A new approach to reaching control for tetraplegic subjects

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References:

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Abstract:

A simple upper limb control strategy to guide reaching in preparation to grasp for tetraplegic subjects is proposed. The control is based on new studies of self-paced human arm movements involving rotations about the shoulder and elbow joints. An experimental study of reaching, while grasping, by able-bodied humans, allowed us to reduce the dimensionality of the control vector from two to a single variable. This was accomplished by detailed analysis of the synergy between shoulder and elbow joint angles. This study examined only movements in the horizontal plane. In the experiments we varied: (a) the shape of targets; (b) their position relative to the initial position of the hand; and (c) the speed of reaching. A synergy between shoulder and elbow joint angles was found in most analysed movements, and it was characterized by a scaling parameter between elbow and shoulder angular velocities. The scaling parameter was determined from the target position presented in the visual perceptive field and initial shoulder and elbow angles. The same experimental setup in studies with tetraplegics with retained shoulder movements showed that this natural synergism is preserved even though the motor and sensory components of the upper limb are reduced or absent. Tetraplegics originally showed a very different reaching pattern, but after short training sessions they developed a reaching behaviour which was similar to able-bodied subjects. The results presented can be used in the following way: a tetraplegic subject lacking elbow extension and flexion may be fitted with an assistive system which will be volitionally controlled only from ipsilateral shoulder movements. The assistive system can comprise either a motorized brace, or a functional electrical stimulation system applied to elbow flexors and extensors. With this system volitional movements at the shoulder would bring the hand into the correct position to accomplish an assisted grasping motion.

Keywords:

Control; Reaching; Synergy; Tetraplegic