Instrumented elbow orthosis

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Introduction

- Upper limb exoskeletons are used in rehabilitation and long term conditions such as stroke, peripheral nerve injuries, cerebral palsy, trauma, and spinal cord injured patients (SCI) [1]
- Many of these people have not only lost function but also feeling
- There is limited attention to the interaction between the exoskeleton and the human [2, 3]
- Healthy elbow joint torques vary between -2.5 to 3.5 Nm for performing activities of daily life (ADL) [4]
- The compensation of function loss due to SCI is an essential component that must be evaluated by new exoskeleton designs in order to enable the performance activities of daily life

Aim:

- Create a design to instrument a commercially available arm orthosis to:
  a. Measure force at the exoskeleton-human interface
  b. Allow the user to toggle between elbow flexion and extension while selecting the speed of movement through a mouth and eyebrow switch.
  c. Monitor the flexion/extension/speed strategies that best help for the performance of ADL

Methods

- Literature search on upper limb exoskeletons (with search terms: elbow and exoskeleton in Science Direct and PubMed from 2003) to have an overview of actuation selection, joint torque requirements and general design of the device.
- A search of switches for disabled people in main assistive technology providers in order to find switches that could be used by SCI patients without interfering in the performance of ADL
- A light weight (< 500 g) elbow orthosis was searched for the following features: extending struts to fit different arm lengths, non-slip padding to prevent the migration of orthosis over time and malleable cuffs to bend to the shape of the arm
- After choosing the elbow orthosis, motor and gear the general set up of the control system was designed to take into account a SCI patient's arm movement during ADL including body transfer from wheelchair to bed or toilet.

Results

- Literature search found 41 papers presenting elbow exoskeletons after filtering for duplicates and relevance
- Different elbow actuators were used in the literature (hydraulic, artificial muscle, AC and DC motors) with different torque/force transmission methods to the joint (gears, steel wire rope, pulleys, flexible or stiff rotating shafts, electrical clutch, magneto-resistive brake)
- Commercially available force sensitive resistors were chosen to be installed at 4 locations between the non-slip padding of the orthosis and the human arm
- Safety measures regarding range of motion (ROM) and speed of movement will be setup through the software where the control system will be designed. The researcher will be able to select maximum values for both ROM and speed.

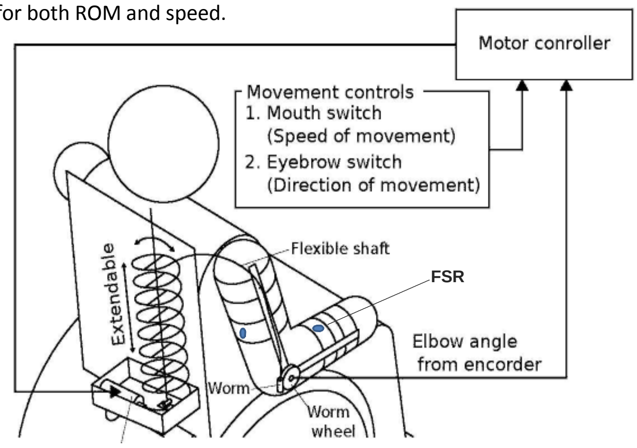

Figure 1: General setup of DC motor (50W) with gearbox (1:51) with a flexible shaft connected to a worm and worm wheel at the elbow joint. The extendable flexible shaft will allow the subject to move the shoulder freely without disturbing the function of the motor, gear and flexible shaft. The subject will control the speed of the elbow flexion or extension through a mouth switch. The direction of movement is understood as flexion or extension, which the subject will control with an eyebrow switch.

Discussion and Conclusions

- We have planned modifications for the commercial orthosis which will be able to compensate for function loss due to SCI during ADL (self care, domestic life and mobility) while measuring forces exerted by the active orthosis on the surface of the arm.
- After reinforcing the elbow orthosis, the instrumentation will be installed and tested in a healthy adult with UCL ethical approval.
- This modified orthosis will be used in a future study in individuals with spinal cord injury from C5 to C8 levels with NHS approval.

References

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4. Rosen, J., et al. *The human arm kinematics and dynamics during daily activities - toward a 7 DOF upper limb powered exoskeleton*. in *Advanced Robotics, 2005. ICAR '05. Proceedings., 12th International Conference on*. 2005.

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