DESIGN OF UPPER LIMB EXOSKELETON ORTHOSIS FOR REHABILITATION PURPOSES

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Introduction

Automated rehabilitation orthosis typically focuses on lower limbs and the rehabilitation of lower limb conditions such as paraplegia and other Spinal cord injuries (SCIs). Rehabilitation upper limb exoskeletons (RULE) made for rehabilitation purposes are prohibitively expensive and are usually stationary apparatus. The aim of this work is to design and produce a RULE that is cheaper than the current existing options and portable to improve the quality of life of the user [1].

Methods

Five sections of 3D printed pieces were made and assembled to accommodate a human arm in a way that would provide motion assistance to the user, including shoulder movement, upper arm rotation and elbow extension. The exoskeleton was mounted into a standard backpack for mobility, where the user uses a remote control to move each joint. A control system was designed that uses servo motors for each degree of freedom. These motors work via an Arduino board that controls the motion range and speed for each joint. According to Plagenhoef et al, the average human arm requires a torque of 16.7 Nm to move at full extension [2]. To accommodate the variance in human arms and the mass of the exoskeleton, a servo motor was chosen for the shoulder that, when in 1:6.8 gear ratio, will produce 40 Nm of torque.

Results & Discussion

The first prototype of the exoskeleton allowed for five degrees of freedom, abduction/adduction from the shoulder, flexion, and extension of both the arm and elbow, internal and external rotation of the upper arm and lateral rotation of the shoulder. It is portable via a standard backpack with adjustable straps to allow simplified access and egress for the user. The user can integrate with the exoskeleton using 3 adjustable Velcro straps (see Fig 1).

The exoskeleton was made using a combination of machining and 3D printing. Most of the exoskeleton is printed with Polylactic Acid (PLA) which is a biocompatible material source from sugar cane.[3] Aluminum was used to make the backplate, mount and joint shafts. The full assembly, not including the machinery or 3D printer, costs under €400 to produce. Most of this comes from the cost of the aluminum stock and the servo motors used in the control system. The exoskeleton is relatively lightweight compared to the mass of an average human, weighing 4.6kg.

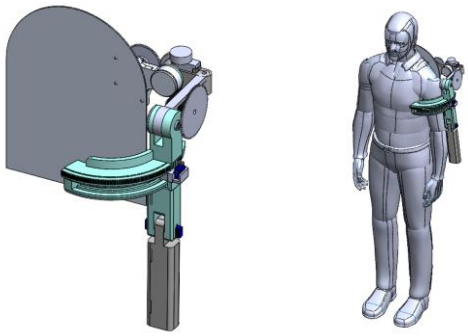

Figure 1 - The exoskeleton is seen here in isolation and with respect to a 183cm tall male.

Further testing is to be conducted on the exoskeleton, with additional improvements to be made such as a wireless remote control and an ABS 3D printed prototype.

Conclusion

The RULE can be used for its primary goal of patient rehabilitation. In addition, due to its low cost, it can be manufactured and used in developing countries where healthcare is more difficult to access.

References

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2. Plagenhoef et al, Res Q Exerc Sport, 54(2):169-178, 1983.
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