

Mechatronics and Making

Mid Project Report

Exoskeleton Robotic Hand With

Wolf Claw Mechanism

Bryan Li – SN 25003743

Yan Pei Zhu – SN 25103352

Nolan Yu – SN 25113715

October 31, 2025

Contents

1	Introduction	2
1.1	Project Objectives and Description	2
1.2	Similar Mechanisms	2
1.3	Industrial Applications	2
2	Mechanical and Mechanism Analysis	2
2.1	Drive Method and Transmission	2
2.1.1	Transmission Process Details	3
2.2	Fingers and Wrist Mechanisms	5
2.3	Wolf Claw Mechanism Comparison	5
2.3.1	Version 1: Planetary Gear	5
2.3.2	Version 2: Compound Gear Train	5
3	Mathematical Modelling and Analysis	5
3.1	Fingers and Wrist Modelling	5
3.2	Wolf Claw Mechanism Version 1: Planetary Gear	5
3.3	Wolf Claw Mechanism Version 2: Compound Gear Train	5
4	Conclusion and Future Work	5

1 Introduction

1.1 Project Objectives and Description

1.2 Similar Mechanisms

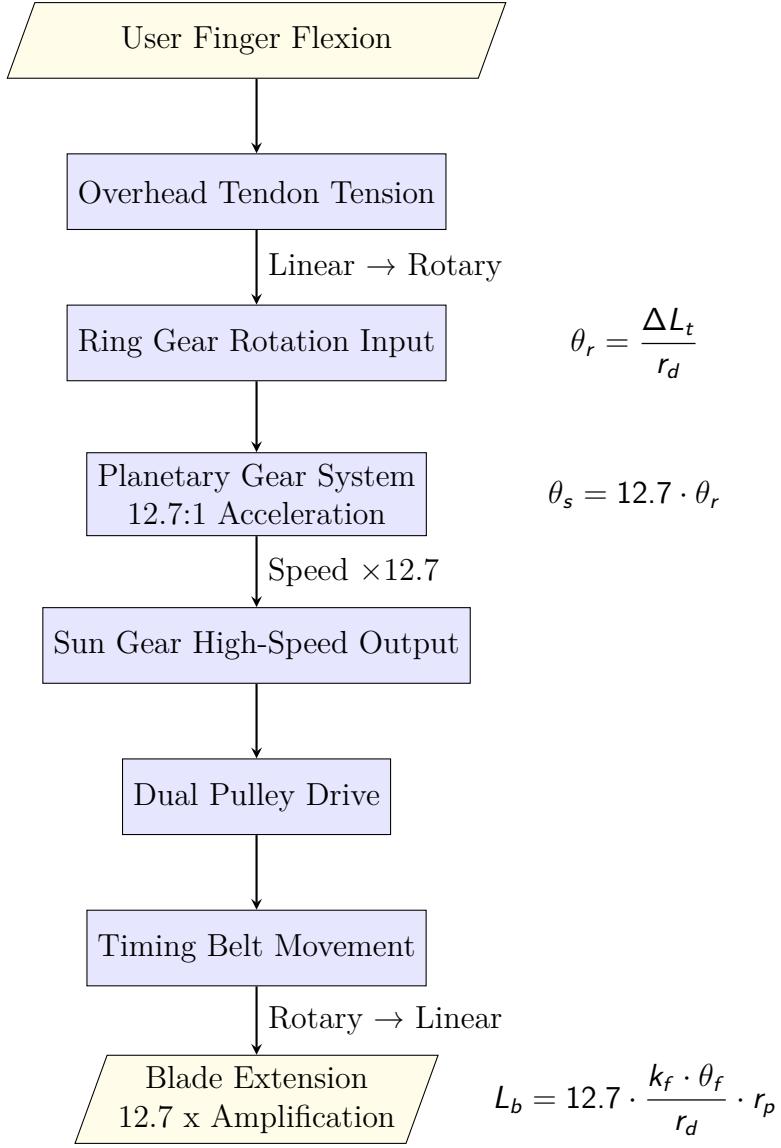
1.3 Industrial Applications

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 ($k_f = 0.8 \text{ mm/degree}$ 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°) result in significant tool deployment (182 mm).

The complete transmission system achieves:

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

Where small finger movements (θ_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