école
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Writing with NAO

Adrien Bardes, Marius Dufraisse, Pierre Guetschel, Mengda Li

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Goal of our project

- We want to make our robot NAO write!

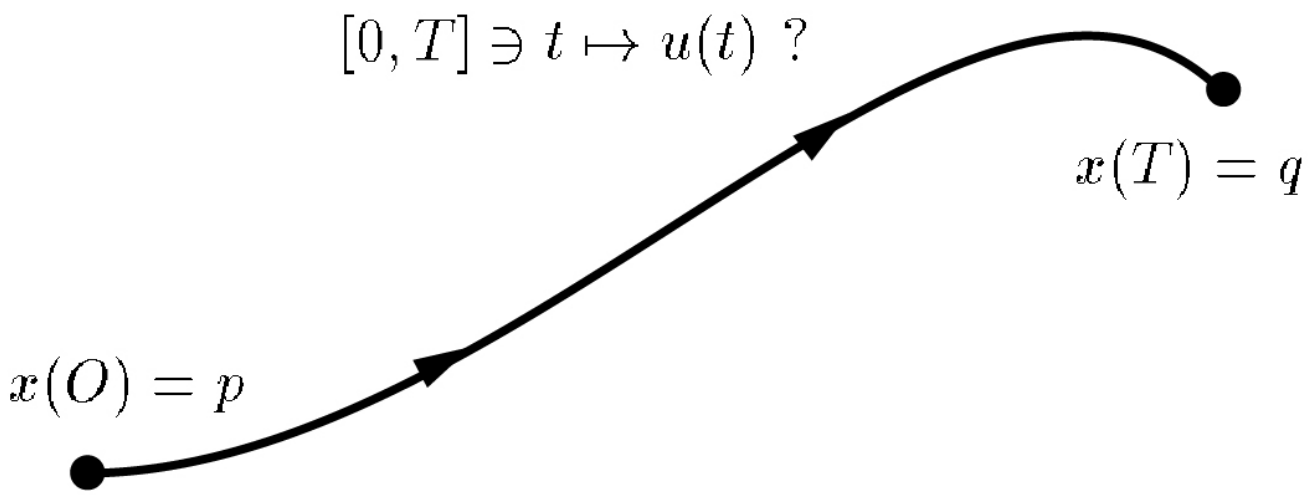
[1]

Methodology

Analysis of handwriting and extraction of trajectory function

trajectory function

We formalize what we want to write by a trajectory function.



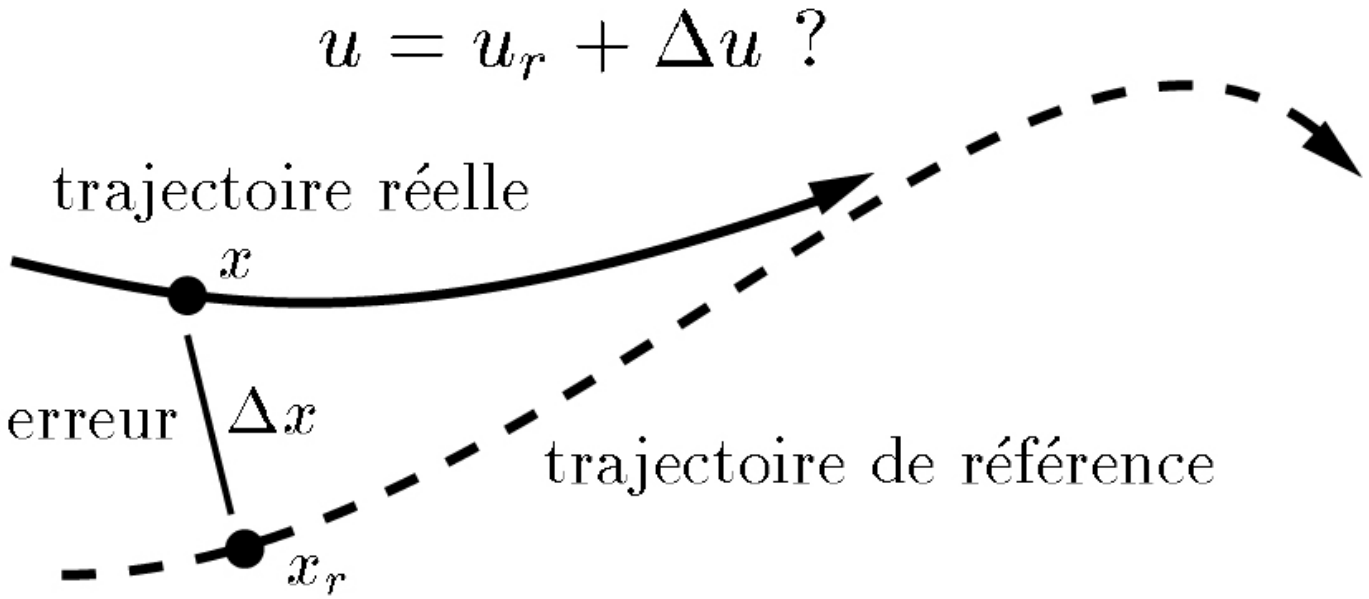
$$\frac{dx}{dt} = f(x,u)$$

[2]

Inverse kinematics

approching the goal trajectory

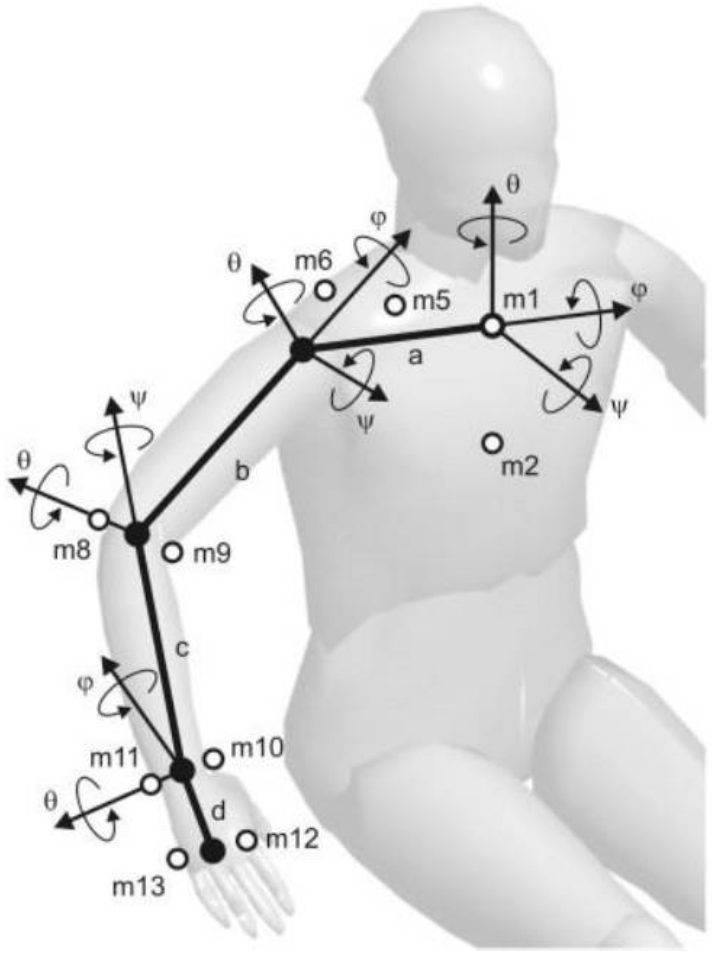
We approach this goal trajectory by solving a sequence of optimization problem: minimizing the errors betwenn the goal trajectory and the real trajectory.



[2]

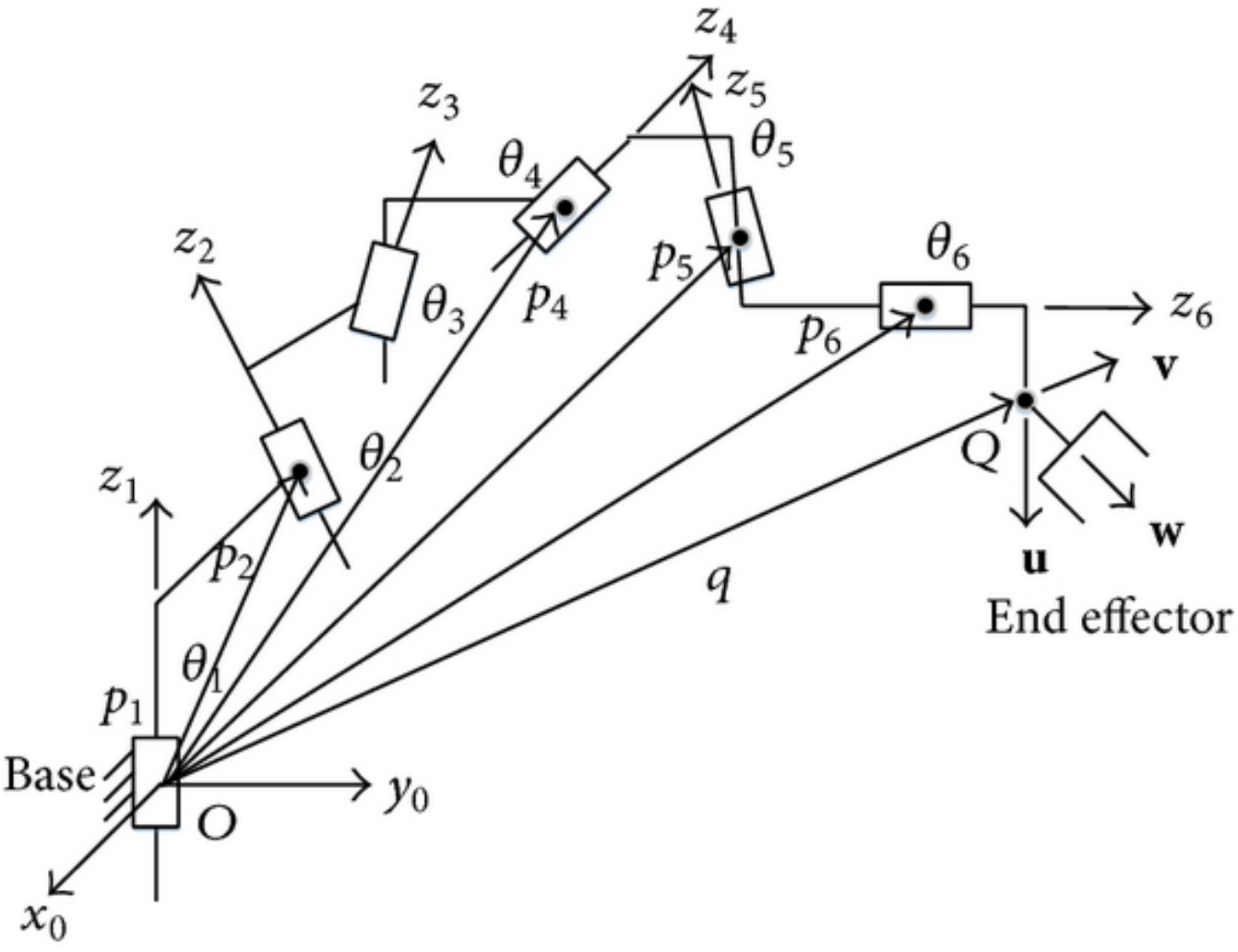
modeling the coordinate system i

The robot is a n-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 jacobien i

Inverse Kinematics - Jacobian

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

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

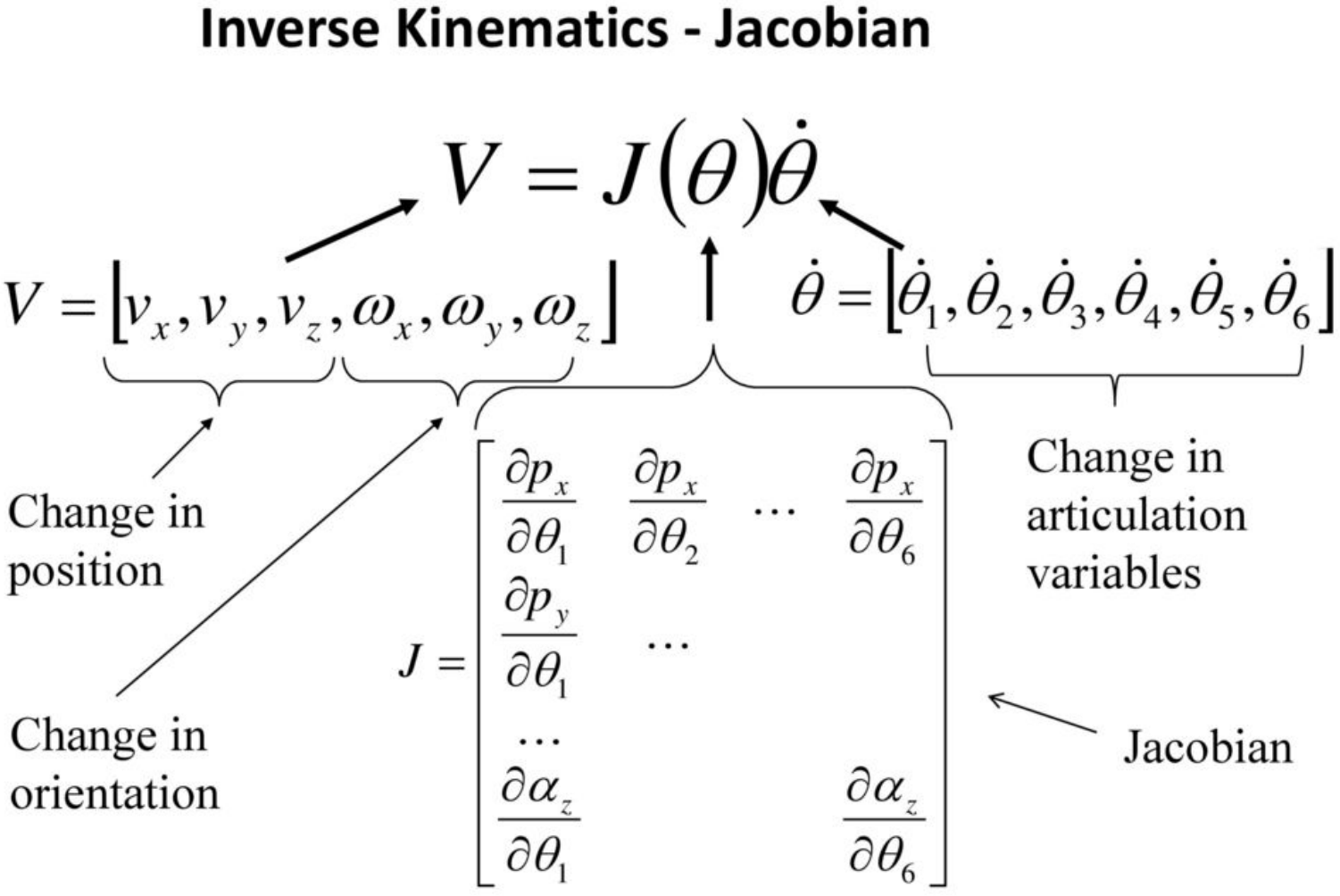
Desired motion of end effector

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

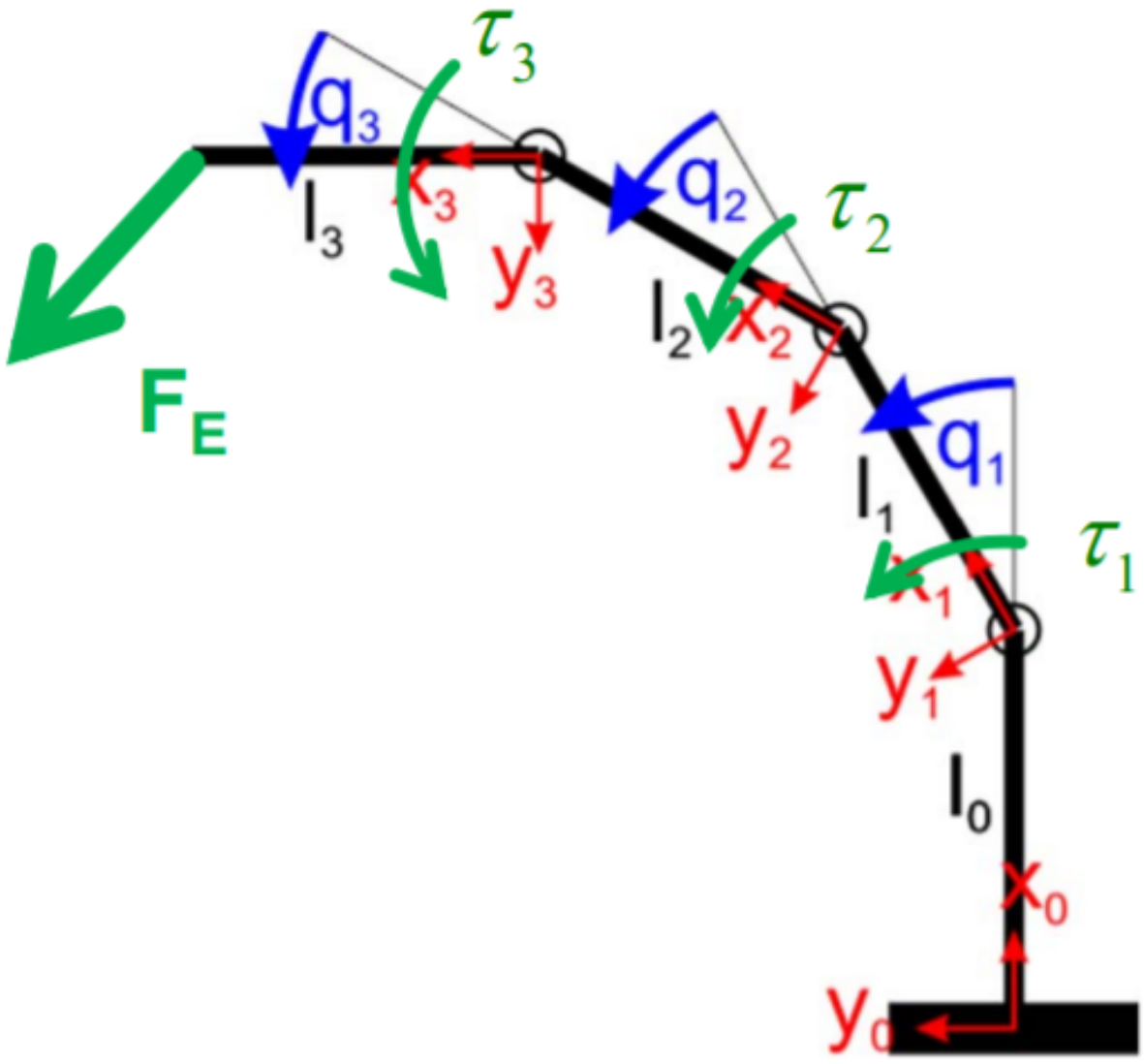
[5]

finding the next “angles step” by computing jacobien ii



[5]

finding the next “angles step” by computing jacobien iii



[6]

finding the next “angles step” by computing jacobien 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]

Bibliography i

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