Robotik: NAO Drawing Basic Shapes Using Inverse Kinematics

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1   The Goal

The main goal of these task is to use what you have learned in the lecture regarding how to build a forward and an inverse kinematics model for a robotic arm. As an application we address drawing skills for basic shapes by NAO robot left arm.

2   Task Description

2.1   Forward Kinematics

- Build a forward kinematics model for NAO left arm with a consideration of the frame assignment as in Fig. 1 and the D-H parameters of the arm as descried in Fig. 1. Work out all transformation matrices:

    - A_0^{base}, A_1^0, A_2^1, A_3^2, A_4^3, A_5^4.
    - A_1^{base}, A_2^{base}, A_3^{base}, A_4^{base}, A_5^{base}.

    Use $t1, t2, t3, t4, t5$ as joint variables in your code.
    Use $A0$ to describe A_0^{base} in your code.
    Use $A1$ to describe A_1^0 in your code.
    Use $A2$ to describe A_2^1 in your code.
    Use $A3$ to describe A_3^2 in your code.
    Use $A4$ to describe A_4^3 in your code.
    Use $A5$ to describe A_5^4 in your code.
    Use $A01$ to describe A_1^{base} in your code.
    Use $A012$ to describe A_2^{base} in your code.
    Use $A0123$ to describe A_3^{base} in your code.

Use $A01234$ to describe A_4^{base} in your code.
Use $A012345$ to describe A_5^{base} in your code.

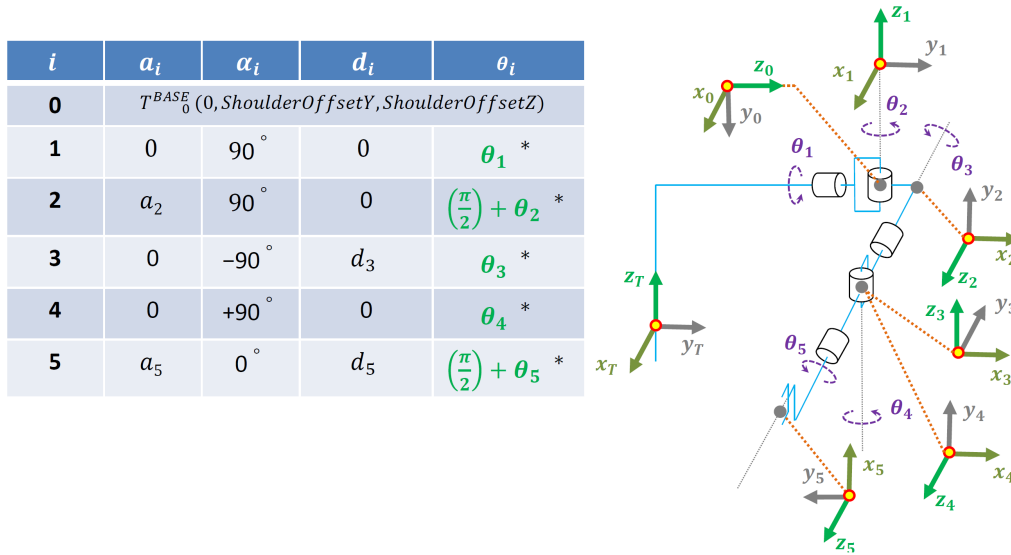| i	a_i	α_i	d_i	θ_i
0	T^{BASE}_0 $(0, ShoulderOffsetY, ShoulderOffsetZ)$			
1	0	90°	0	θ_1 *
2	a_2	90°	0	$\left(\frac{\pi}{2}\right) + \theta_2$ *
3	0	–90°	d_3	θ_3 *
4	0	+90°	0	θ_4 *
5	a_5	0°	d_5	$\left(\frac{\pi}{2}\right) + \theta_5$ *

Figure 1: Right: Frame assignment for NAO left arm. Left: D-H parameters for the arm.

- Do a verification phase of your forward model by testing it with different configurations. Please show the final transformation matrix $A012345$ for 4 configurations.

2.2 Inverse Kinematics 5 DOF

- Build the inverse kinematics model for NAO left arm with a consideration of the frame assignment as in Fig. 1 and the D-H parameters of the arm as descried in Fig. 1.

- Do a verification phase of your inverse model by testing it with different configurations. Please show the obtained joints' parameters for four different transformations $A012345$ (use results obtained in step.1 as an input for this step).

2.3 Simplified Inverse Kinematics 2 DOF

- Build a simplified inverse kinematics model for NAO left arm that consider two degree of freedom (Shoulder roll and Elbow roll). Other

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joints are not moving and fixed in a way that allow the robot to draw on horizontal plan.

- Do a verification phase of your inverse model by testing it with different configurations.

2.4 Drawing Shapes

Without taking in consideration the joints' velocities, this step address drawing basic shapes with the simplified inverse model that was build in the previous step.

- Define your operational space where the robot can write using a marker.

- Using the simplified inverse kinematics model you have build previously, control the NAO in order to draw:

    - A circle (diameter $> 4cm$).
    - A regular triangle (side $> 4cm$).

3 Results to Submit

- A PDF report containing description, comments of each subtask. Please use the template.

- Source code and the project directory. Not the binaries, etc.

- Note: Comment your code. Also, write your names at the beginning of the source code file.

- Make a demo video showing the results of step.3.

- Compress all the required results into a .zip or .tar.gz file.

- Naming convention: LastName1_LastName2_GroupNo_TaskNo.
  Example: If two students from group "Y" Franz Müller and Peter Maier work together on task 2, then they submit the file Müller_Maier_GY_T2.zip
  or
  Müller_Maier_GY_T2.tar.gz.
  Don't send the video file if it is too big. You can send a link on it [max size 20 MB].

  Submit the file containing your results before the deadline to:
  john.nassour@informatik.tu-chemnitz.de

4   Deadline

Jan. 10th 2016