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Hometask1

Link to github: https://github.com/StalkerSanya/Kinematic-Problem-For-R-2000iC-165F-

Forward kinematic problem for robot R 2000ic -165f

Figure 1 (scheme of robot)

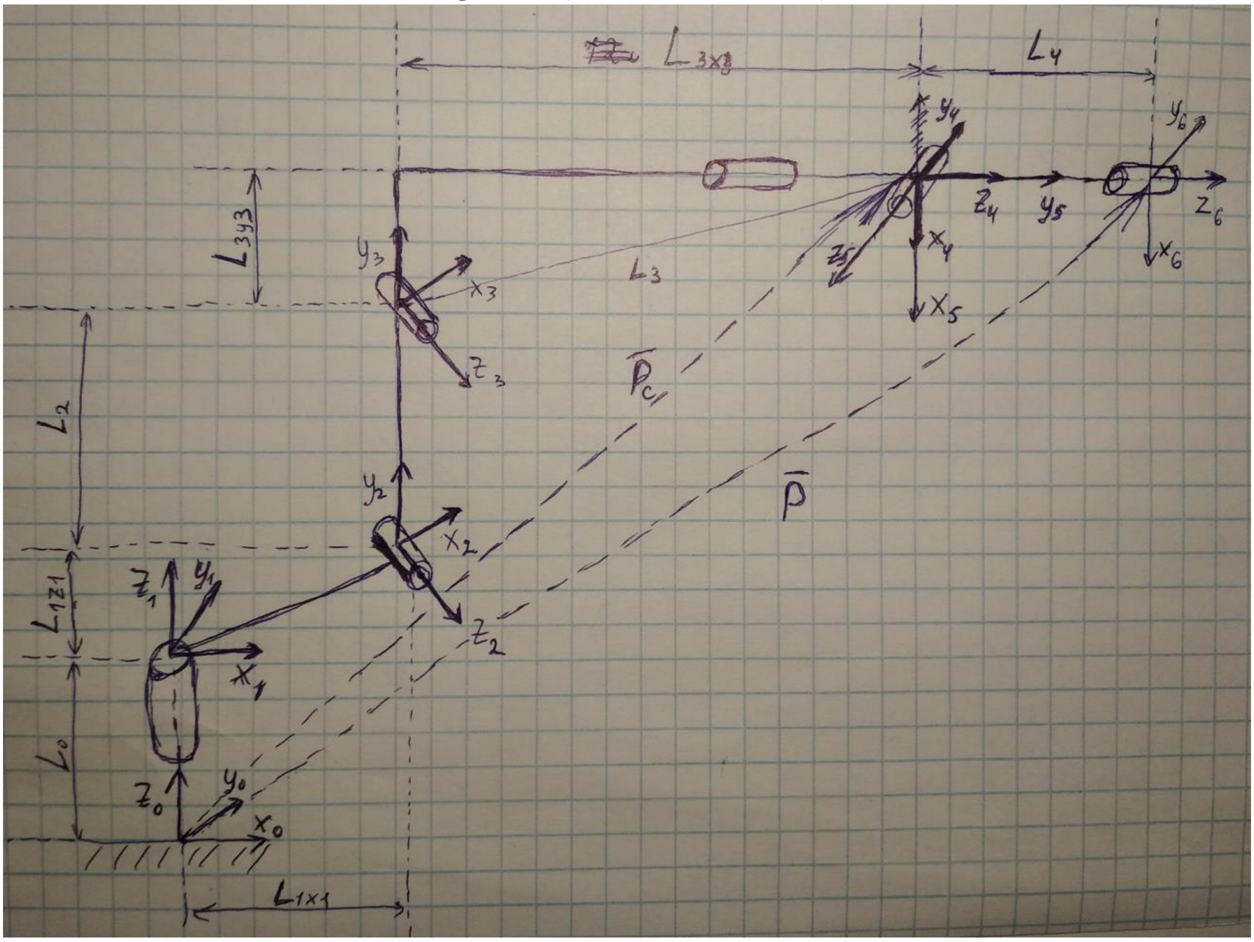


Table1 (sizes of robot)

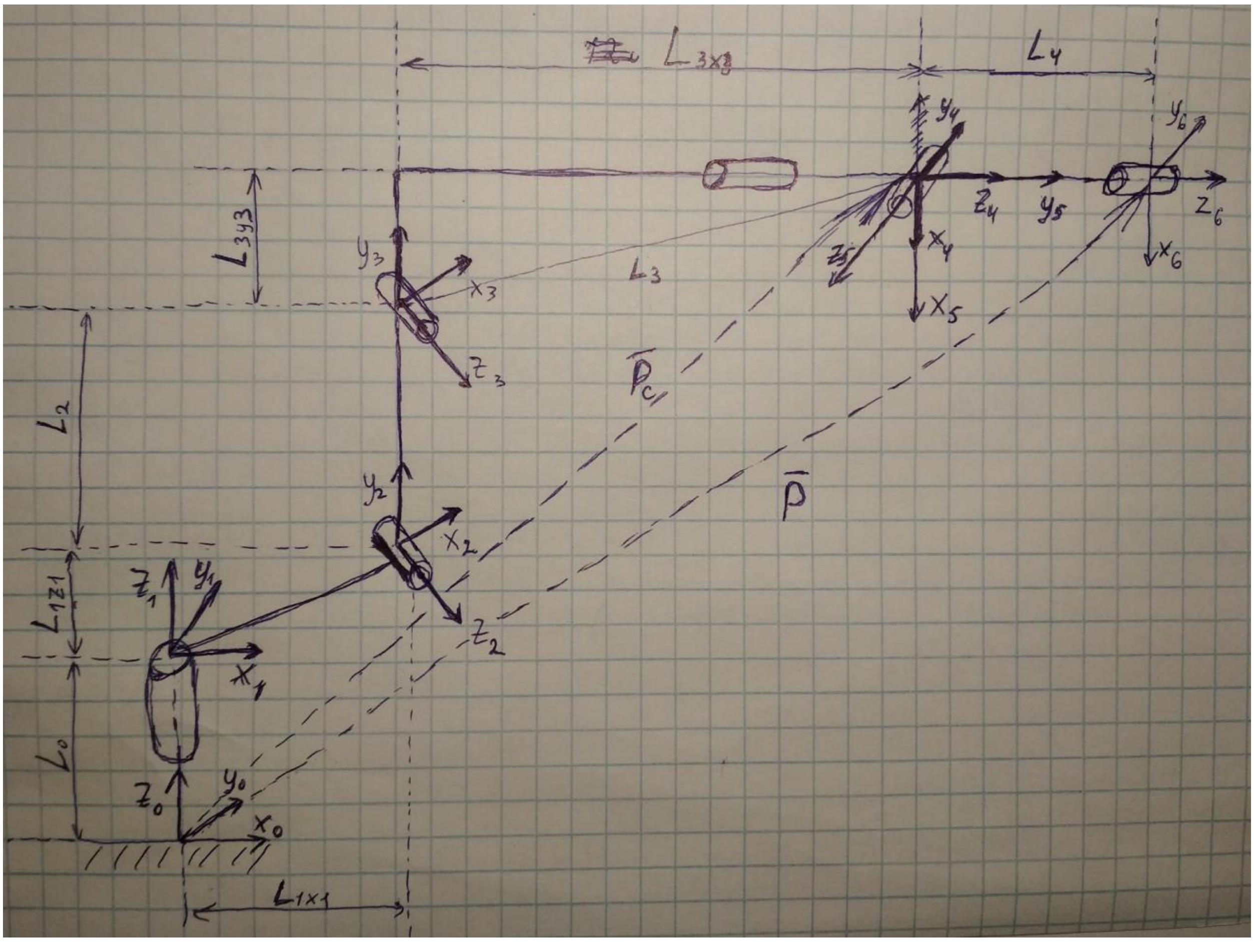
lengths	L_0	L_{1x1}	L_{1z1}	L_2	L_{3y3}	L_{3x3}	L_4
value, mm	346	312	324	1075	225	1280	225

1) $H_1^0 = T_{z0}(L_0)R_z(q_1)$
2) $H_2^1 = T_{x1}(L_{1x1})T_{z1}(L_{1z1})R_x(90^o)R_z(q_2)$
3) $H_3^2 = T_{y2}(L_2)R_z(q_3)$
4) $H_4^3 = T_{y3}(L_{3y3})T_{x3}(L_{3x3})R_y(90^o)R_z(-90^o)R_z(q_4)$
5) $H_5^4 = R_x(90^o)R_z(q_5)$
6) $H_6^5 = T_{y5}(L_4)R_x(-90^o)R_z(q_6)$
7) $H_6^0 = H_1^0H_2^1H_3^2H_4^3H_5^4H_6^5$

In forward kinematic problem we can find position of end-effector using angles of joints and H-transformation matrix. I solved this problem in matlab. I used 6 joints. Also I used position of joint6 as end-effector. File name “robot_FK.m” is example of forward kinematic. File name “forward_k..m” is function of forward kinematic which uses additional function “Rotx.m” , “Roty.m”, “Rotz.m”.

Inverse kinematic problem

Figure 2 (scheme robot)



I have $H_6^0 = \begin{pmatrix} r_{11} & r_{12} & r_{13} & x_p \\ r_{21} & r_{22} & r_{23} & y_p \\ r_{31} & r_{32} & r_{33} & z_p \\ 0 & 0 & 0 & 1 \end{pmatrix}$ for end-effector.

For solving this task I can do $P_c = P - L_4 * r$, where

$$r = \begin{bmatrix} r_{13} \\ r_{23} \\ r_{33} \end{bmatrix}; \; P = \begin{bmatrix} x_p \\ y_p \\ z_p \end{bmatrix}; \; P_c = \begin{bmatrix} x_c \\ y_c \\ z_c \end{bmatrix}.$$

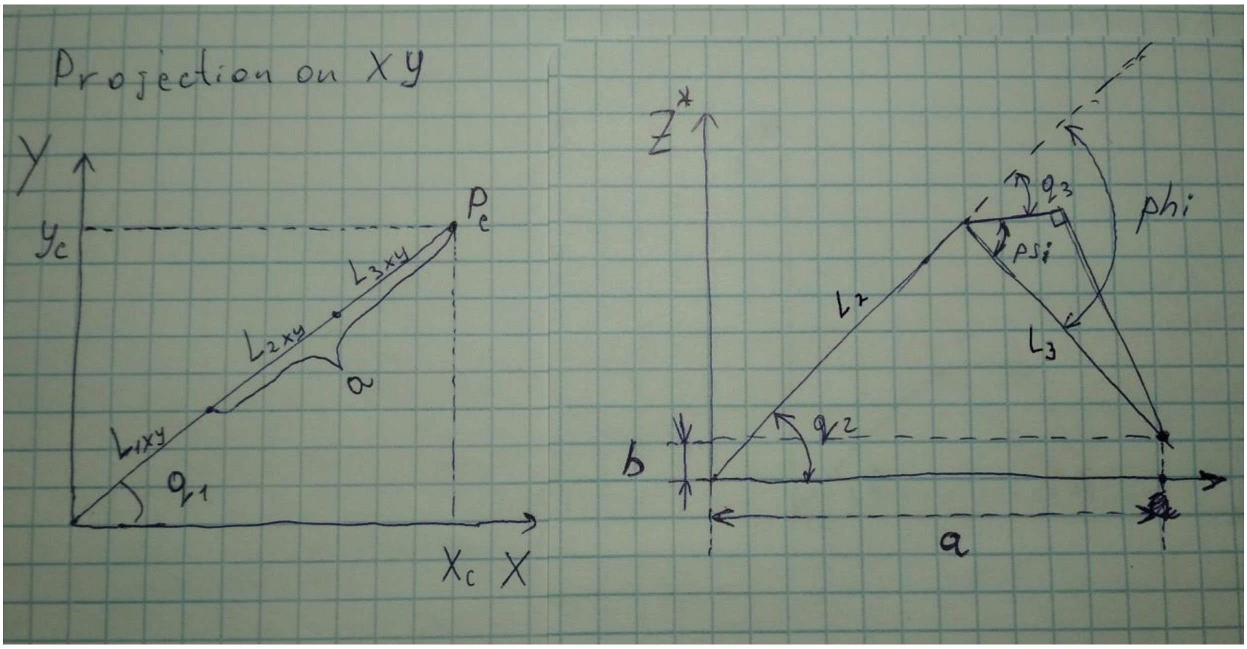
Then I can go to task with 3 joint, because joint 4 and 5 doesn’t affect to position point P_c.

$q_1 = atan2(y_c, x_c)$ + pi(n);

if $x_c = y_c = 0$, then $q_1$undefined.

For robot R 2000ic -165f I considered only elbow-up orientation, because robot can't have elbow-down most likely

Figure 3 (Projections of robot)



1) $a = \sqrt{{x_c}^2 + {y_c}^2} - L_{1xy}, where\ L_{1xy} = L_{1x1}$;

2) $b = z_c - L_0 - L_{1z}, where\ L_{1z} = L_{1z1}$;

3) $L_3 = \sqrt{{L_{3x3}}^2 + {L_{3y3}}^2}$;

4) $q_3 = phi - psi;\ \ q_3 = \cos^{-1}\left(\frac{a^2 + b^2 - {L_2}^2 - {L_3}^2}{2L_2L_3}\right) - \cos^{-1}\left(\frac{L_{3y3}}{L_3}\right)$;

6) $q_2 = atan2(a, b) - atan2(L_3\, sin(phi), L_2 + L_3 \cos(phi))$;

After application above we know q_1, q_2, q_3 with respect of coordinates and orientation of end-effector .

So we can find H_3^0 using q_1, q_2, q_3. So we will know R_3^0 from H_3^0. Then we can find $R_6^3 = (R_3^0)^{-1} * R_6^0$, where R_6^0 from H_6^0. Then we will have a matrix R_6^3 with q_4, q_5, q_6 . Due to R_6^3 we can find q_4, q_5, q_6. For check I used H1 and H2 from previous task (forward kinematic). File name "robot_IK.m" is example of inverse kinematic. File name “inverse_k..m” is function of inverse kinematic which uses additional function “Rotx.m” , “Roty.m”, “Rotz.m”.

In result my algorithm works quite successfully.