MS Thesis (Graduation: 2019)

An Active Orthosis with Tenodesis Effect for Grasp Force Augmentation of Daily Life

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Introduction

Background

What is Tenodesis Effect?

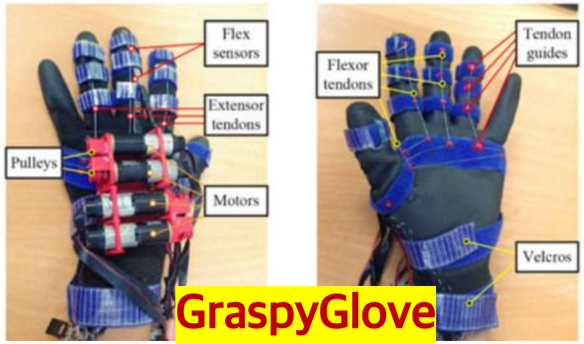
✓ Wrist motion driven finger motion mechanism
- Voluntary wrist extension
- Minimal grasp force

✓ Wrist driven mechanical device assisting in making grasp for activities of daily living
- C6-C7 spinal cord injury patients

State of the art

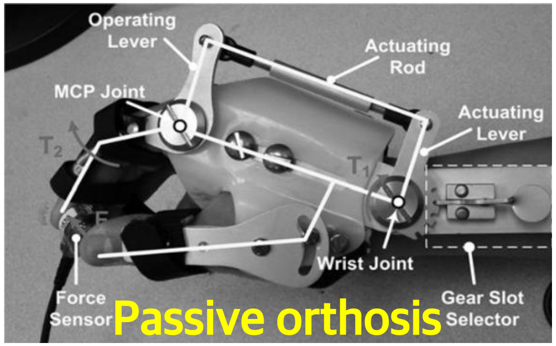
- 3 motors
- Complex tendon routing
- Fixed grasp force (20N)
- Difficult to sanitize

➢ Robots with multiple motors/sensors



- 4 motors + IR + flex sensor
- Complex tendon routing
- Fixed grasp force (16N)
- Difficult to sanitize

➢ No way to adjust or tune grasp force



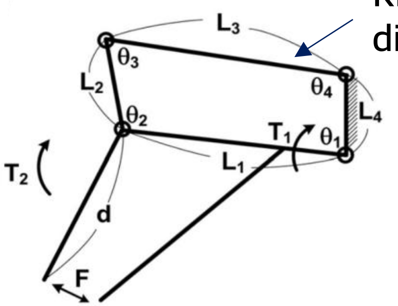
- Minimum grasp force
- Lower tasks accomplishments
- No force tuning

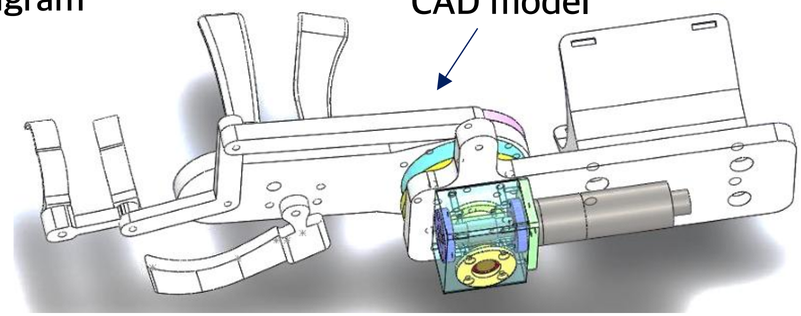
➢ Difficulty in sanitization

Methodology

Experimental Setup

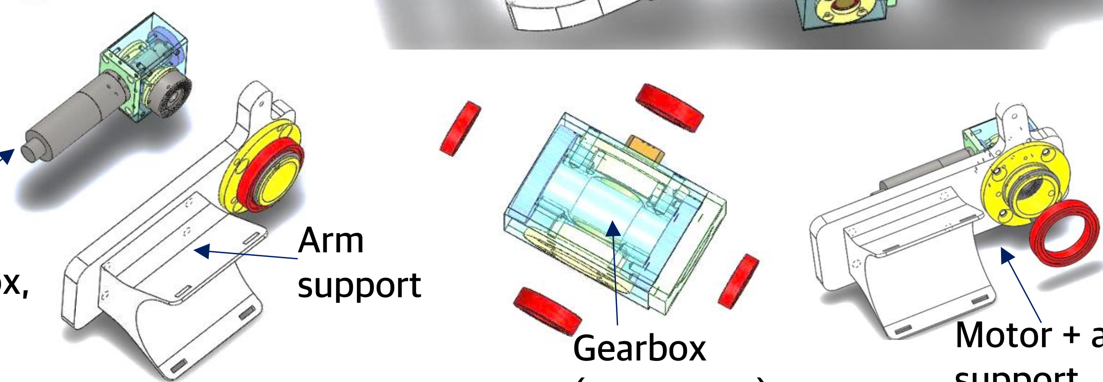
Active 4-bar Mechanism

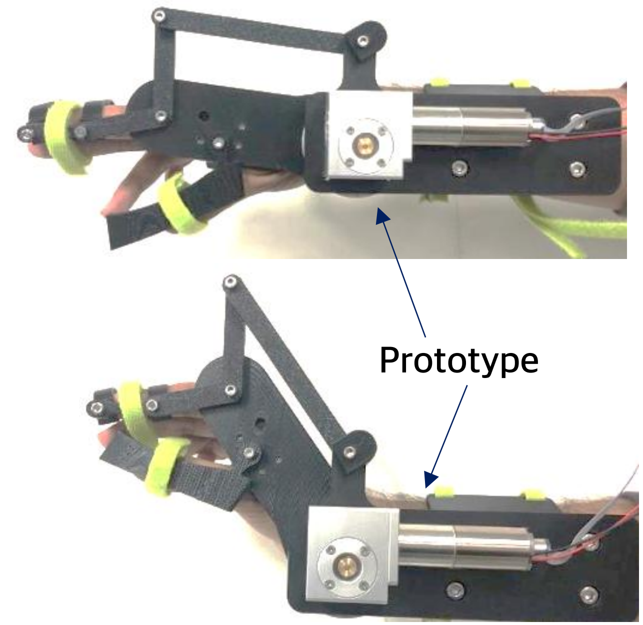




$$F = \frac{L_2 \cos(90-\theta 3)}{L_2 \cos(90-\theta_3)+L_1 \sin(\theta_1+\theta_4)} \text{ x } \frac{1}{d} \; (T_m + T_w)$$

Tm = Constant motor torque, Tw= wrist torque



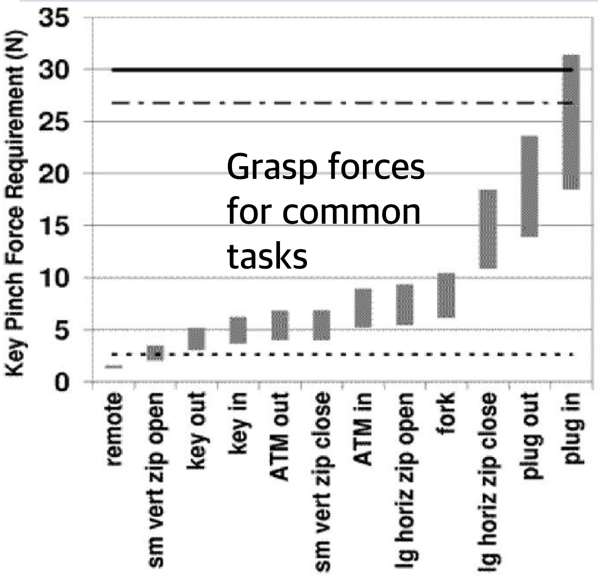


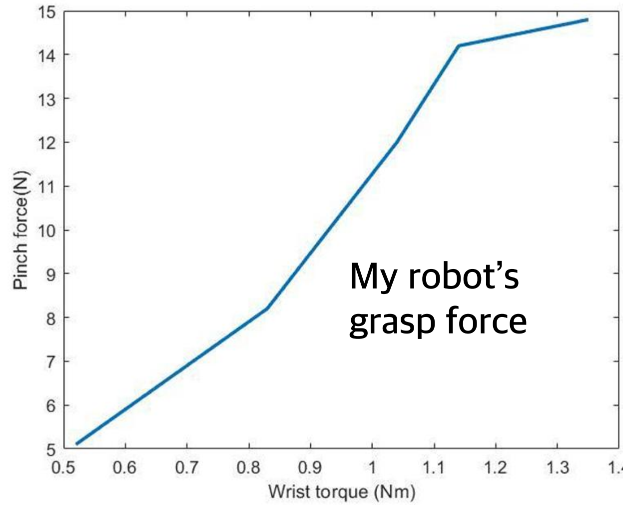
- Designed in SolidWorks
- Uses single MAXON BLDC motor with EPOS controller
- Mini gearbox with mini clutch mechanism for 90-degree force transmission
- Optimized linkage lengths through kinematics derivation
- Safety mechanism

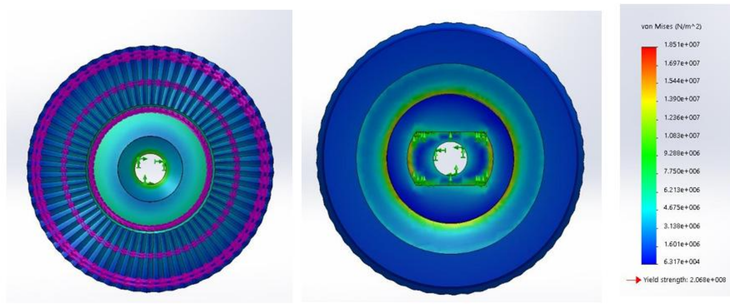
Results

Advantages

Solved problems







Stress analysis
- FEM SolidWorks

- Generates up to 15N grasp force
- Accomplishes more than 75% of daily life activities
  - 10.4 N is required for 75% tasks
- Uses only 1 motor and no sensor
- Can operate in both active and passive mode
- Grasp force can be adjusted/tuned according to user's need
- Safety mechanism included to prevent excessive motor torque
- Easy to wear and sanitize

Other robots	My robot
Multiple motors & s ensors	1 motor, 0 sensor
No force tunning	Force tuning
Sanitization issues	Easy sanitization