HAND ASSIST ROBOT

로봇공학입문

기계공학전공

2016121150 윤준영

Introduction

source: neofect

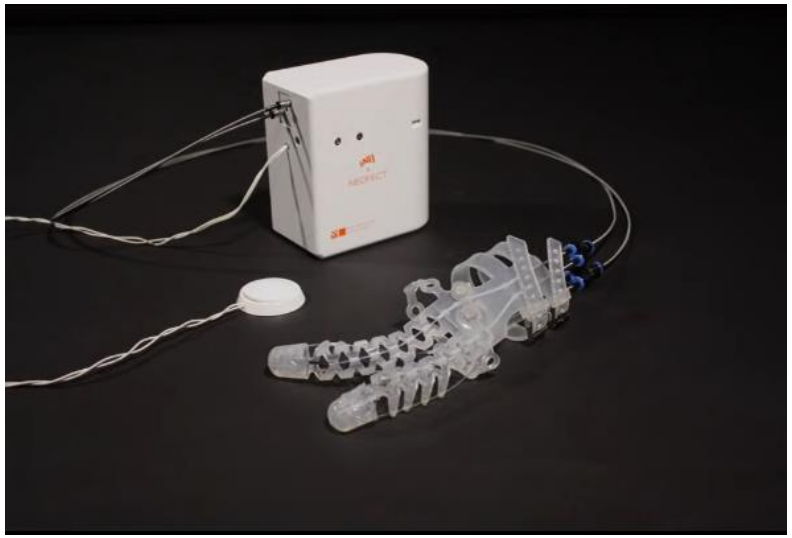
source: Harvard Wyss Institute

Hand-assist robots

Necessity

Limitation

Breakthrough?



source: SNU BioRobotics Lab

source: Rehab Technologies

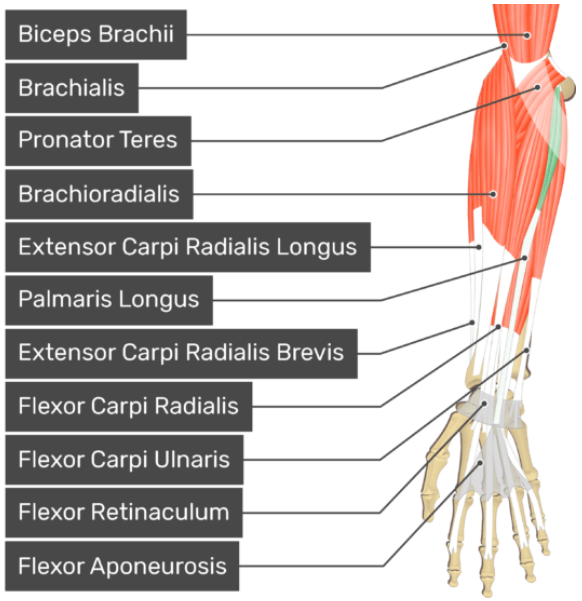
Project Target & Goals

- Improve independence

- Easy to control
    - freely controllable with adaptation

- Rehabilitation
    - Improve muscle and grabbing power

Mechanism

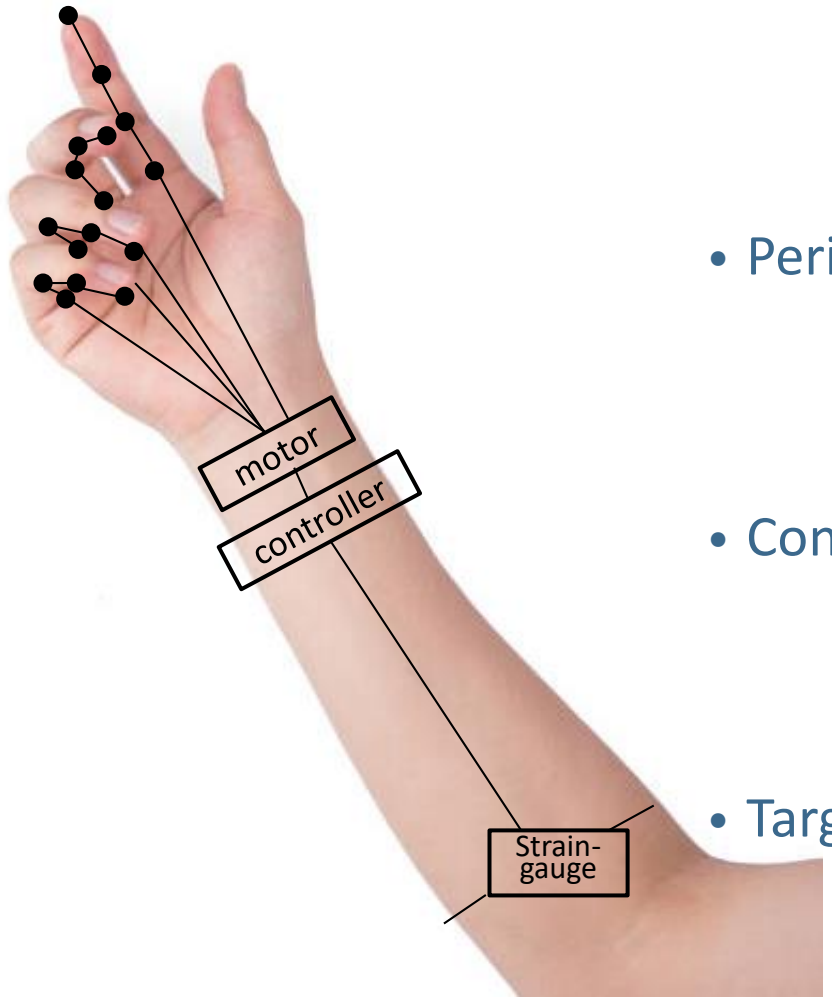


source: GetBodySmart

- How to?
  - electric signal (X)
  - perimeter (O)

- Hand related arm muscles
  - brachioradialis(완요골근) : lifting
  - **palmaris longus(수장근) : grabbing**

Structure



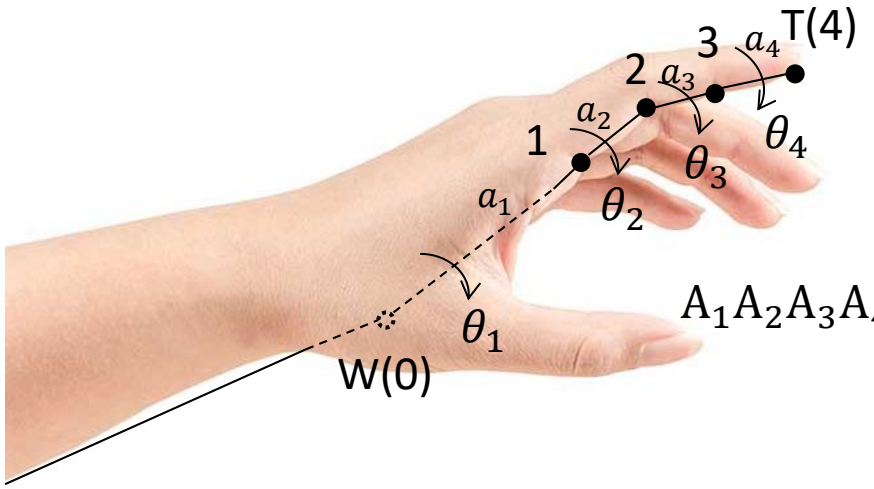
- DOF (1+3 fingers)
  - (1 x 3) + (3 x 3) DOF
- Perimeter measurement
  - strain gauge
- Control
  - with wire (PE)
- Target grabbing power
  - 10 ~ 20N

source: Movement Control Lab., Washington Univ.

50mm below elbow	perimeter
with no grasp	248mm
with grasp	252mm

wire control		wire length
with no grasp		0 (reference)
grasp	index finger	-50mm
	middle finger	-55mm

Mechanics



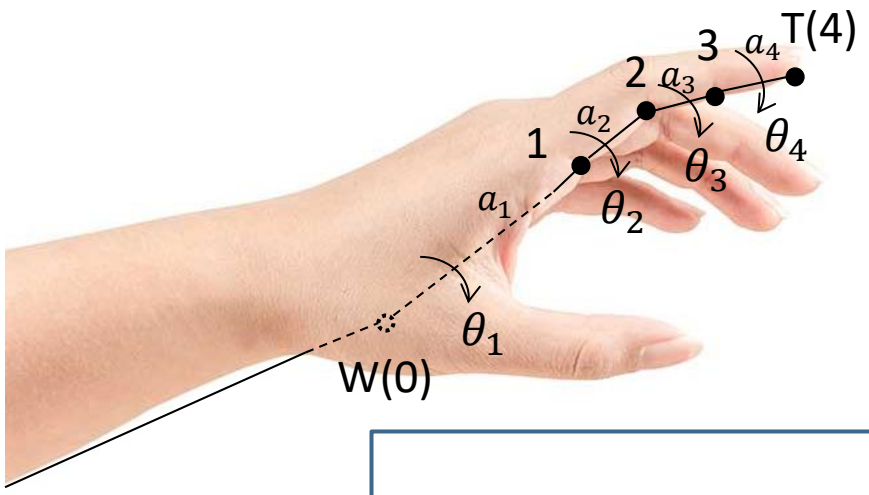
$$A_1A_2A_3A_4 = \begin{bmatrix} C_\gamma & -S_\gamma & 0 & a_1 + a_2C_1 + a_3C_\alpha + a_4C_\beta \\ S_\gamma & C_\gamma & 0 & a_2S_1 + a_3S_\alpha + a_4S_\beta \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad \begin{aligned} \theta_\alpha &= \theta_1 + \theta_2 \\ \theta_\beta &= \theta_1 + \theta_2 + \theta_3 \\ \theta_\gamma &= \theta_1 + \theta_2 + \theta_3 + \theta_4 \end{aligned}$$

Position of W(0), 1, T(4)

$$P_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}, \qquad P_1 = A_1P_0 = A_1 \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

$$P_4 = A_1A_2A_3A_4P_0 = A_1A_2A_3A_4 \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1 + a_2C_1 + a_3C_\alpha + a_4C_\beta \\ a_2S_1 + a_3S_\alpha + a_4S_\beta \\ 0 \\ 1 \end{bmatrix}$$

Mechanics



$$P_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}, \qquad P_1 = A_1 P_0 = A_1 \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

$$P_4 = A_1 A_2 A_3 A_4 P_0 = A_1 A_2 A_3 A_4 \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1 + a_2 C_1 + a_3 C_\alpha + a_4 C_\beta \\ a_2 S_1 + a_3 S_\alpha + a_4 S_\beta \\ 0 \\ 1 \end{bmatrix}$$

Vectors, 0→1 & 1→4

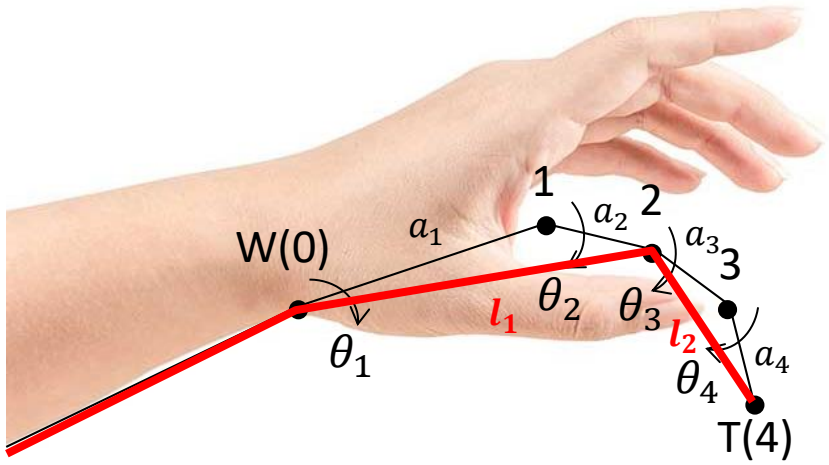
$$\overrightarrow{P_{01}} = \begin{bmatrix} a_1 \\ 0 \\ 0 \end{bmatrix}, \qquad \overrightarrow{P_{41}} = \begin{bmatrix} a_2 C_1 + a_3 C_\alpha + a_4 C_\beta \\ a_2 S_1 + a_3 S_\alpha + a_4 S_\beta \\ 0 \end{bmatrix}$$

For P_4 on line $\overline{P_0 P_1}$, $\dfrac{\overrightarrow{P_{01}}}{|\overrightarrow{P_{01}}|} = -\dfrac{\overrightarrow{P_{41}}}{|\overrightarrow{P_{41}}|} \Rightarrow$

$$a_2 S_1 + a_3 S_\alpha + a_4 S_\beta = 0,$$

$$\frac{a_2 C_1 + a_3 C_\alpha + a_4 C_\beta}{\sqrt{\left(a_2 C_1 + a_3 C_\alpha + a_4 C_\beta\right)^2 + \left(a_2 S_1 + a_3 S_\alpha + a_4 S_\beta\right)^2}} = -1$$

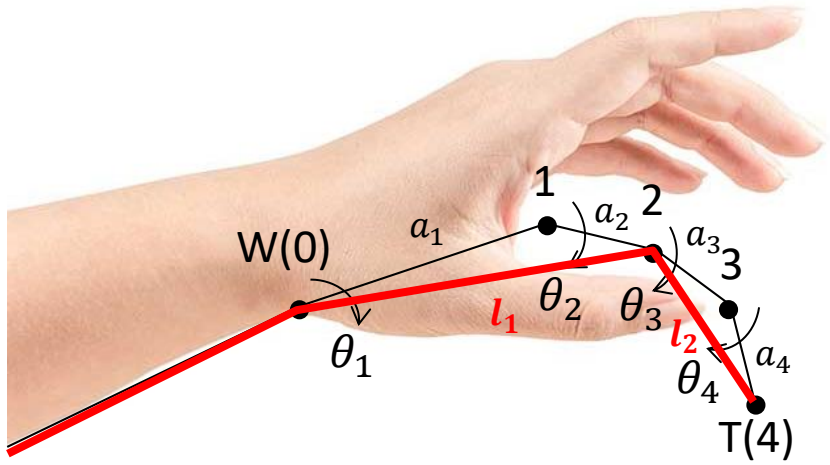
Mechanics



Thread length from W to T

$$l = l_1 + l_2 = \frac{a_1 + a_2 C_2}{C_1} + \frac{a_3 + a_4 C_4}{C_4}$$

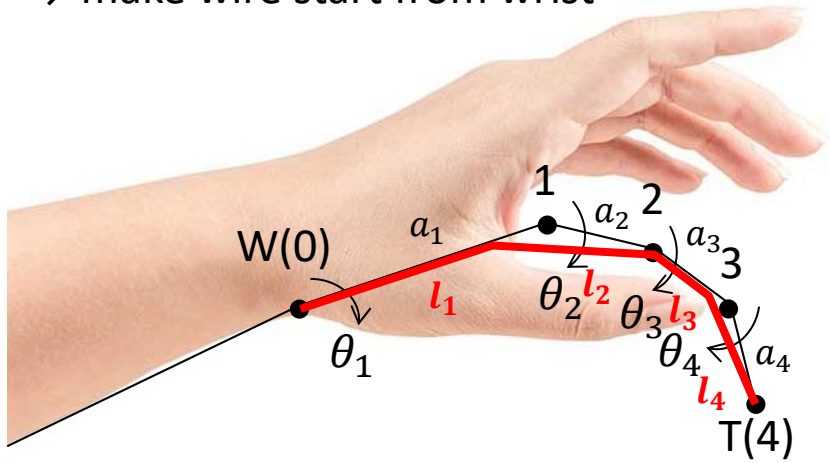
Mechanics – 2



Thread length from W to T

$$l = l_1 + l_2 = \frac{a_1 + a_2 C_2}{C_1} + \frac{a_3 + a_4 C_4}{C_4}$$

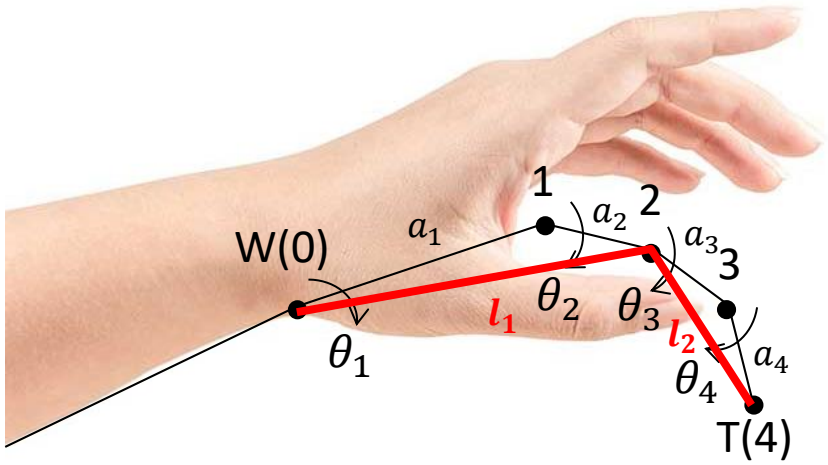
to remove wire length difference cause by wrist posture
→ make wire start from wrist



Thread length from W to T

$$l = l_1 + l_2 + l_3 + l_4 = \frac{a_1 - l_1 + a_2 C_2}{C_1} + \frac{a_3 - l_3 + a_4 C_4}{C_4}$$

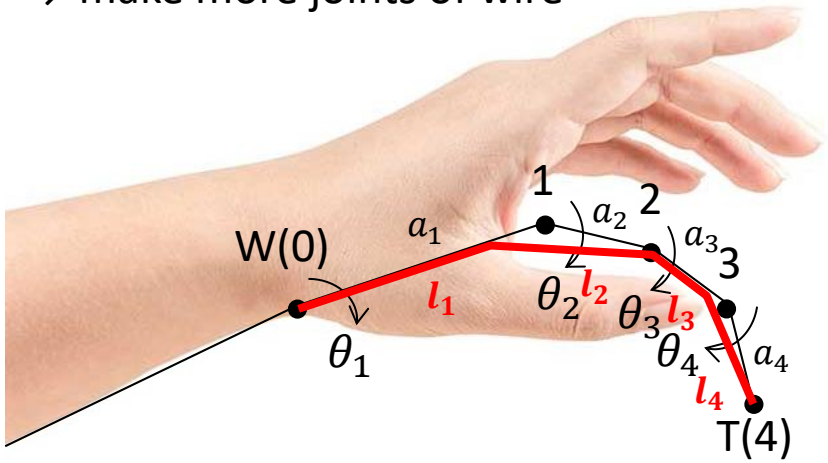
Mechanics – 3



Thread length from W to T

$$l = l_1 + l_2 = \frac{a_1 + a_2 C_2}{C_1} + \frac{a_3 + a_4 C_4}{C_4}$$

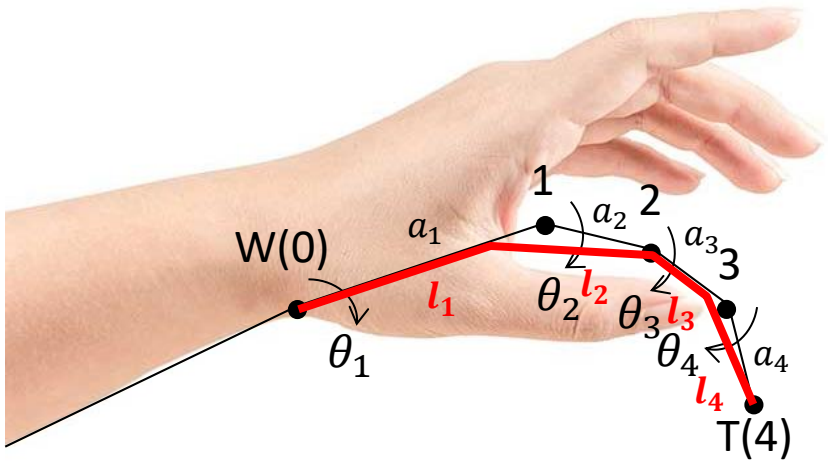
to reduce interference between wire and grabbing object
→ make more joints of wire



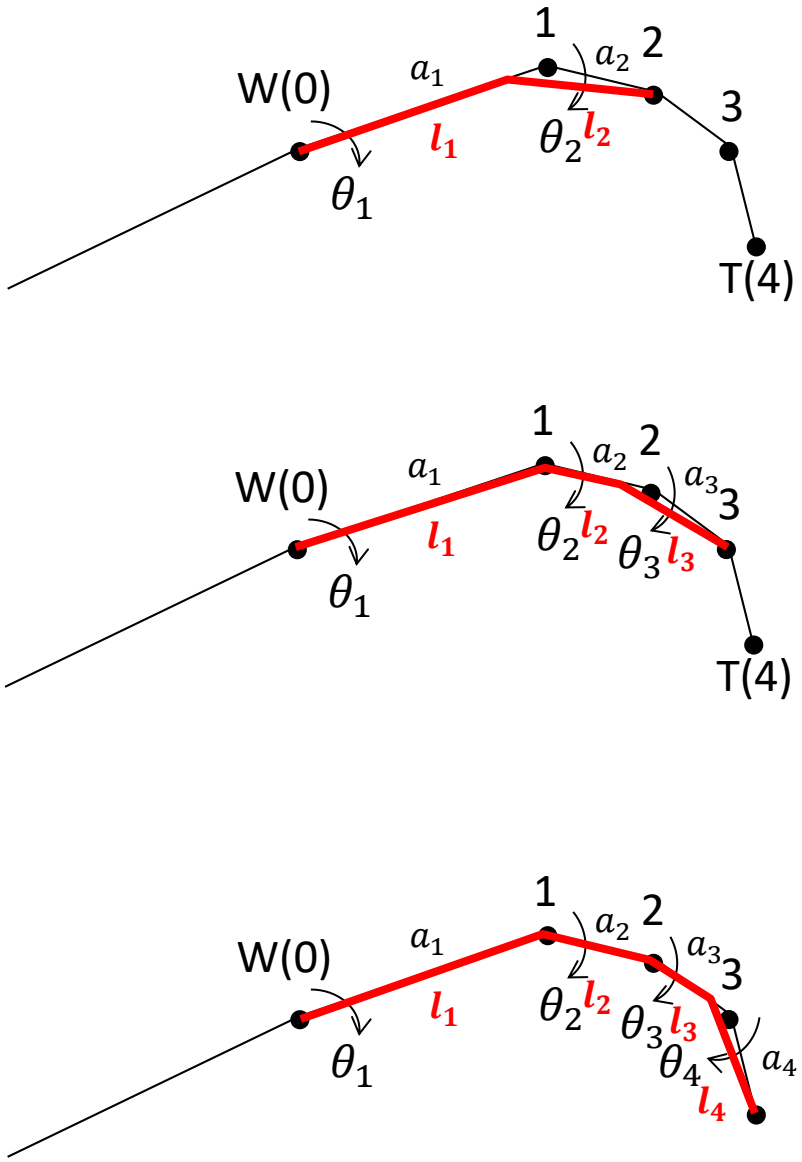
Thread length from W to T

$$l = l_1 + l_2 + l_3 + l_4$$
$$= \sqrt{(a_1 - l_1)^2 + a_2^2 + 2(a_1 - l_1)a_2 C_2} + \sqrt{(a_3 - l_3)^2 + a_4^2 + 2(a_3 - l_3)a_4 C_4}$$

Mechanics – 4

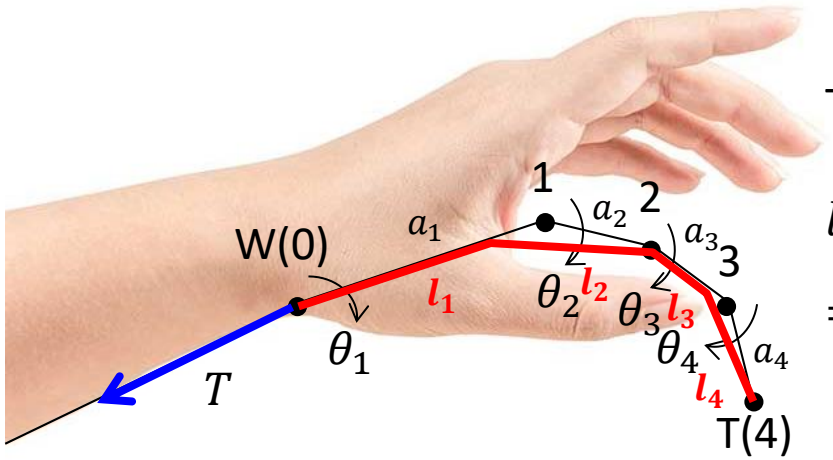


θ_2: 0°~75°
θ_3: 0°~85°
θ_4: 0°~90°



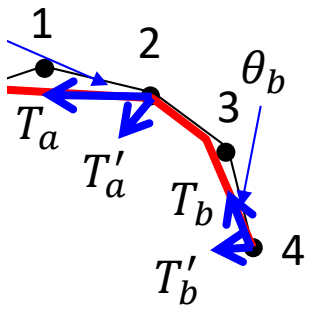
Required Tension

$$\theta_\alpha = \theta_1 + \theta_2$$
$$\theta_\beta = \theta_1 + \theta_2 + \theta_3$$
$$\theta_\gamma = \theta_1 + \theta_2 + \theta_3 + \theta_4$$



Thread length from W to T

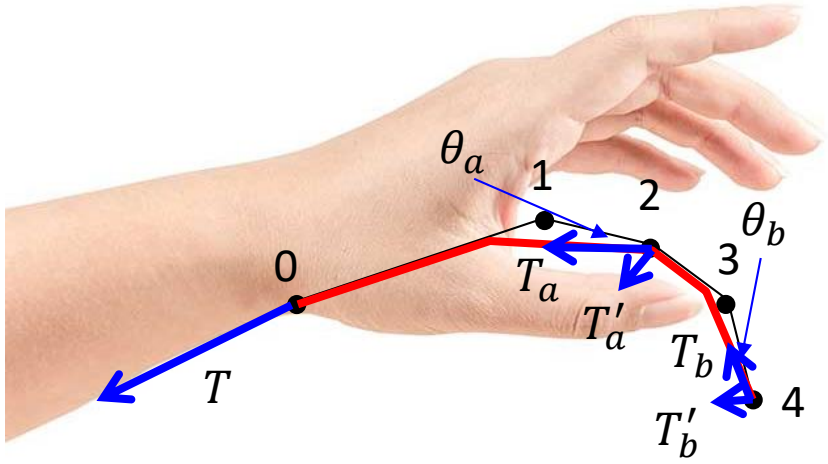
$$l = l_1 + l_2 + l_3 + l_4$$
$$= \sqrt{(a_1 - l_1)^2 + a_2^2 + 2(a_1 - l_1)a_2 \mathrm{C}_2} + \sqrt{(a_3 - l_3)^2 + a_4^2 + 2(a_3 - l_3)a_4 \mathrm{C}_4}$$



$$T = T_a + T_b,$$
$$T' = T_a' + T_b'$$
$$T_a' = T_a \sin\theta_a$$
$$T_b' = T_b \sin\theta_b$$

$$\theta_a = \sin^{-1}\frac{(a_1 - l_1)\sin\theta_2}{l_2}$$
$$\theta_b = \sin^{-1}\frac{(a_3 - l_3)\sin\theta_4}{l_4}$$

Required Tension



$$T = T_a + T_b$$

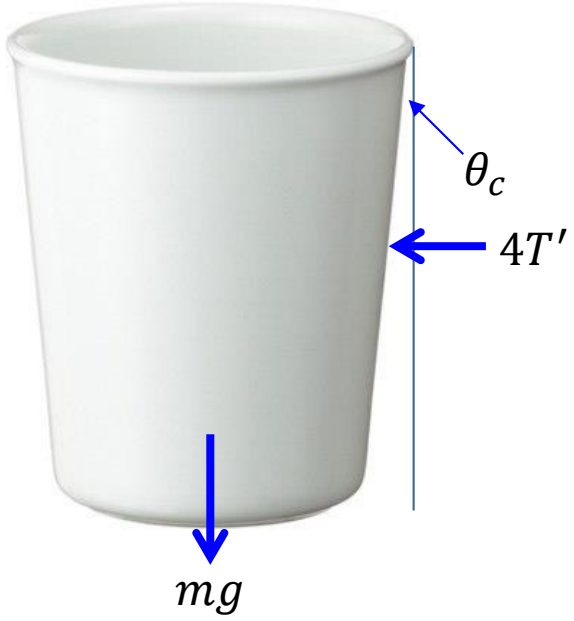
$$T_a' = T_a \sin\theta_a$$

$$T_b' = T_b \sin\theta_b$$

$$\theta_a = \sin^{-1}\frac{(a_1 - l_1)\sin\theta_2}{l_2}$$

$$\theta_b = \sin^{-1}\frac{(a_3 - l_3)\sin\theta_4}{l_4}$$

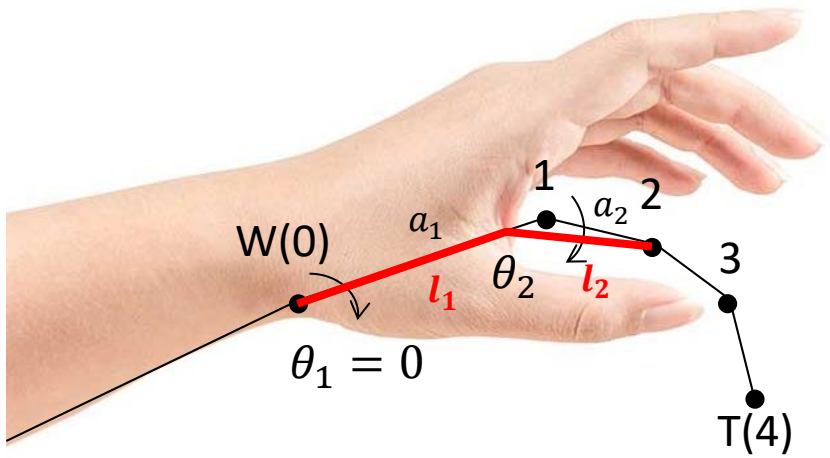
source: iStock



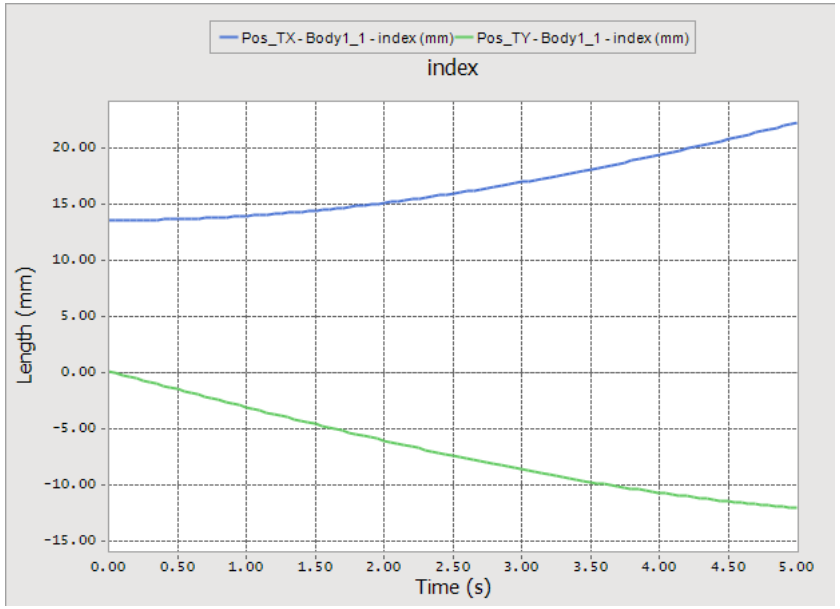
$$T' = T_a' + T_b'$$

$$mg = 4T'\cos^2\theta_c$$

Mechanics

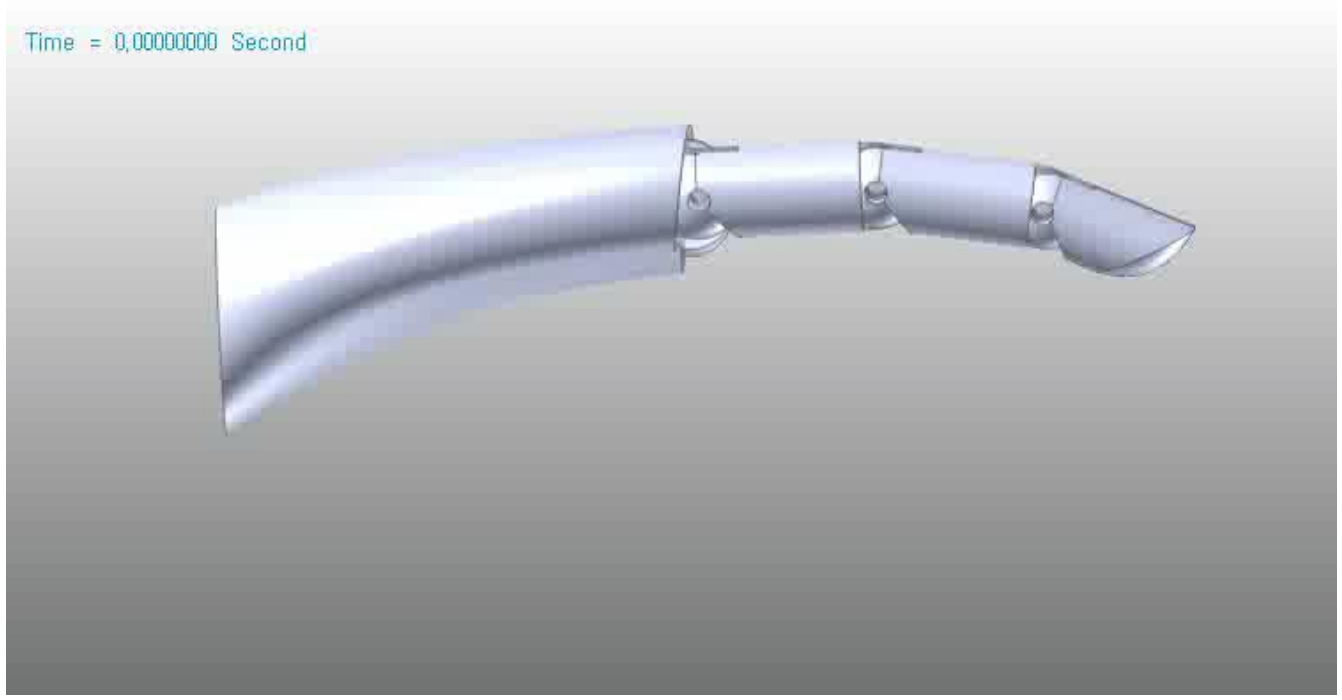


$a_1 = 85mm$
$a_2 = 25mm$
$l_1 = 65mm$
$\theta_1 = 0°$
$\theta_2 = 0°\sim75°$

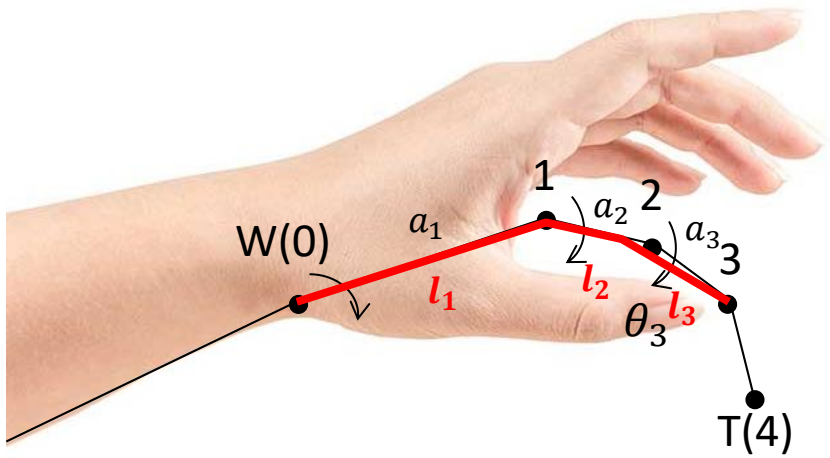


$$l = l_1 + l_2$$
$$= l_1 + \sqrt{(a_1 - l_1)^2 + a_2^2 + 2(a_1 - l_1)a_2 C_2}$$

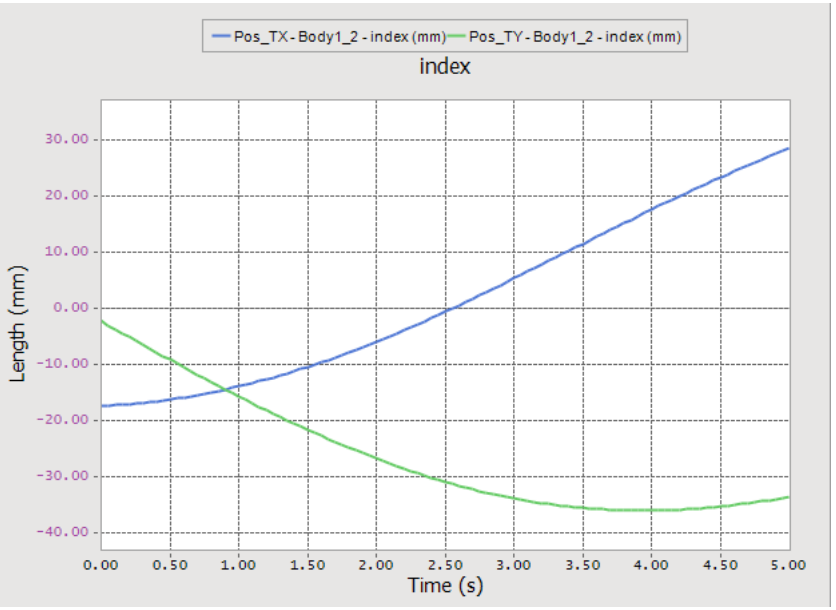
$\theta_2 = 0° : l = a_1 + a_2 = 110mm$
$\theta_2 = 75° : l = 100.83mm$



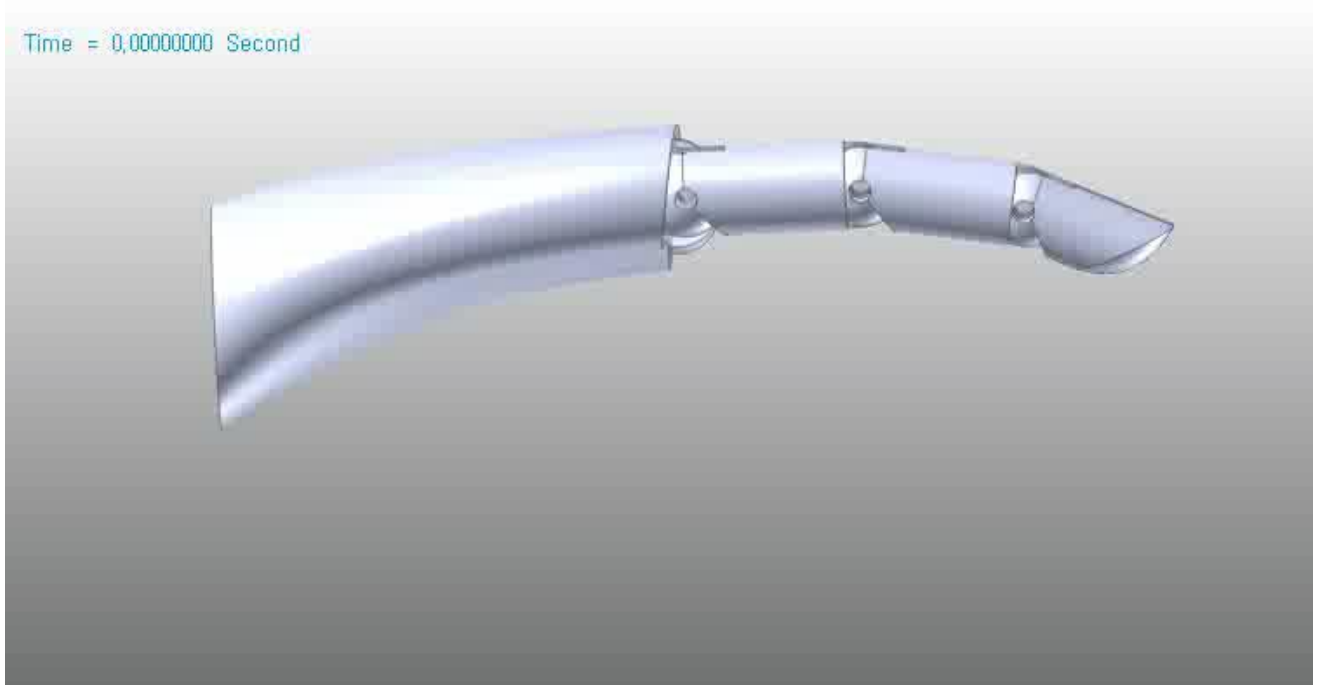
Mechanics



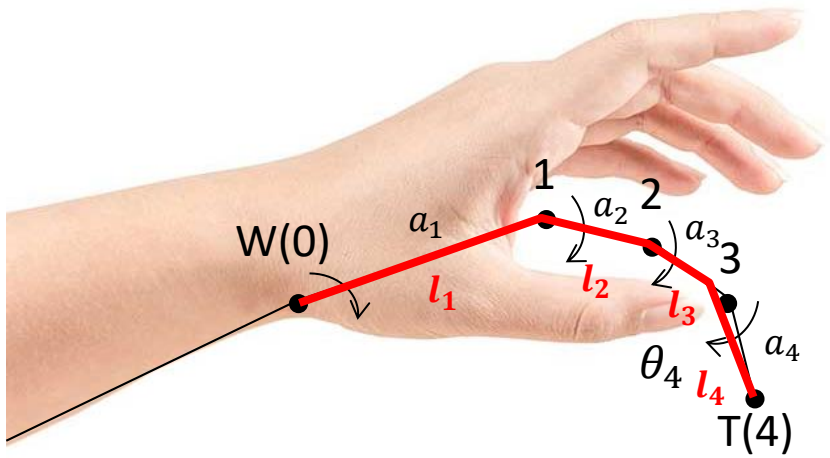
$$a_1 = 85mm$$
$$a_2 = 25mm$$
$$a_3 = 25mm$$
$$l_1 = a_1$$
$$l_2 = 20mm$$
$$\theta_3 = 0°\sim85°$$



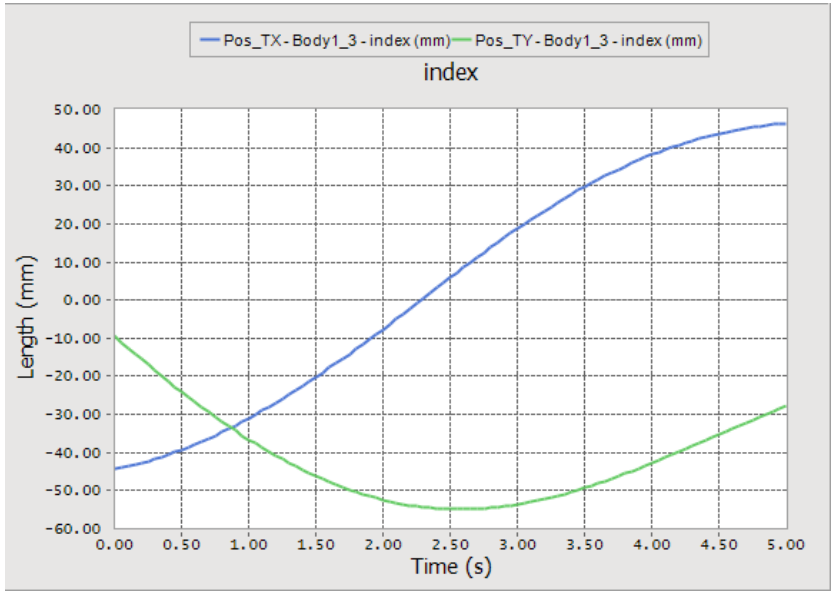
$$l = l_1 + l_2 + l_3$$
$$= l_1 + l_2 + \sqrt{(a_2 - l_2)^2 + a_3^2 + 2(a_2 - l_2)a_3 C_3}$$
$$\theta_3 = 0° \ : \ l = a_1 + a_2 + a_3 = 135mm$$
$$\theta_3 = 85° \ : \ l = 130.92mm$$



Mechanics



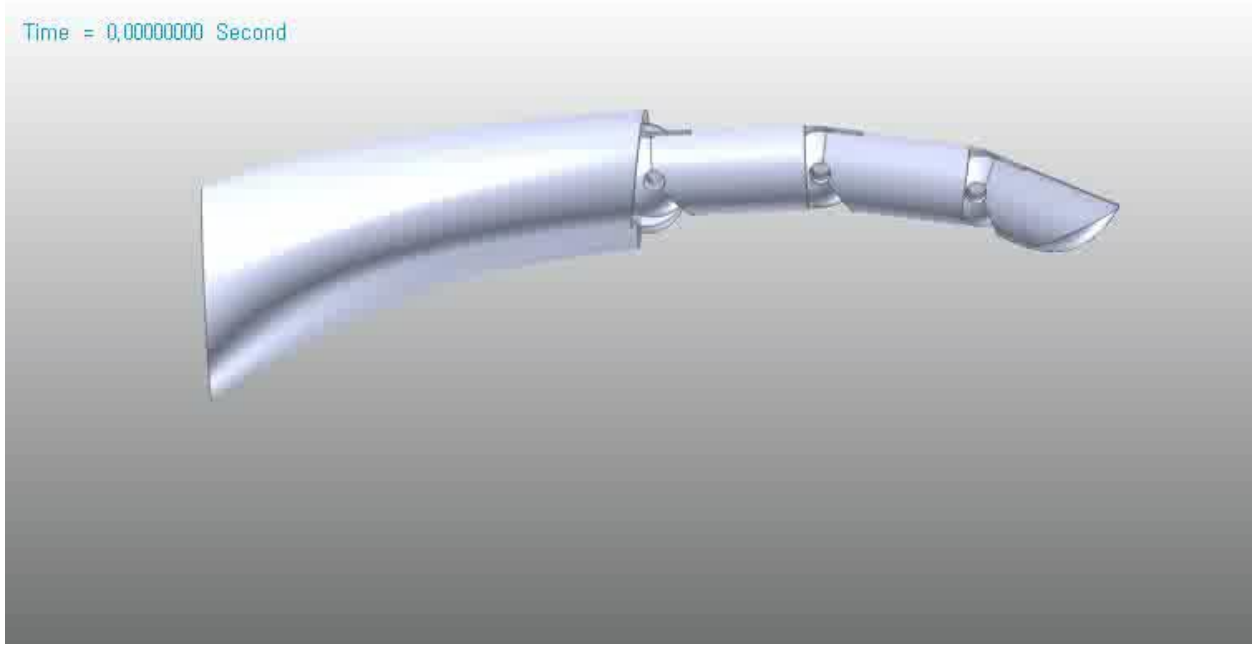
$a_1 = 85mm$
$a_2 = 25mm$
$a_3 = 25mm$
$a_4 = 25mm$
$l_1 = a_1$
$l_2 = a_2$
$l_3 = 20mm$
$\theta_2 = 0°\sim90°$

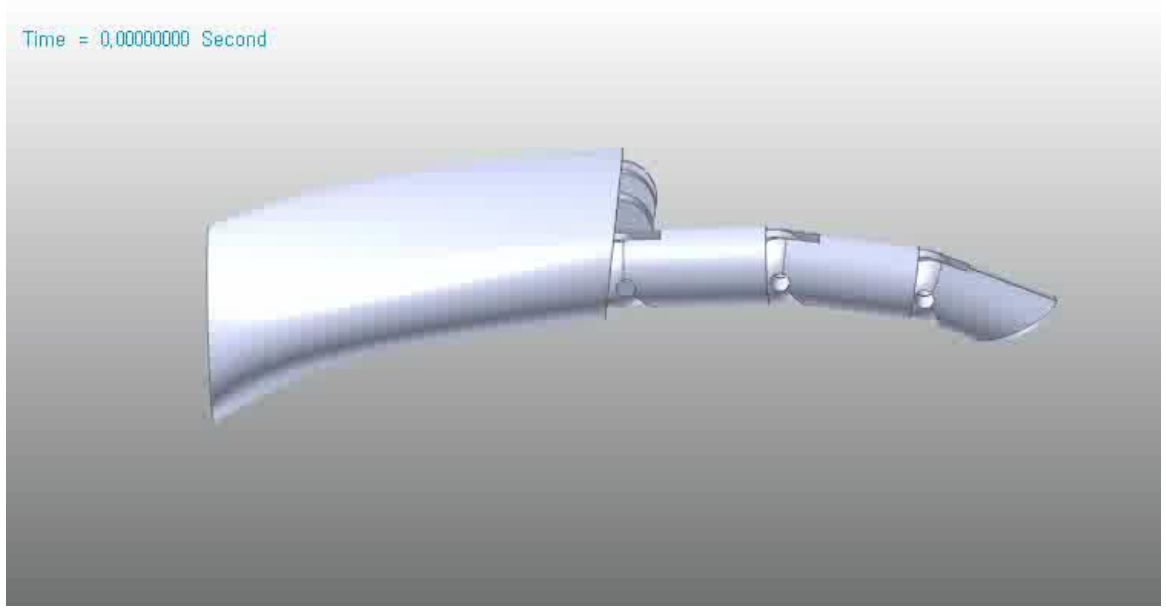


$$l = l_1 + l_2 + l_3 + l_4$$

$$= l_1 + l_2 + l_3 + \sqrt{(a_3 - l_3)^2 + a_4^2 + 2(a_3 - l_3)a_4 C_4}$$

$\theta_4 = 0° : l = a_1 + a_2 + a_3 + a_4 = 160mm$
$\theta_4 = 90° : l = 155.50mm$




Time = 0,00000000 Second