

# **Mechatronics and Making Mid Project Report Exoskeleton Robotic Hand With Wolf Claw Mechanism**

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# **1 Introduction**

## **1.1 Project Objectives and Description**

## **1.2 Similar Mechanisms**

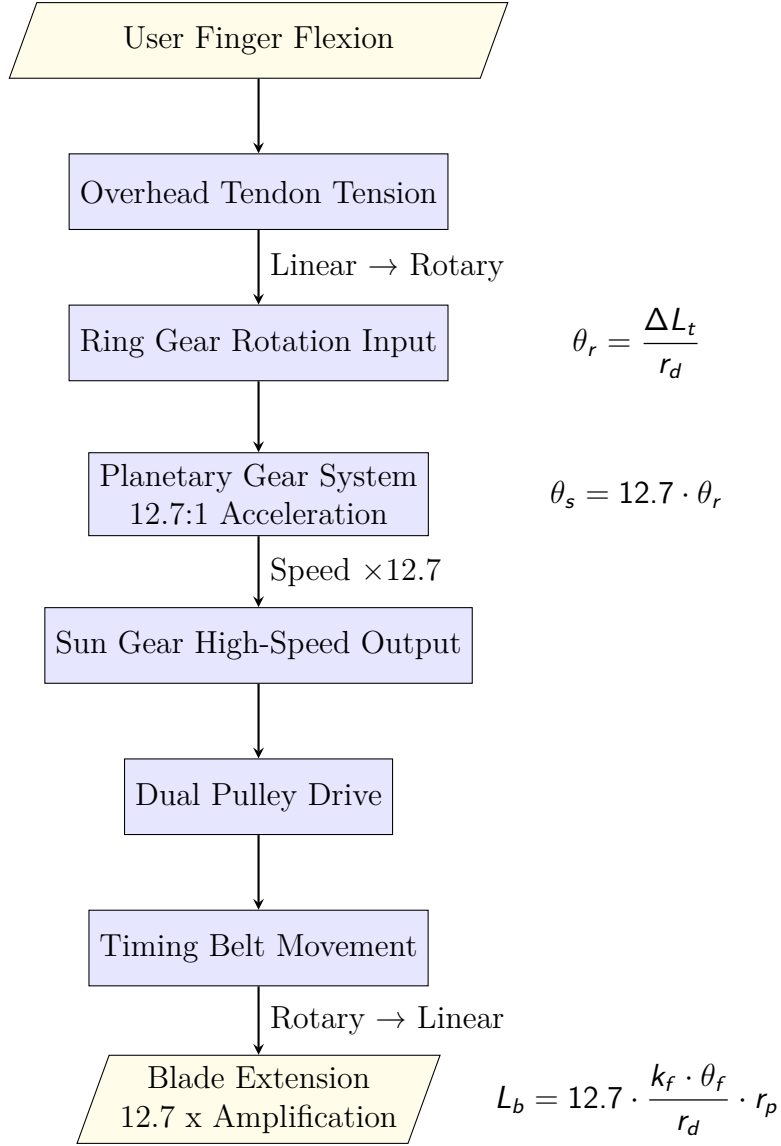
## **1.3 Industrial Applications**

# **2 Mechanical and Mechanism Analysis**

## **2.1 Drive Method and Transmission**

The exoskeleton robotic hand employs an acceleration-based transmission system where finger movements are amplified through a planetary gear mechanism to achieve significant blade extension.

Below is the detailed transmission process illustrated through a flowchart:



### 2.1.1 Transmission Process Details

**Biomechanical Input (Finger Flexion):** Natural finger flexion creates geometric displacement through overhead tendon routing on the finger dorsal side.

Using Smith et al's tendon displacement equation:

$$\Delta L_t = k_f \cdot \theta_f \quad (1)$$

and substituting typical finger geometry data ( $k_f = 0.8$  mm/degree for index finger), we then get approximately 24 mm tendon displacement for 30 degrees of flexion. Finally, this linear displacement provides the input to the transmission system.

**Tendon to Rotary Conversion:** The tendon wraps around a drum connected to the ring gear, converting linear displacement to rotational input. Using the drum conversion

equation:

$$\theta_r = \frac{\Delta L_t}{r_d} \quad (2)$$

and substituting our drum radius ( $r_d = 5$  mm) and previous tendon displacement (24 mm), we then get 4.8 radians of ring gear rotation. Finally, this rotational input drives the planetary gear system.

**Planetary Gear Acceleration:** The ring gear serves as input in an unconventional configuration where planet gears transfer motion to the sun gear. Using the planetary gear ratio equation:

$$\theta_s = 12.66 \cdot \theta_r \quad (3)$$

and substituting our ring gear rotation (4.8 radians), we then get 60.77 radians of sun gear rotation. Finally, this represents the 12.66:1 acceleration that enables significant blade extension.

**Pulley and Belt Transmission:** The sun gear shaft drives dual synchronized pulleys with timing belts maintaining parallel blade alignment. Three blades are mounted perpendicular between the belts. Using the pulley-belt transmission relationship, the rotational motion is converted to linear blade movement with the pulley radius ( $r_p = 3$  mm) determining the final extension.

**Final Blade Deployment:** Belt movement translates to linear blade extension through the complete kinematic chain. Using the comprehensive deployment equation:

$$L_b = 12.66 \cdot \frac{k_f \cdot \theta_f}{r_d} \cdot r_p \quad (4)$$

and substituting all our parameters ( $k_f = 0.8$ ,  $\theta_f = 30^\circ$ ,  $r_d = 5$  mm,  $r_p = 3$  mm), we then get 182.3 mm total blade extension. Finally, this demonstrates how subtle finger movements ( $30^\circ$ ) result in significant tool deployment (182 mm).

The complete transmission system achieves:

$$\text{Overall Ratio} = \underbrace{\frac{k_f}{r_d}}_{\text{Tendon}} \times \underbrace{12.7}_{\text{Planetary}} \times \underbrace{r_p}_{\text{Pulley}} = 12.7 \cdot \frac{k_f \cdot r_p}{r_d} \quad (5)$$

Where small finger movements ( $\theta_f$ ) result in proportionally larger blade extensions ( $L_b$ ), making the system both responsive and precise for its intended applications.

This acceleration-based transmission represents an innovative approach to exoskeleton tool deployment, leveraging planetary gear mechanics to amplify natural human movements into effective tool operations.

## **2.2 Fingers and Wrist Mechanisms**

## **2.3 Wolf Claw Mechanism Comparison**

### **2.3.1 Version 1: Planetary Gear**

### **2.3.2 Version 2: Compound Gear Train**

## **3 Mathematical Modelling and Analysis**

### **3.1 Fingers and Wrist Modelling**

### **3.2 Wolf Claw Mechanism Version 1: Planetary Gear**

### **3.3 Wolf Claw Mechanism Version 2: Compound Gear Train**

## **4 Conclusion and Future Work**