2DOF 기구학

로봇팔 세미나 - 김혜윤 -

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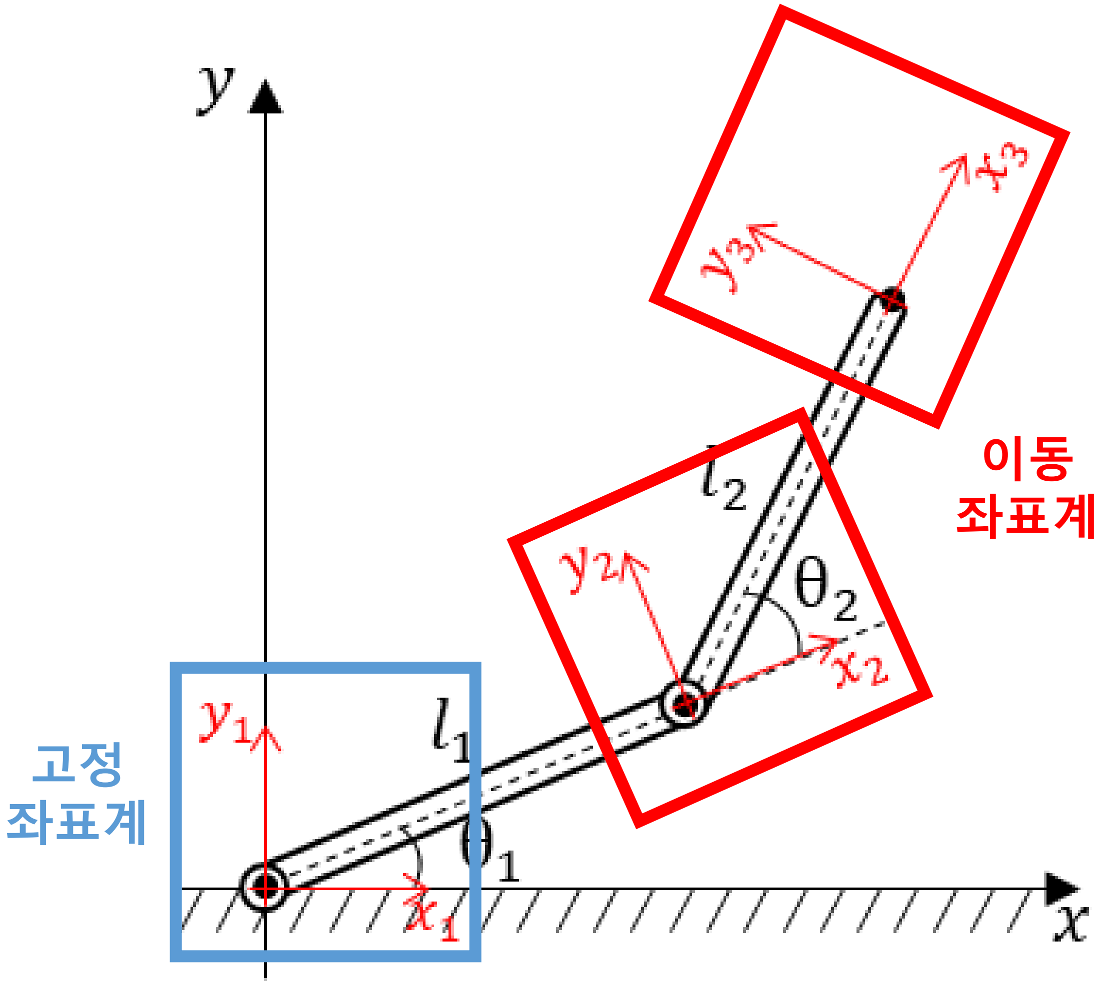


그림 출처: https://www.minthee.kr/matlab%ec%9c%bc%eb%a1%9c-dynamixel-%ea%b5%ac%eb%8f%99%ed%95%98%ea%b8%b0-03-two-link%eb%a1%9c%eb%b4%87-kinematics/

2DOF 정기구학

동차 변환 행렬 (회전 / 이동)

$$\boldsymbol{A}(x,\ \theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\boldsymbol{A}(y,\ \theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\boxed{\boldsymbol{A}(z,\ \theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}$$

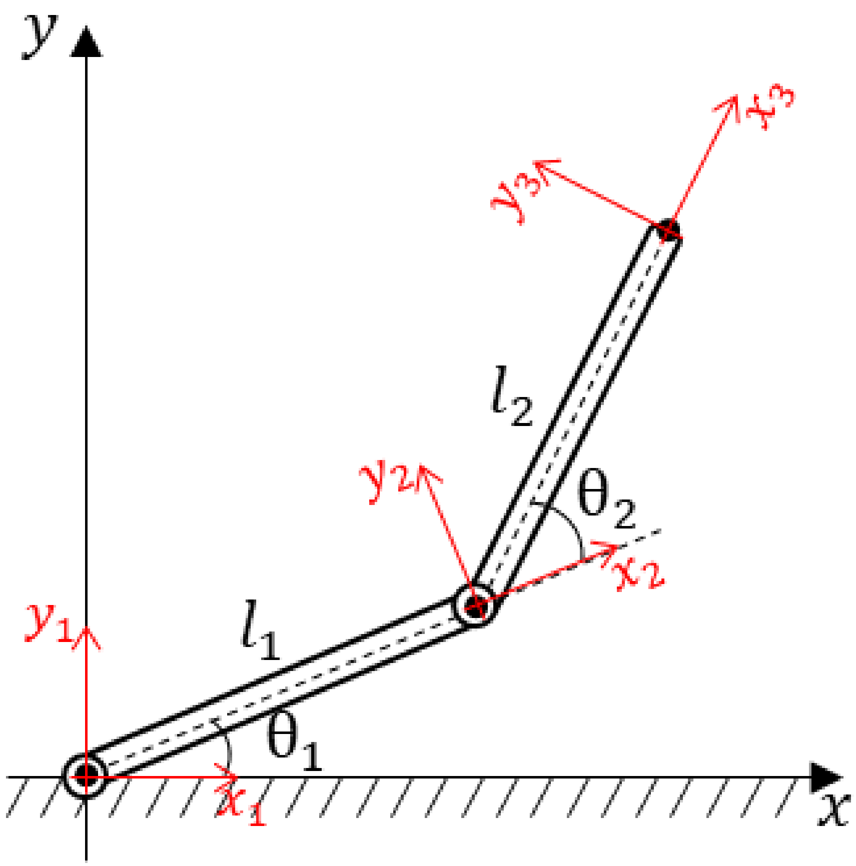
Z축 회전

이동 좌표

$$\boldsymbol{A}(p_{0x'},\ p_{0y'},\ p_{0z'}) = \begin{bmatrix} 1 & 0 & 0 & p_{0x} \\ 0 & 1 & 0 & p_{0y} \\ 0 & 0 & 1 & p_{0z} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

그림 출처: https://ddangeun.tistory.com/25

2DOF Manipulaor 동차 변환 행렬



동차 변환 행렬

$$
{}^{0}\mathrm{T}_1 = \begin{bmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 & l_1\cos(\theta_1) \\ \sin(\theta_1) & \cos(\theta_1) & 0 & l_1\sin(\theta_1) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^{1}\mathrm{T}_2 = \begin{bmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & l_2\cos(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & l_2\sin(\theta_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

그림 출처: https://www.minthee.kr/matlab%ec%9c%bc%eb%a1%9c-dynamixel-%ea%b5%ac%eb%8f%99%ed%95%98%ea%b8%b0-03-two-link%eb%a1%9c%eb%b4%87-kinematics/

2DOF Manipulaor 동차 변환 행렬

동차 변환 행렬

$$
{}^0\mathrm{T}_1 = \begin{bmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 & l_1\cos(\theta_1) \\ \sin(\theta_1) & \cos(\theta_1) & 0 & l_1\sin(\theta_1) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
{}^1\mathrm{T}_2 = \begin{bmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & l_2\cos(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & l_2\sin(\theta_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

전체 동차 변환 행렬

$$
{}^0\mathrm{T}_2 = \begin{bmatrix} \cos(\theta_{12}) & -\sin(\theta_{12}) & 0 & l_1\cos(\theta_1) + l_2\cos(\theta_{12}) \\ \sin(\theta_{12}) & \cos(\theta_{12}) & 0 & l_1\sin(\theta_1) + l_2\sin(\theta_{12}) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
\theta_{12} = \theta_1 + \theta_2
$$

그림 출처: https://www.minthee.kr/matlab%ec%9c%bc%eb%a1%9c-dynamixel-%ea%b5%ac%eb%8f%99%ed%95%98%ea%b8%b0-03-two-link%eb%a1%9c%eb%b4%87-kinematics/

2DOF 역기구학

2DOF Manipulaor 동차 변환 행렬

동차 변환 행렬

$$^{0}T_1 = \begin{bmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 & l_1\cos(\theta_1) \\ \sin(\theta_1) & \cos(\theta_1) & 0 & l_1\sin(\theta_1) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$^{1}T_2 = \begin{bmatrix} \cos(\theta_2) & -\sin(\theta_2) & 0 & l_2\cos(\theta_2) \\ \sin(\theta_2) & \cos(\theta_2) & 0 & l_2\sin(\theta_2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

전체 동차 변환 행렬

끝점 x y 좌표

$$^{0}T_2 = \begin{bmatrix} \cos(\theta_{12}) & -\sin(\theta_{12}) & 0 & \boxed{\begin{matrix} l_1\cos(\theta_1) + l_2\cos(\theta_{12}) \\ l_1\sin(\theta_1) + l_2\sin(\theta_{12}) \end{matrix}} \\ \sin(\theta_{12}) & \cos(\theta_{12}) & 0 & \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\theta_{12} = \theta_1 + \theta_2$$

그림 출처: https://www.minthee.kr/matlab%ec%9c%bc%eb%a1%9c-dynamixel-%ea%b5%ac%eb%8f%99%ed%95%98%ea%b8%b0-03-two-link%eb%a1%9c%eb%b4%87-kinematics/

역기구학 풀이

$$x = l_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2)$$
$$y = l_1 \sin\theta_1 + l_2 \sin(\theta_1 + \theta_2)$$

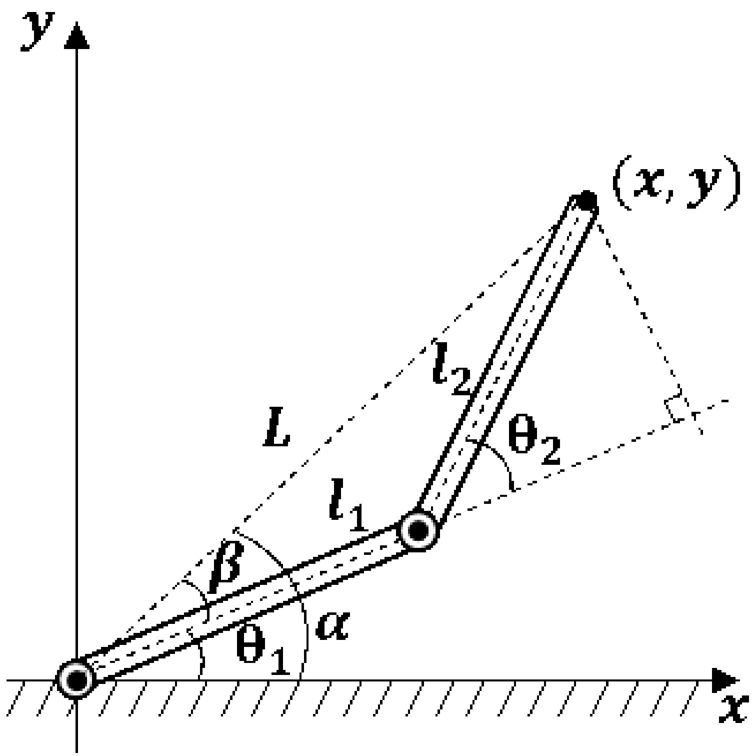
x, y 제곱해서 더하면

$$x^2 + y^2 = l_1^2 + l_2^2 + 2 l_1 l_2 \cos\theta_2$$

$$\boxed{\cos\theta_2 = \frac{x^2 + y^2 - l_1^2 - l_2^2}{2 l_1 l_2}, \sin\theta_2 = \pm\sqrt{1 - \cos^2\theta_2}}$$

그림 출처: https://ddangeun.tistory.com/27

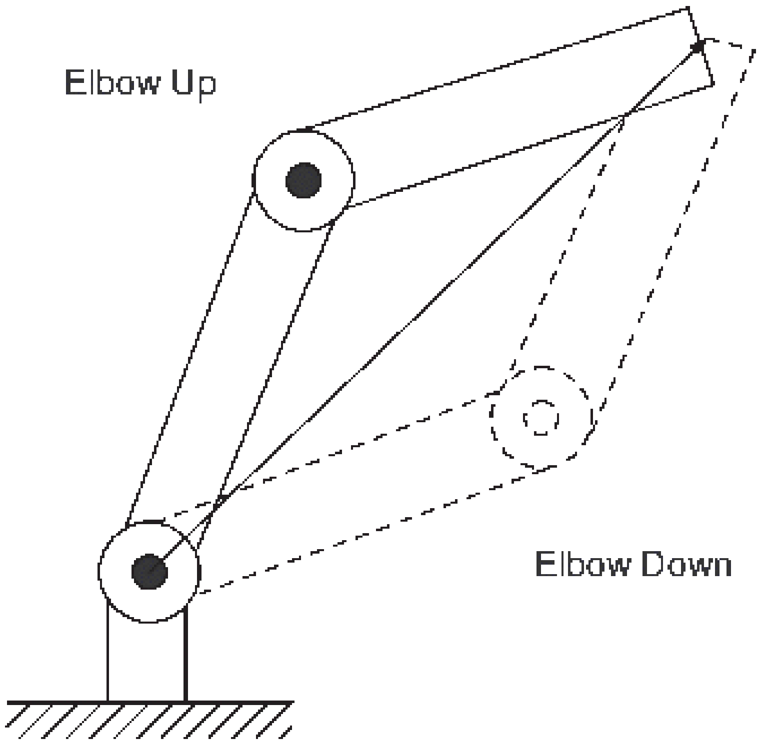
역기구학 풀이



$$\theta_1 = \underbrace{\boxed{atan2(y,x)}}_{\alpha} - \underbrace{\boxed{atan2(l_1 + l_2\cos\theta_2, l_2\sin\theta_2)}}_{\beta}$$

그림 출처: https://www.minthee.kr/matlab%ec%9c%bc%eb%a1%9c-dynamixel-%ea%b5%ac%eb%8f%99%ed%95%98%ea%b8%b0-03-two-link%eb%a1%9c%eb%b4%87-kinematics/

역기구학 풀이



$$\cos\theta_2 = \frac{x^2 + y^2 - l_1^2 - l_2^2}{2l_1 l_2}, \sin\theta_2 = \pm\sqrt{1 - \cos^2\theta_2}$$

$$\theta_1 = \underbrace{\boxed{atan2(y, x)}}_{\alpha} \pm \underbrace{\boxed{atan2(l_1 + l_2\cos\theta_2, l_2\sin\theta_2)}}_{\beta}$$

그림 출처: https://ddangeun.tistory.com/27
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