MECHANICAL DESIGN AND CONTROL OF A NEW MYOELECTRIC HAND PROSTHESIS

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Abstract

The development of modern, myoelectrically controlled hand prostheses can be difficult, due to the many requirements its mechanical design and control system need to fulfill [1]. The hand should be controllable with few input signals, while being able to perform a wide range of motions. It should be lightweight and slim, but be able to actuate all fingers separately. To accomplish this, new control and mechanical design techniques are implemented in a modern hand prosthesis prototype.

1 Introduction

Modern hand prostheses offer a variety of grasps and gestures, which require many degrees of freedom (DOF). Their mechanical design needs to accommodate enough actuators to move all of the hand's DOF, whereas their control systems should allow the user to intuitively access all grasps and gestures the hand is capable of.

The anthropomorphic mechanical design of such a hand means the actuation for all DOF needs to fit inside the palm of the hand. Most joints will therefore need to be underactuated, which reduces their controllability. A joint locking system has been developed to fit inside the joints of the fingers, using small solenoid actuators to block joint motion at will [2]. This allows an underactuated finger to perform several different motions with a single main actuator.

In earlier research, the performance of several low-level control systems was evaluated in simulation and on a robotic hand [3]. This low-level control can be combined with EMG classification and high-level grasp control to coordinate all degrees of freedom using only a small number of user input signals.

In this paper, the results of this earlier research are integrated into a complete myoelectric prosthesis control system, and the design for a prosthesis prototype is developed and evaluated.

2 Mechanical Design

The mechanical design is based on a small number of main actuators, which control the flexion and extension of a single finger each. The underactuated finger joints are linked by a tendon-pulley system; the PIP and MCP joints of each finger are individually controlled by joint locks. A two-finger prototype is designed and fabricated to evaluate the joint locks and grasp performance.

3 Control System

The control system first uses a classification program to select one of several control signals based on myoelectrical signals from the user. These control signals can select a specific grasp type, or open and close the hand. Once a grasp type has been selected, the grasp planner determines the positions the finger should take to preshape the hand. Preshaping allows the user to position the hand around an object before closing it.

The grasp planner's desired finger positions are sent to the low-level finger controller, which determines the joint torques that should be applied. This control system is based on Intrinsically Passive Control [3], which offers an inherently stable, compliant grasp.

The completed system is evaluated by myoelectrically controlling the prototype to perform several grasp types. The prototype's performance is compared to commercial and research prostheses.

References

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