Module 6 : Robot manipulators kinematics

Lecture 20 : Forward kinematics of 6R manipulators using D-H representations

Objectives

In this course you will learn the following

- Forward kinematics of serial 6R manipulator

Forward Kinematics for 6R Manipulator using D-H Parameters (Refer Fig. 20.1)

Here given the a_i, a_i, d_i, θ_i for i=1 to 6; Find out position and orientation of all links w.r.t. global x_0, y_0, z_0. i.e. to find ${}^0T_K$ for all K th links where ${}^0T_K = {}^0T_1\ {}^1T_2 \ldots\ldots\ldots\ldots {}^{k-1}T_k$. Set up intermediate reference frame X_m, Y_m to get Transformation Matrix T.

Fig. 20.1 Generalized transformations

Therefore ${}^{i-1}T_i = {}^{i-1}T_m\ {}^mT_i$ from above figure,

$$= {}^{i-1}T_i = {}^{i-1}T_m\ {}^mT_i$$

$$= \begin{bmatrix} \cos\theta_i & -\cos\alpha_i \sin\theta_i & \sin\alpha_i \sin\theta_i & a_i \cos\theta_i \\ \sin\theta_i & \cos\alpha_i \cos\theta_i & -\sin\alpha_i \cos\theta_i & a_i \sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Substituting the values of a_i, a_i, d_i, θ_i for each transformation matrix ${}^{(K-1)}TK$, we get ${}^0T_6$ as ${}^0T_6 = {}^0T_1\ {}^1T_2\ {}^2T_3\ {}^3T_4\ {}^4T_5\ {}^5T_6$. This forward kinematics is required to check for obstacles & end effecter fouling in robot work space. Substituting values from tables; we get following ${}^0T_3$ and ${}^3T_6$ where $C_i = \cos\theta_i$; $S_i = \text{Sin}\ \theta_i$; $Cij = \cos(\theta i + \theta j)$; $Sij = \sin(\theta i + \theta j)$;

$$ {}^{0}T_{3} = {}^{0}T_{1}\,{}^{1}T_{2}\,{}^{2}T_{3} = \begin{bmatrix} C_1C_{23} & -S_1 & C_1S_{23} & a_2C_1C_2 + a_3C_1C_{23} - d_2S_1 \\ S_1C_{23} & C_1 & S_1S_{23} & a_2S_1C_2 + a_3S_1C_{23} + d_2C_1 \\ -S_{23} & 0 & S_1S_{23} & -a_2S_2 - a_3S_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{3}T_{6} = {}^{3}T_{4}\,{}^{4}T_{5}\,{}^{5}T_{6} = \begin{bmatrix} C_4C_5C_6 - S_4S_6 & -C_4C_5S_6 - S_4C_6 & C_4S_5 & d_6C_4S_5 \\ S_4C_5C_6 + C_4S_6 & -S_4C_5S_6 + C_4C_6 & S_4S_5 & d_6S_4S_5 \\ -S_5C_6 & S_5S_6 & C_5 & d_6C_5 + d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

The matrices can be solved for given linkages parameters tabulated above. And matrix ${}^{0}T_{6}$ can be obtained. Forward kinematics is required to check for obstacles & end effecter fouling in robot work space.

Recap

In this course you will learn the following

- How to obtain the homogeneous transformation matrix for serial 6R PUMA robot (forward kinematics)

Congratulations, you have finished Lecture 20. To view the next lecture select it from the left hand side menu of the page