INDUSTRIAL ROBOT SIMULATION

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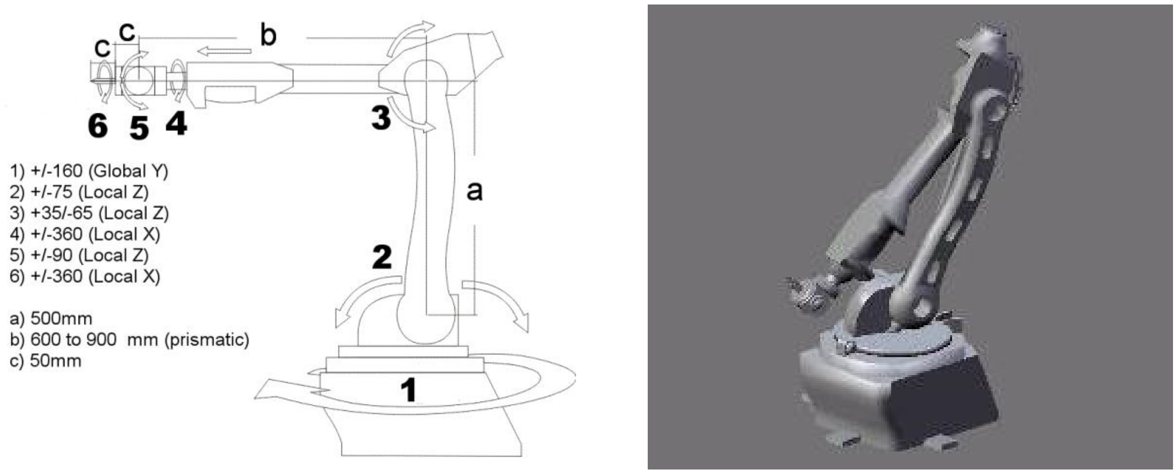
ABSTRACT

In this paper author shows a simulation of an industrial robot. The model and the animation are made in Blender 2.45, all calculations and simulation logic are based on Blender Engine. The position of the middle of grasper is defined in Cartesian coordinate system, employment idea of forward kinematics.

1. INTRODUCTION

In accordance with FK (forward kinematics) propositions [4], It is essential to know lengths of all arms and their angles relatively to the horizon. Movement of the robot is a real time rendering animation [2], angles are known from a simple presumption, that 10 frames of animation is a 1-degree rotation, or 1 mm movement. The length of arms is definite on robot concept, but the main problem is with the angles, because the only angle relative to the horizon is the second angle (the first one rotates in local Z axis). The rest of angles are relative to two arms, which create it, so it is needful to point it.

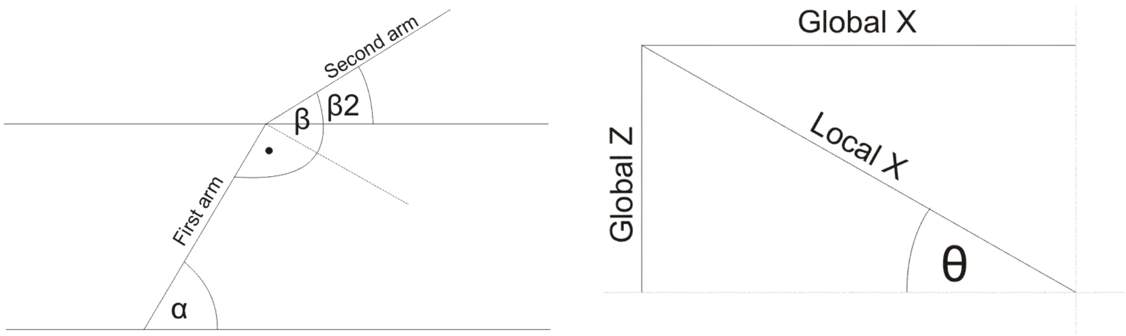


Obrázek 1: a) robot schema, b) 3D model of the robot

At the beginning, it is necessary to retrieve local positions of ends of two first arms in two dimensions (X, Y). Next, first angle is used to recalculate 2D local position to global 3D position. Then it belongs to retrieve global 3D position of the middle of the grasper, in regard to the end of the first pair of arms in the same way. Finally, we receive the global 3D position of the middle of the grasper in Cartesian coordinate system [4] with reference to the robot base, by adding results of those calculations.

2. POINTING OUT THE ANGLES AND POSITIONS.

2.1. LOCAL AND GLOBAL POSITION OF THE END OF THE SECOND ARM.



Obrázek 2: a) robot schema, b) 3D model of the robot

As it was said earlier, the lengths of the first and the second arm, and α, β and θ angles are known, but the β2 angle must be calculated. This value should be defined by some formulas. Because the value of α and β angles evolve during the animation, it is necessary to put both of them in a formula. This reliance can be described as:

$$\beta_2 = 90° + \beta - (180° - \alpha) \tag{1}$$

When α and β2 angles are known, it is possible to find the local position of the end of the second arm. If „a" is the length of the first arm, and „b" is the length of the second arm, then (accordingly to propositions of trigonometry [3]) there are two formulas for local X and Y coordinates:

$$\mathrm{X}_{\mathrm{LOC}} = \mathrm{a} * (\cos\alpha) + b * (\cos\beta_2) \tag{2}$$

$$\mathrm{Y}_{\mathrm{LOC}} = \mathrm{a} * (\sin\alpha) + b * (\sin\beta_2) \tag{3}$$

At this moment, only the local position of the end of the second arm is known. According to the author's idea, now it is necessary to convert this local position to a global one, using the first angle. Formula for Y_{GLOB} is the same like for the Y_{LOC}, but now X_{GLOB}, and Z_{GLOB} are calculated:

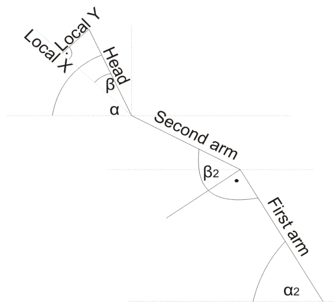
$$\mathrm{X}_{\mathrm{GLOB1}} = (\cos\theta) * \mathrm{X}_{\mathrm{LOC}} \tag{4}$$

$$\mathrm{Y}_{\mathrm{GLOB1}} = \mathrm{Y}_{\mathrm{LOC}} \tag{5}$$

$$\mathrm{Z}_{\mathrm{GLOB1}} = (\sin\theta) * \mathrm{X}_{\mathrm{LOC}} \tag{6}$$

2.2. LOCAL AND GLOBAL POSITION OF THE MIDDLE OF THE GRASPER - RELATIVELY TO THE END OF THE SECOND ARM.

This part of calculations is more complex, because the grasper of the robot has two levels of freedom (it is able to rotate along local X and local Z axis), and both of them are transformed with prior angles. At the beginning, it is necessary to point out local X, Y and Z position:



a = head length

θ = local X rotation of head

θ2 = global Y rotation of robot

α = 90 + β2 – (180 – α2) + β

Obrázek 3: a) Bones schema, b) commentary

$$X_{LOC} = (\cos\beta) * a \tag{7}$$

$$Y_{LOC} = (\cos\theta) * ((\sin\beta) * a) \quad ; \quad Z_{LOC} = (\sin\theta) * ((\sin\beta) * a) \tag{8; 9}$$

$$X_{GLOB2} = (\cos\theta_2) * ((\cos\alpha) * \sqrt{(Y_{LOC})^2 + (X_{LOC})^2}) \tag{10}$$

$$Y_{GLOB2} = (\sin\alpha) * \sqrt{(Y_{LOC})^2 + (X_{LOC})^2} \tag{11}$$

$$Z_{GLOB2} = (\sin(\theta_2 + \arcsin\theta\left(\frac{Z_{LOC}}{a}\right))) * a \tag{12}$$

And finally, the global position of the middle of the grasper relatively to the robot base:

$$X_{GLOBAL} = X_{GLOB1} + X_{GLOB2} \quad ; \quad Z_{GLOBAL} = Z_{GLOB1} + Z_{GLOB2} \tag{13; 14}$$

300mm must be added to the global Y, as a correction of height of the robot base:

$$Y_{GLOBAL} = Y_{GLOB1} + Y_{GLOB2} + 300 \tag{15}$$

3. CONCLUSIONS AND FUTURE WORK

As the effect of this simulation, I receive the global position of the middle of the grasper in Cartesian coordinate system, according to my plan. A computer simulation like this one is a simple and effective way of finding the range of a robot, or to explain what FK is and how does it work. It is also a good way to present capabilities of a robot, without requirement to building it.

In the future, I will try to add the invert kinematics, and make a simulation of a mobile robot, which will be useful in way finding, or tasks planning.

REFERENCES

[1] Blender manual and forum, available on-line: http://www.blender.org

[2] Cewe, A., Nahorska, C., Pancer, I., "Tablice matematyczne", ISBN 83-88299-15-8

[3] Praca Zbiorowa, "Podstawy robotyki. Teoria i elementy manipulatorów i robotów", ISBN 83-204-2331-7