智能机器人技术第一次作业

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4. （1）同一点但由基坐标系描述：$u' = Fu = 8i + 23j + 3k$

（2）$\{F\}$绕基坐标系y轴旋转$90°$的旋转矩阵为 $Rot(y, 90°) = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$，按$x$轴方向平移20 的变换矩阵为$Trans(20, 0, 0) = \begin{bmatrix} 1 & 0 & 0 & 20 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$，则变换所得坐标系$\{H\} = Trans(20, 0, 0)Rot(y, 90°)\{F\} = \begin{bmatrix} 0 & 0 & 1 & 21 \\ 1 & 0 & 0 & 20 \\ 0 & 1 & 0 & -10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

5. (1)

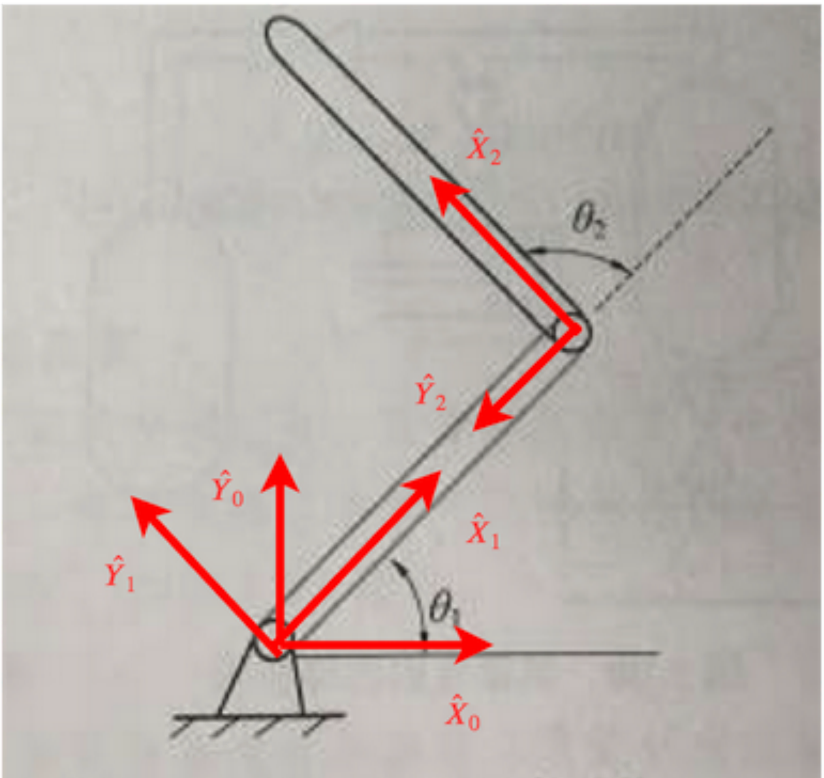

图 3.31　两连杆结构图

(2) 连杆参数：

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	0	L_1	0	θ_2

则连杆变换矩阵为:

$$A_n = Rot(z, \theta_n)Trans(0, 0, d_n)Trans(a_n, 0, 0)Rot(x, \alpha_n)$$

$$= \begin{bmatrix} cos\theta_n & -sin\theta_n & 0 & 0 \\ sin\theta_n & cos\theta_n & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & a_n \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_n \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos\alpha_n & -sin\alpha_n & 0 \\ 0 & sin\alpha_n & cos\alpha_n & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} cos\theta_n & -sin\theta_n cos\alpha_n & sin\alpha_n sin\theta_n & a_n cos\theta_n \\ sin\theta_n & cos\theta_n cos\alpha_n & -sin\alpha_n cos\theta_n & a_n sin\theta_n \\ 0 & sin\alpha_n & cos\alpha_n & d_n \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

带入得:

$$A_1 = \begin{bmatrix} cos\theta_1 & -sin\theta_1 & 0 & 0 \\ sin\theta_1 & cos\theta_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} cos\theta_2 & -sin\theta_2 & 0 & L_1 * cos\theta_2 \\ sin\theta_2 & cos\theta_2 & 0 & L_1 * sin\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

6. 连杆参数:

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	0	d_2	0	0

运动方程:

$$T_2 = A_1 A_2$$

$$A_1 = \begin{bmatrix} cos\theta_1 & -sin\theta_1 & 0 & 0 \\ sin\theta_1 & cos\theta_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} 1 & 0 & 0 & d_2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

则$T_2 = A_1 A_2 = \begin{bmatrix} cos\theta_1 & -sin\theta_1 & 0 & d_2 * cos\theta_1 \\ sin\theta_1 & cos\theta_1 & 0 & d2 * sin\theta_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

7. 各连杆D-H参数如下：

i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0°	0	0	$\theta_1(90^\circ)$
2	-90°	0	d_2	$\theta_2(0^\circ)$
3	0°	a_2	0	$\theta_3(-90^\circ)$
4	-90°	a_3	d_4	$\theta_4(0^\circ)$
5	90°	0	0	$\theta_5(0^\circ)$
6	-90°	0	0	$\theta_6(0^\circ)$

由$A_n = Rot(z, \theta_n) Trans(0, 0, d_n) Trans(a_n, 0, 0) Rot(x, \alpha_n)$可得：

$$A_1 = \begin{bmatrix} cos\theta_1 & -sin\theta_1 & 0 & 0 \\ sin\theta_1 & cos\theta_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} cos\theta_2 & 0 & -1.0 * sin\theta_2 & 0 \\ sin\theta_2 & 0 & 1.0 * cos\theta_2 & 0 \\ 0 & -1 & 0 & d2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} cos\theta_3 & -sin\theta_3 & 0 & a2 * cos\theta_3 \\ sin\theta_3 & cos\theta_3 & 0 & a2 * sin\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_4 = \begin{bmatrix} cos\theta_4 & 0 & -1.0 * sin\theta_4 & a3 * cos\theta_4 \\ sin\theta_4 & 0 & 1.0 * cos\theta_4 & a3 * sin\theta_4 \\ 0 & -1 & 0 & d4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_5 = \begin{bmatrix} cos\theta_5 & 0 & 1.0 * sin\theta_5 & 0 \\ sin\theta_5 & 0 & -1.0 * cos\theta_5 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_6 = \begin{bmatrix} cos\theta_6 & 0 & -1.0 * sin\theta_6 & 0 \\ sin\theta_6 & 0 & 1.0 * cos\theta_6 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

则运动学方程$T_6 = A_1 A_2 A_3 A_4 A_5 A_6 = \begin{bmatrix} 0 & 1 & 0 & -d_4 \\ 0 & 0 & 1 & 0 \\ 1 & -0 & -0 & a_2 + a_3 + d_2 + d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$