Computer Vision Based Controlled Gripping of the HERO Glove Insight

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Introduction

Chronic stroke survivors that receive three or more hours of high intensity upper limb therapy per day show substantial, clinically meaningful, gains in motor recovery [1]. Soft exoskeletons have the potential to be made portable and provide comfortable motion assistance, enabling people with impaired motor function to practice more engaging therapeutic tasks and integrate their affected hand throughout everyday life. By improving the grip strength of the HERO Glove system, more Activities of Daily Living can be performed. This coupled with increased environmental awareness of the HERO Glove will allow users to use the system more easily.

Objectives

The HERO Glove Insight was designed to:

- Improve manufacturing methods of HERO Glove system.
- Develop a method to identify the object the user intends to grip.
- Develop a method to sense how much force the HERO Glove system and user are exerting on an object.
- Develop a method to control the force being exerted by the user and HERO Glove system.

To improve the grip strength of the HERO Glove, 3D printed anchor points were added behind the finger tips of the HERO Glove to pull the fingers closed. To sense the force exerted by the system, an FSR sensor was taped to the thumb of the HERO Glove. The changes made to the HERO Glove system can be observed in Fig. 1.

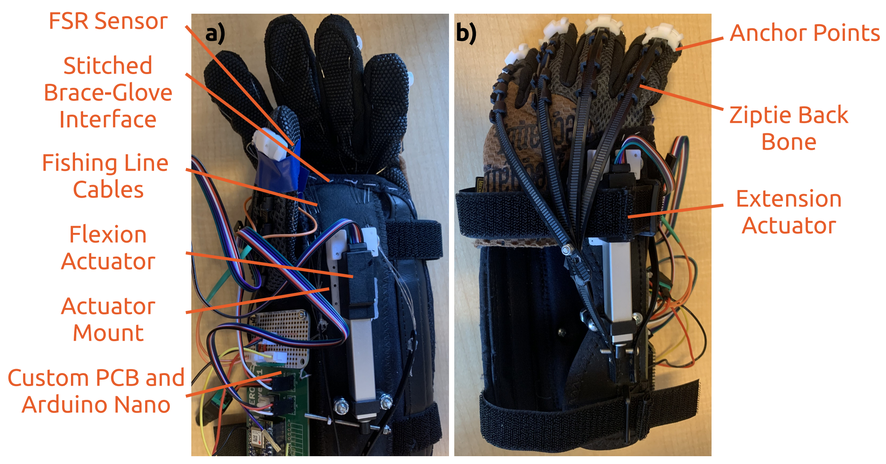


Fig. 1. HERO Glove Insight a) proximal and b) dorsal side views highlighting the modifications made to the original HERO Grip Glove.

Using the improved HERO Glove system, the YOLO V3 computer-vision model [2], and the control system, a series of grip tests, Fig. 2., were conducted. First using a hand dynamometer, to verify the relationship between the force FSR sensor and the ground truth, and then to evaluate the system.

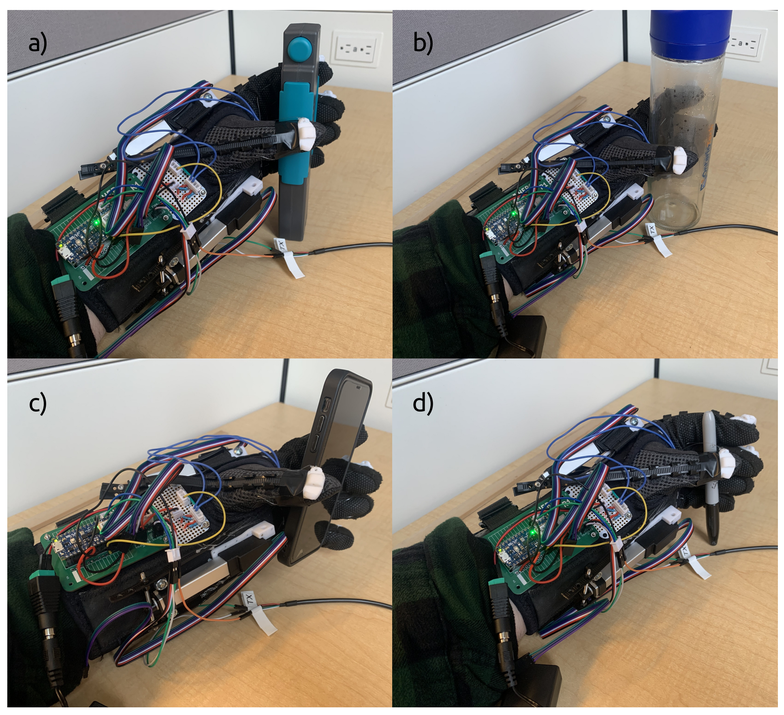


Fig. 2. Grip tests used to evaluate the system.

Results

Fig. 3. shows the performance of the system gripping each object. The system can grasp each object with the correct force. The key metrics of the grasping tasks are presented in Table 1.

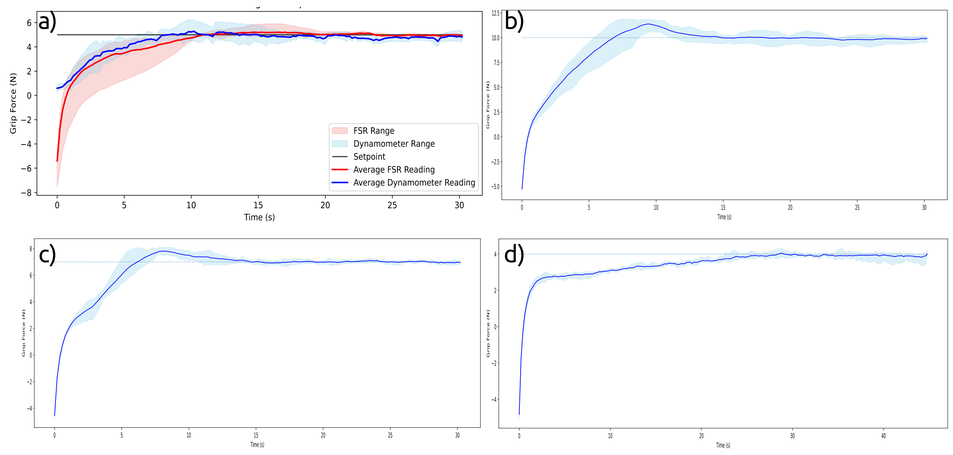


Fig. 3. Grasping Task Outputs. a) Calibration curve. b) Bottle task. c) Phone task. d) Pen Task.

Metric	Average Reading		
	Bottle	Phone	Pen
Rise Time (s)	5.06 (1.09)	4.66 (0.62)	24.04 (8.24)
Settling Time (s)	27.40 (6.46)	29.91(0.70)	42.80 (3.89)
Percent Overshoot (%)	15.00 (4.27)	13.22 (2.85)	4.28 (2.85)

Table 1: Key Characteristics of Gripping Tasks

Discussion

The maximum grip force increased from 8.9 N to **13.2 N**. This increased maximum grip force allows the HERO Glove Insight to perform **32% more activities of daily living**.

Table 1 shows that, the two larger objects, water bottle and phone, followed a much closer relationship to each other than the pen. It can be seen that the proportional gain was insufficient for smaller objects as the linear actuator could not move faster to close the hand.

Conclusion

The HERO Glove Insight increased the maximum grip force and the system's robustness. Automated object specific grip force was achieved using a computer-vision – PID control system. This system demonstrates opportunities that sensing and computer vision can provide to increase the functionality and ease of use of soft exoskeletons. Future developments will explore enabling user control of grasp posture, model predictive control to reduce rise time and overshoot while encouraging volitional movement [3] and clinical trials to evaluate assistive and rehabilitative effectiveness.

References

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