

**Fig. 2.23.** Anthropomorphic arm**Table 2.4.** DH parameters for the anthropomorphic arm

Link	$a_i$	$\alpha_i$	$d_i$	$\vartheta_i$
1	0	$\pi/2$	0	$\vartheta_1$
2	$a_2$	0	0	$\vartheta_2$
3	$a_3$	0	0	$\vartheta_3$

The homogeneous transformation matrices defined in (2.52) are for the single joints:

$$\mathbf{A}_1^0(\vartheta_1) = \begin{bmatrix} c_1 & 0 & s_1 & 0 \\ s_1 & 0 & -c_1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{A}_i^{i-1}(\vartheta_i) = \begin{bmatrix} c_i & -s_i & 0 & a_i c_i \\ s_i & c_i & 0 & a_i s_i \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad i = 2, 3.$$

Computation of the direct kinematics function as in (2.50) yields

$$\mathbf{T}_3^0(\mathbf{q}) = \mathbf{A}_1^0 \mathbf{A}_2^1 \mathbf{A}_3^2 = \begin{bmatrix} c_1 c_{23} & -c_1 s_{23} & s_1 & c_1(a_2 c_2 + a_3 c_{23}) \\ s_1 c_{23} & -s_1 s_{23} & -c_1 & s_1(a_2 c_2 + a_3 c_{23}) \\ s_{23} & c_{23} & 0 & a_2 s_2 + a_3 s_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (2.66)$$

where  $\mathbf{q} = [\vartheta_1 \ \vartheta_2 \ \vartheta_3]^T$ . Since  $z_3$  is aligned with  $z_2$ , Frame 3 does not coincide with a possible end-effector frame as in Fig. 2.13, and a proper constant transformation would be needed.