école
normale
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paris–saclay

Writing with NAO

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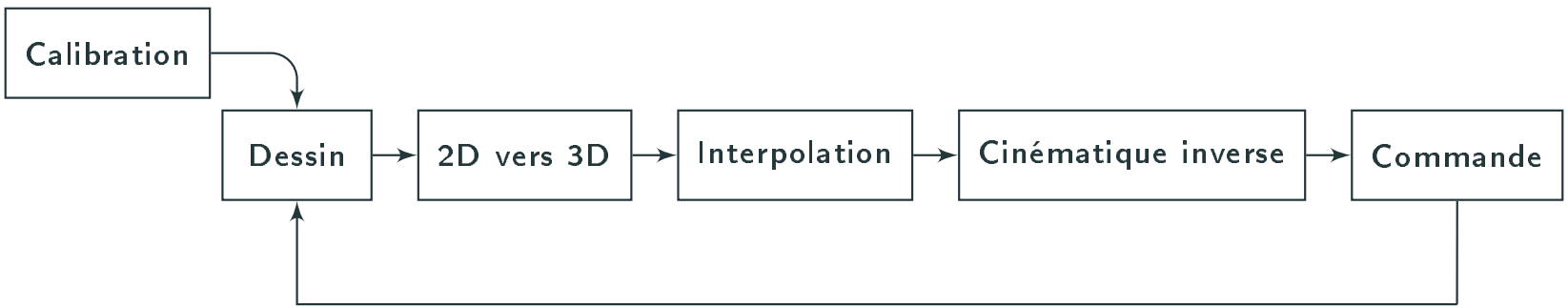
Goal of our project

- We want to make our robot NAO write!

[1]

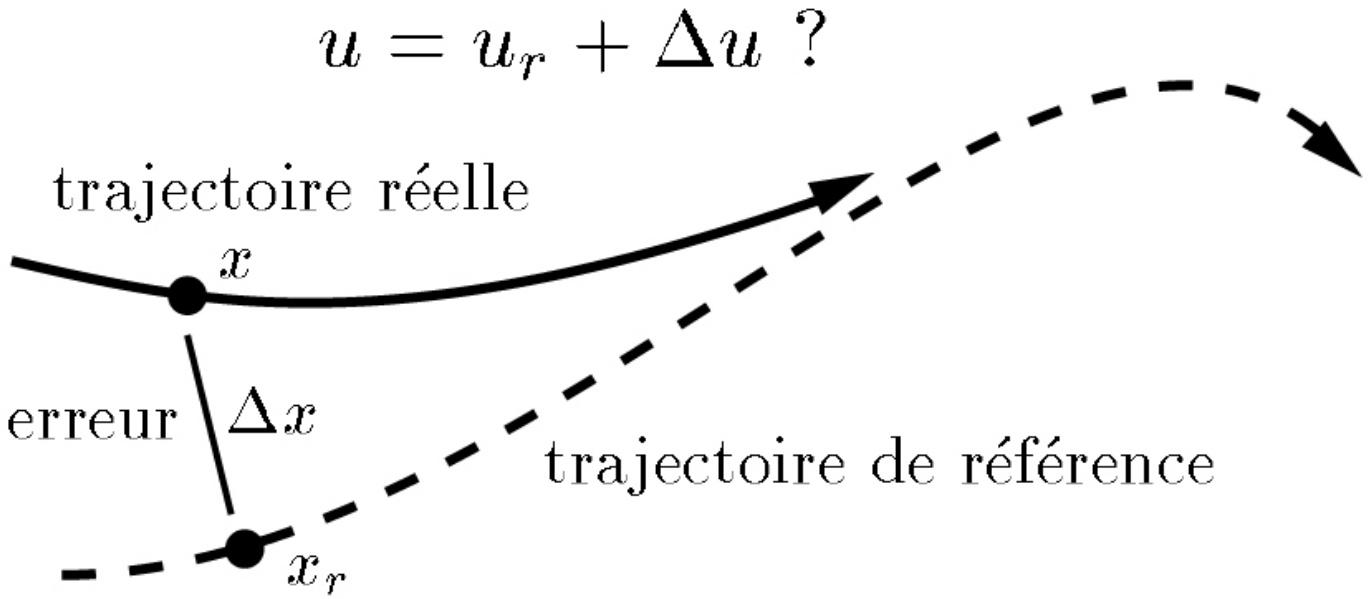
Methodology



Inverse kinematics

Approching the goal trajectory

We approach this goal trajectory by solving a sequence of optimization problems: minimizing the errors between the goal trajectory and the real trajectory.

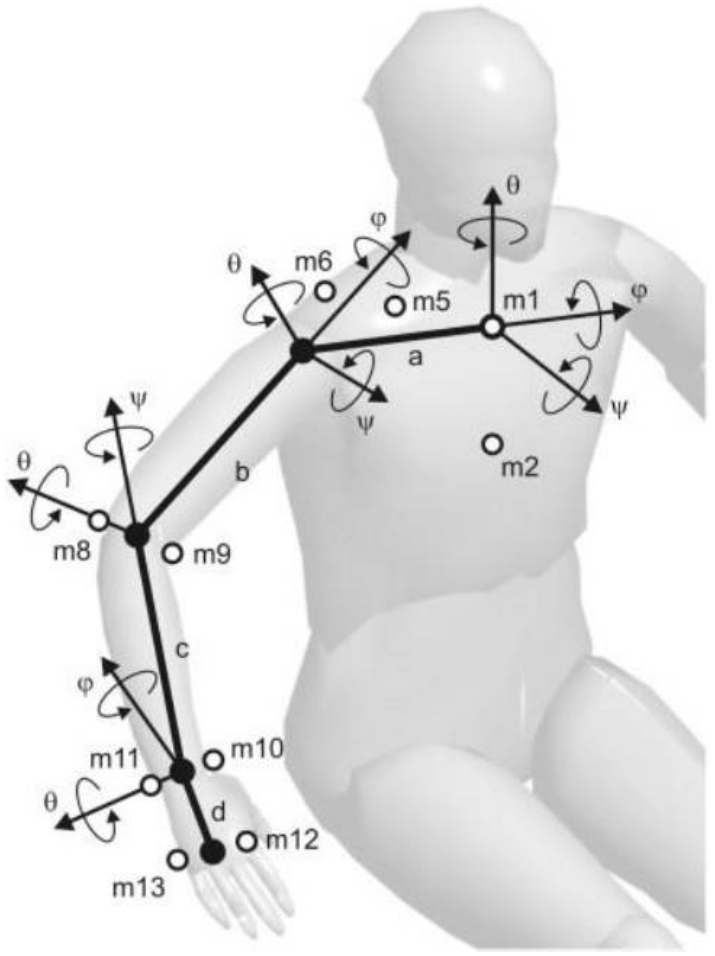


[2]

modeling the coordinate system i

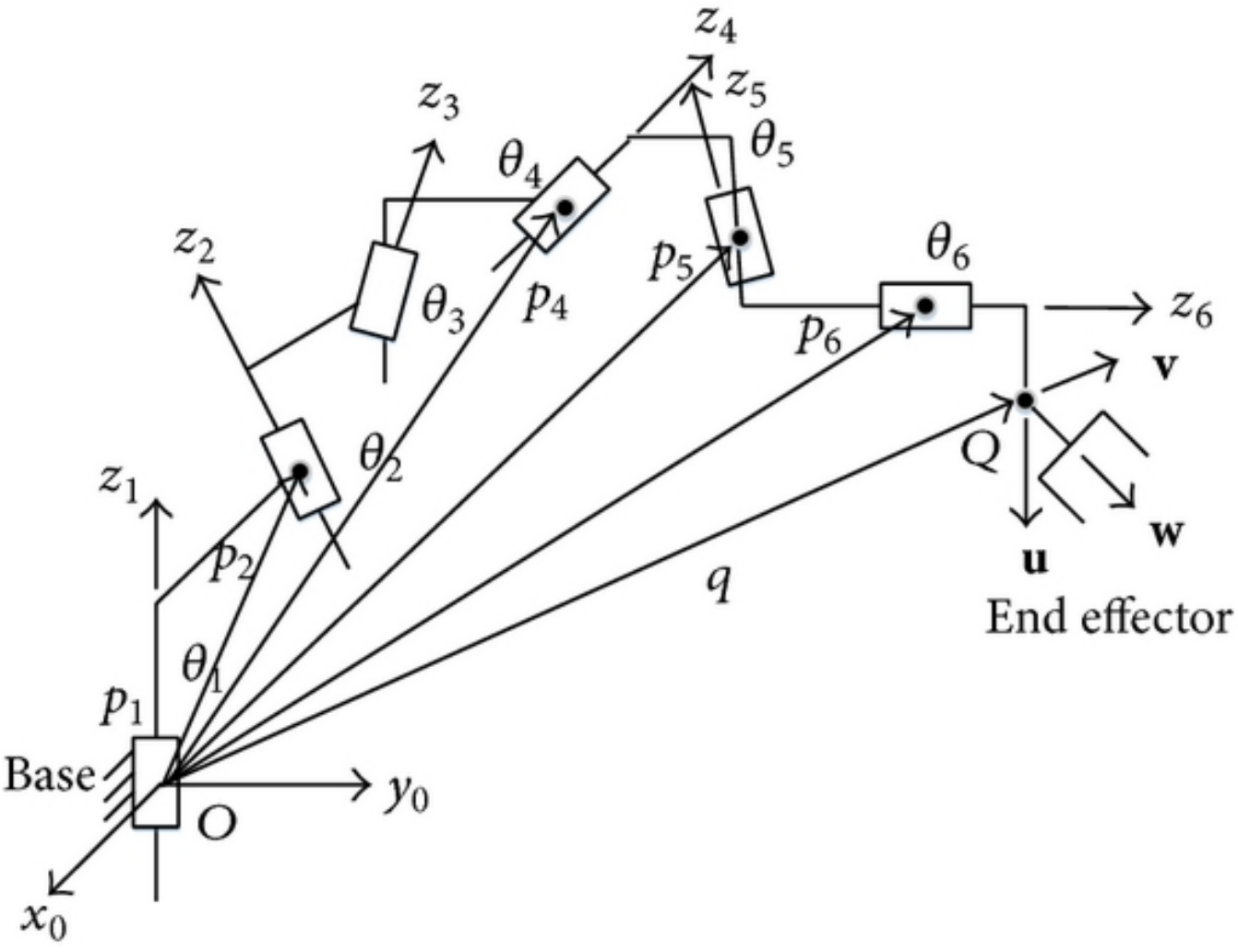
The robot's arm is a 6-joint system.

We find the position of end-effector (the pen) by composing a sequence of *change of coordinates* matrix.



[3]

modeling the coordinate system ii



[4]

Finding the next "angles step" by computing Jacobian i

Inverse Kinematics - Jacobian

$$\dot{Y} = \frac{\partial F}{\partial X}\dot{X}$$

$$V = J(\theta)\dot{\theta}$$

Desired motion of end effector

Unknown change in articulation variables

The *Jacobian* is the matrix relating the two: describing how each coordinate changes with respect to each joint angle in our system

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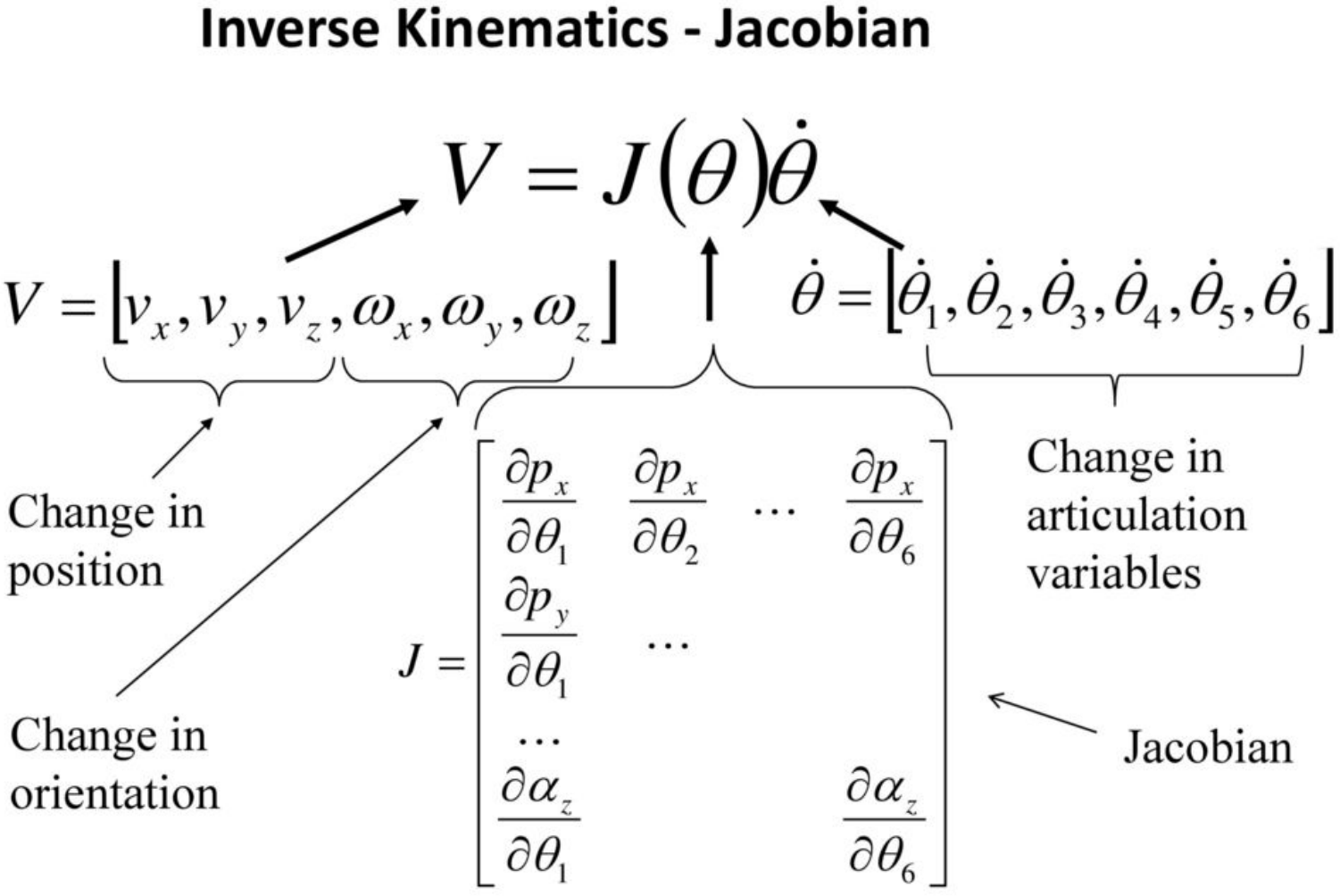
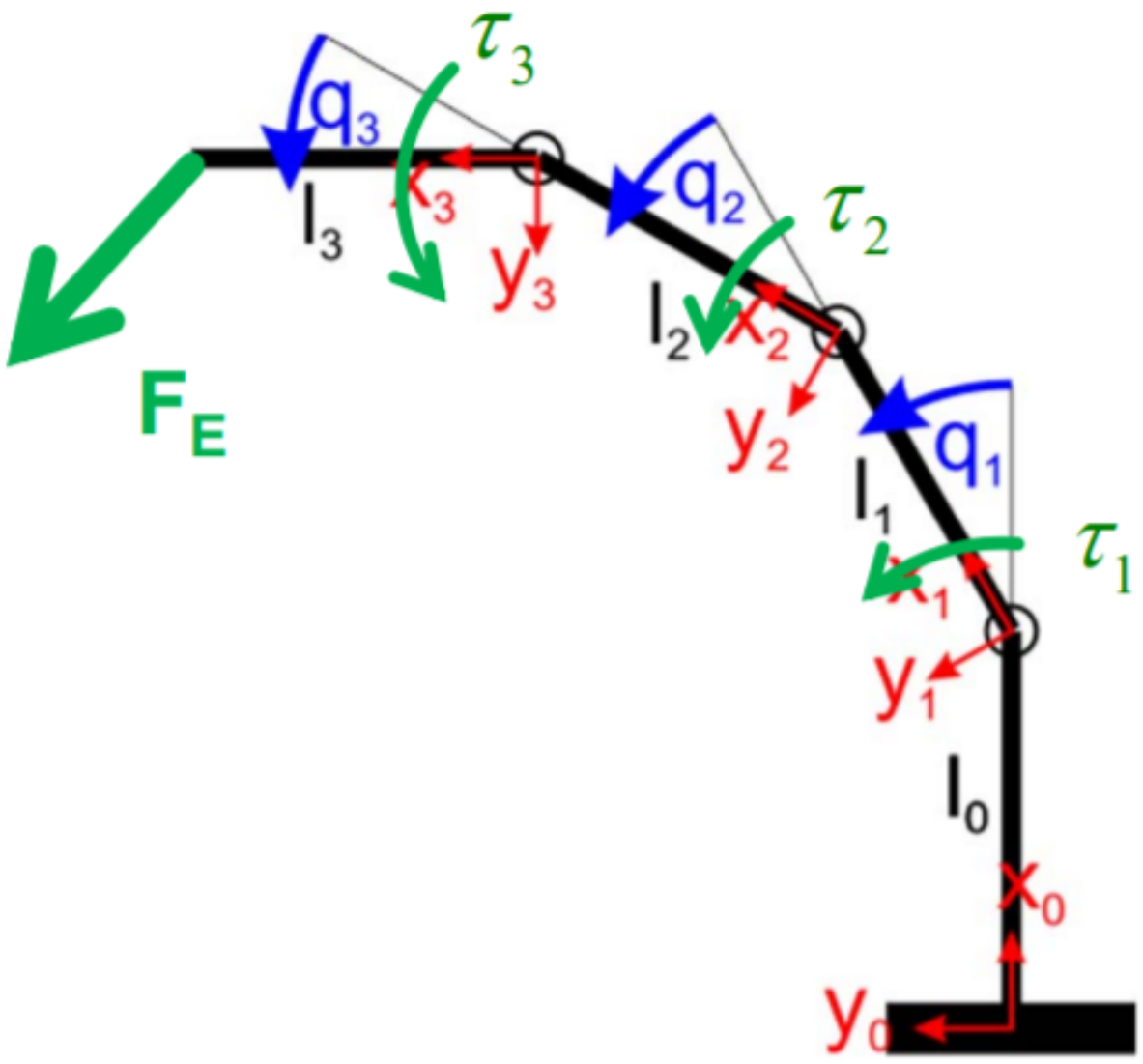
Finding the next "angles step" by computing the jacobian ii



[5]

Finding the next "angles step" by computing the jacobian iii



[6]

Finding the next "angles step" by computing the jacobian iv

Algorithm 1 Numerical Inverse Kinematics

1: $\mathbf{q} \leftarrow \mathbf{q}^0$ ▷ Start configuration
2: **while** $\|\boldsymbol{\chi}_e^* - \boldsymbol{\chi}_e(\mathbf{q})\| > tol$ **do** ▷ While the solution is not reached
3: $\quad \mathbf{J}_{eA} \leftarrow \mathbf{J}_{eA}(\mathbf{q}) = \frac{\partial \boldsymbol{\chi}_e}{\partial \mathbf{q}}(\mathbf{q})$ ▷ Evaluate Jacobian for $\mathbf{q}$
4: $\quad \mathbf{J}_{eA}^+ \leftarrow (\mathbf{J}_{eA})^+$ ▷ Calculate the pseudo inverse
5: $\quad \Delta\boldsymbol{\chi}_e \leftarrow \boldsymbol{\chi}_e^* - \boldsymbol{\chi}_e(\mathbf{q})$ ▷ Find the end-effector configuration error vector
6: $\quad \mathbf{q} \leftarrow \mathbf{q} + \mathbf{J}_{eA}^+ \Delta\boldsymbol{\chi}_e$ ▷ Update the generalized coordinates
7: **end while**

[6]

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