UNIVERSITAT POLITÈCNICA DE CATALUNYA

FOMAR

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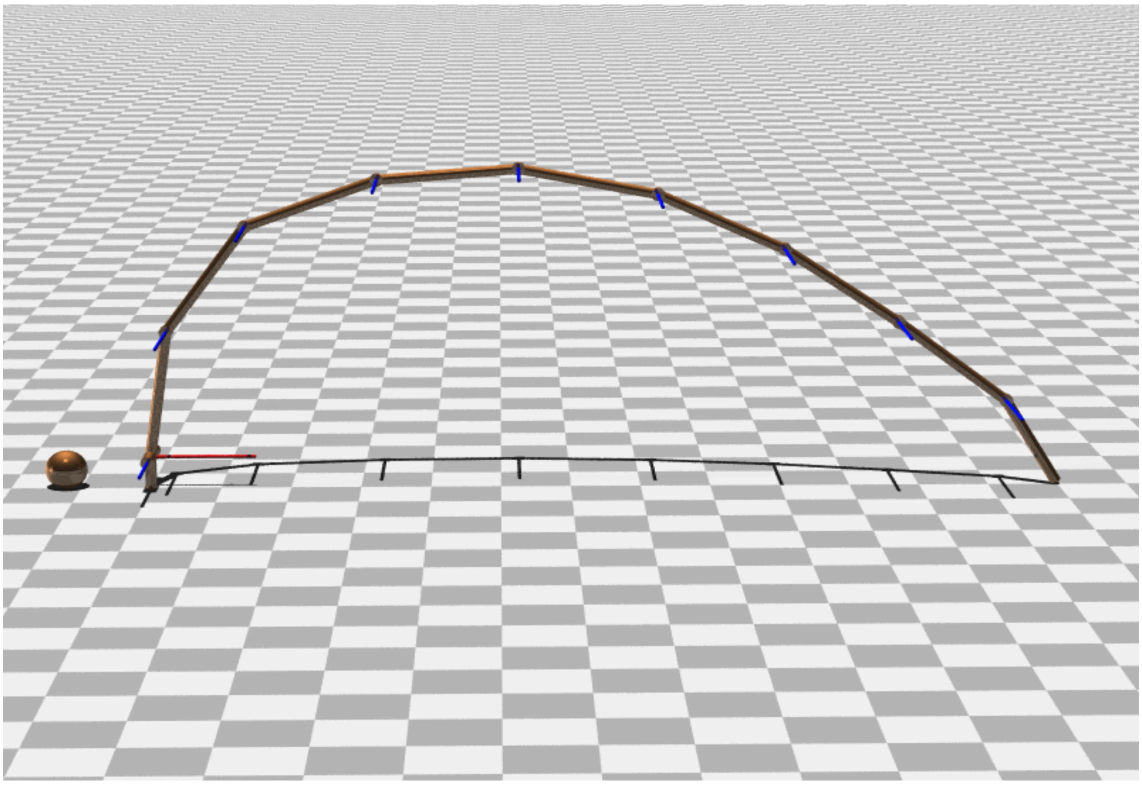
LABORATORY ASSIGNMENT 4: Inverse Kinematics



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Exercise 1

The procedure we have implemented is clearly based on the instructions given at the PDF files, that is identifying the three requested external variables in the homogeneous matrix:

$$X_W = {}^0_W T = \begin{bmatrix} \square & . & . & \square \\ \square & . & . & \square \\ \square & . & . & \square \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{array}{l} \rightarrow X_1 \\ \rightarrow X_2 \\ \quad X_3 \\ \\ \end{array}$$

Where X1 and X2 are the X and Y coordinates of the end effector and X3 is dependant on the end effector orientation.

Then for each joint variable the DX matrix is constructed:

$$DX = {}^0_1 T \, {}^1_2 T \ldots {}_{j-1} T \, {}_j D \, {}_{j+1} T \, \ldots \, {}_N T \, {}^N_W T$$

Where the T matrix are transformation matrices and D is a revolution joint matrix (which is the derivative of a T matrix with respect to theta j).
This matrix last column gives the three partial derivatives of X1,X2 and X3 with respect to the theta of the DX.

Then the Jacobian is constructed using these partial derivatives for each joint.

Knowing the requested rates of change for the external variables:

$$x(i) = 13 + (4 - 13)\frac{i}{N}$$

$$y(i) = -1/2$$

$$n_x(i) = 1/2$$

And with the formula for the rates of change of the set of conditions of the system related to the Jacobian and the rate of change of the system's components (angles of joints in our case):

$$\triangle x = J \triangle \theta$$

We can isolate the increment of theta with the help of the pseudo-inverse of the Jacobian, thus obtaining the angles required in our system to obtain the desired rate of change, solving the inverse kinematics problem.

Exercise 2 and 3

Find the attached code at ex23.py and the resulting gif at ex23.gif.

Exercise 4a

Find the attached code at ex4a.py and the resulting gif at ex4a.gif. Where we have modified the fifth Jacobian column to zeros, making the fifth axis stiff during the movement.

Exercise 4b

Find the attached code at ex4b.py and the resulting gif at ex4b.gif. Where we have modified the desired increment of the x coordinate in order not only to end in $x = 7$ (our last ID digit) but also to arrive there in a non-linear movement following another formula.