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Design of a New Mechanism for a Hand Exoskeleton

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ABSTRACT

Over the last two decades, the usage of robotic-assisted treatments has grown, allowing for high-intensity and interactive rehabilitative procedures, while assessing the treatment success. Thanks to the rapid advancement in the field of bio-robotics, high dexterity can be achieved but at the cost of an increased weight, size, and complexity of robotic solutions. An approach to reduce the cost, weight and size of the robot is to make the design complex and simplify the control strategy and reduce the number of actuators. We call this approach morphological computation or intelligent by mechanics and aimed to design a hand exoskeleton, that is complex in terms of mechanism but at the same time, uses a simplified the control strategy. A strong emphasis was placed on reducing the size for a compact and lightweight device by reduced number of motors.

A low-cost mechanism design was created through extracting the hand postures during grasping, and implementing a closed chain mechanism that can properly fit above the finger, and replicate the fingers' motions. The dimensions and materials of this finger mechanism design was optimized for 3D printing and 2D manufacturing methods such as waterjet cutting, hence allowing for low costs. Furthermore, through various iterations of the mechanical design, bearings were chosen for the linkage joints to reduce friction and allow the maximum transfer of torque from the motors. Subsequently, the four fingers and a thumb mechanism were attached to the hand and wrist segments of the exoskeleton. The motors used for the finger mechanism were chosen to provide an overall grasping force for holing a 10N-weighed object while minimizing the motor weight.

The dimensions of mechanisms were optimized according to the human hand dimensions and grasp configurations. Different grasp configurations were selected and their positions according to the human finger joint kinematics are experimentally recorded by a motion capture system. In conclusion, the designed mechanism can generate motions similar to those of human fingers and does not restrict joints by motions miss-match or friction. The designed exoskeleton is able to assists the hand to apply force by the fingertips, for the purpose of holding an object. This exoskeleton benefits form a reduced number of motors and simple control strategies.