DEVELOPMENT OF LIGHTWEIGHT GRASPING MECHANISM ENABLING THREE BASIC GRASPING FUNCTIONS FOR MYOELECTRIC PROSTHETIC HANDS

No. 2281294 Kaito Wakao
(Supervised by Prof. Masaya Watada)

ABSTRACT

This study focuses on the development of a lightweight and functional grasping mechanism for myoelectric prosthetic hands, with the goal of reducing the burden on users of myoelectric prosthetic hands. In Japan, where over 50% of individuals with disabilities experience limb impairments, upper limb amputations are notably prevalent. Despite the demand for advanced prosthetic solutions, the adoption rate of myoelectric prosthetic hands remains limited at 2% within the domestic population. The primary obstacles hindering widespread adoption include factors such as cost, weight, and support infrastructure. A survey conducted among prosthetic hand users revealed that the weight of the devices constitutes a significant burden, prompting the need for innovative solutions to address this issue. This research aims to develop a grasping mechanism that is not only capable of basic functions but is also notably lightweight, thereby enhancing user comfort and acceptance.

The proposed approach introduces the utilization of pneumatic actuators, emphasizing their high output-to-weight ratio and excellent backdrivability characteristics. Pneumatic actuators offer the potential to reduce the overall weight of the actuation mechanism by a factor of up to 190:1, while still enabling natural and flexible movements due to their backdrivability. To achieve the targeted grasping functions: power grasp, precision grasp, and lateral grasp, a reduction in the complexity of the grasping mechanism through the elimination of thumb rotation is suggested. The concept of thumb abduction and adduction, defined as the motion of the thumb away from and towards the center of the hand, is crucial for achieving the three essential grasping functions. To innovate in this regard, this study proposes a deviation from conventional designs by altering the opposition angle and flexion direction of the thumb in relation to the index finger. This adjustment aims to enable the three specified grasping actions without the need for additional thumb rotation, contributing to both simplicity and reduced weight.

The research progress is outlined, detailing the conceptualization and fabrication of the two-degree-of-freedom hand based on the proposed development concept. Experimental trials conducted with this hand confirmed the effectiveness of the proposed grasping mechanism, particularly its ability to achieve the three targeted grasping postures without the inclusion of a thumb rotation mechanism. Furthermore, tension measurements were conducted to quantify the force applied to tendons connecting the actuator to the finger during grasping. These tension measurements provided insights into the required power for the pneumatic actuators, crucial for ensuring optimal functionality in real-world scenarios.

In conclusion, this study introduces a novel approach to myoelectric prosthetic hand development, leveraging pneumatic actuators to address the persistent challenges of weight and functionality. The experimental results validate the efficacy of the proposed grasping mechanism, showcasing its potential to enhance the quality of life for individuals with upper limb amputations.