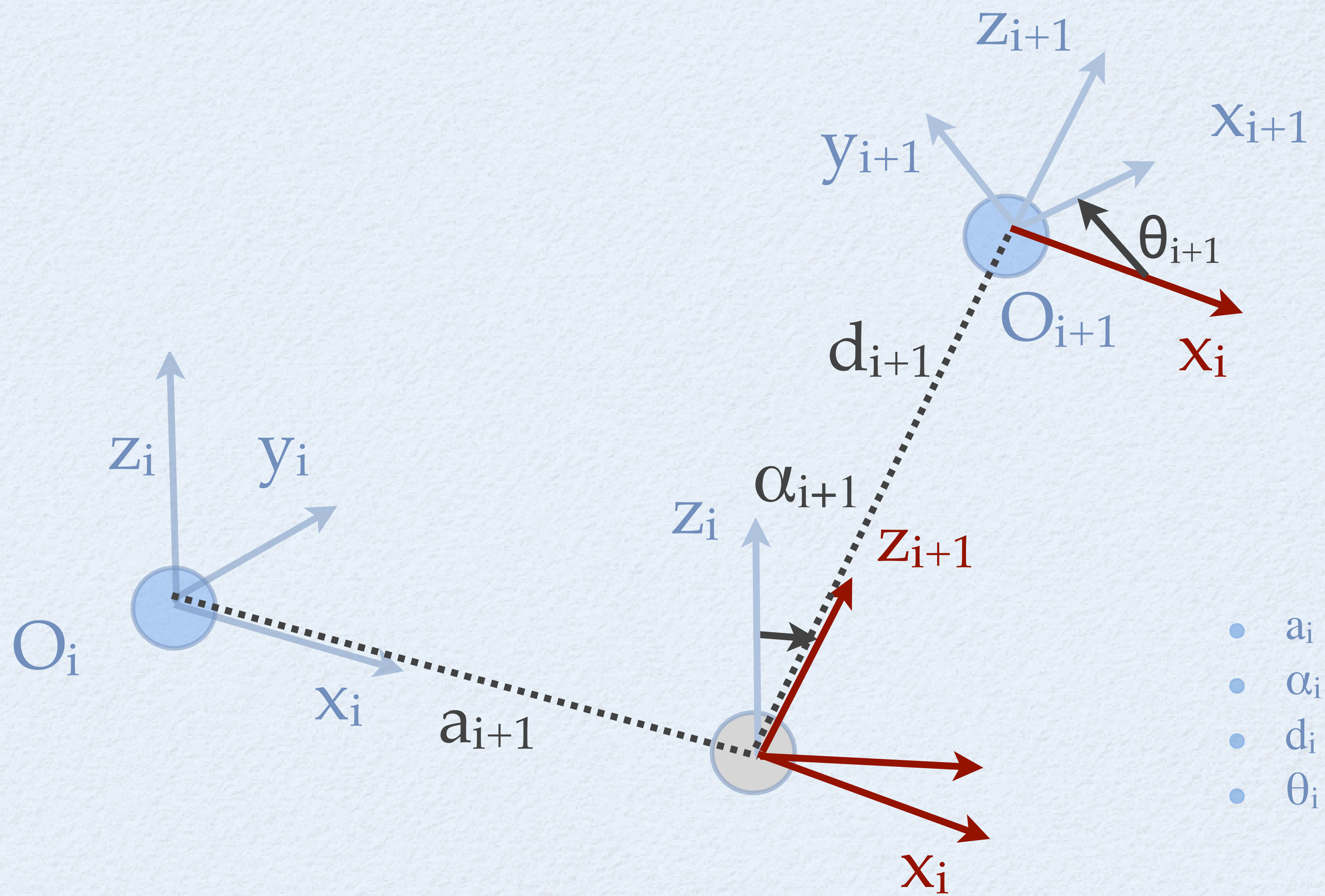
Denavit-Hartenberg Parameters

- Main features :
  - a base coordinate frame
  - n joint axes
  - an end-effector frame, embedded in the final body

Denavit-Hartenberg Parameters

- Rules to place the DH coordinate frames:
  - align z_0 and z_{n+1} with the z axis of the base and end-effector frame
  - align z_i with joint axis i (revolut joint : rotation axis)
  - axis x_i intersects z_i and z_{i+1} and is perpendicular to them
  - y_i is derived from x_i and z_i, right-handed coordinate frame

Denavit-Hartenberg Parameters



- a_i : link (body) length
- α_i : link twist
- d_i : link offset
- θ_i : joint angle

FORWARD VS. INVERSE KINEMTATIC

- **Forward kinematic :**
  - Determine the position of the end-effector knowing the joint angles -> unique solution
- **Inverse kinematic :**
  - Determine the joint angles knowing the position of the end-effector -> multiple solutions.
  - Used in this project

KDL

- KDL = Kinematic and Dynamic Library
- Part of the Open Robot Control Project (Orocos)
- Goal : develop a free software and framework for robot and machine control
- KDL : Modeling and computing of kinematic chains such as robots

KDL AND THE ICUB

- Model arms and legs with kinematic chains using DH parameters (http://eris.liralab.it/wiki/ICubForwardKinematics)
  - API : **Chains**, made of **Segments** which contain a **Joint** to define rotation axis and a coordinate **Frame** expressed with DH parameters
- Forward kinematic
  - API : recursive algorithm to calculate the position from joint space to cartesian space.

KDL and the iCub

- Inverse kinematic
  - API : iterative algorithm based on Newton-Raphson iterations.
  - Idea: begin with an estimate a′ of joint angles.
  - Calculate forward position p′ and compare with input position p.
  - If the difference is very small : stop. Else calculate new estimate and continue.

Some Results

- Comparing forward kinematic found by KDL with matrix multiplication of transformation matrices defined with DH parameters.
    - ➡ Same results.
- Applying forward, inverse, forward kinematic.
    - ➡ Get the same end-effector position.
    - ➡ Get different joint angles (multiplicity of solutions).

Questions ?