Can Iterative Learning Control be used in the Re-Education of Upper Limb Function Post Stroke?

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Introduction

For upper limb post stroke therapy, evidence has shown that robots (Prange et al 2007) and functional electrical stimulation (FES) can improve impairment levels and possibly function (De Kroon et al. 2002), (Burridge & Ladouceur 2001). To date little research has been conducted on combining the two fields.

The aim of this study is to investigate the feasibility of using Iterative Learning Control (ILC) mediated by FES to extend the ability of a stroke patient to perform a two dimensional tracking task with their arm supported by a robot arm. Iterative learning control reduces the error between the actual and desired trajectory during repeated performances of a reaching task by adjusting the level of FES.

A first stage of this project, is the characterisation of muscle activation patterns in neurologically intact participants.

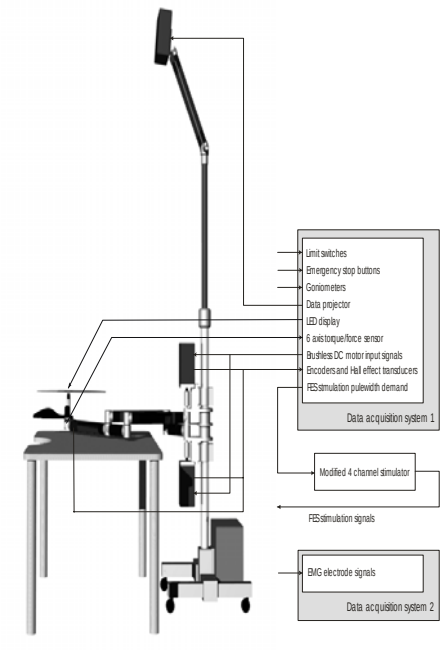

Figure 1: Diagram of robot set up

Method

Seven surface electromyographic electrodes were attached to eight neurologically normal participants (aged fifty years and over) using a standard procedure. The muscles used were the triceps, biceps, anterior deltoid, upper, middle and lower trapezius and pectoralis major (see Figure 2).

The participants sat in front of a robot (see Figure 1) which constrained their forearm in a two dimensional plane. An overhead projector displayed an image of an elliptical trajectory with a moving red dot. The participants then attempted to follow nine different trajectories (in three different directions, at three lengths, speeds and resistances).

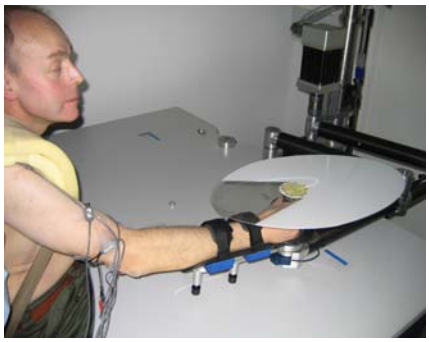

Figure 2: Subject using robot with EMG electrodes

Results

EMG data were bandpass filtered (Butterworth 10-500Hz), full wave rectified, smoothed (moving average 0.1s window) and normalised to maximum voluntary isometric contraction data. For each reaching task the mean data for all subjects was calculated and then integrated to produce a cumulative plot showing the relative activations of each muscle (Figure 3 shows a plot for one of the nine tasks).

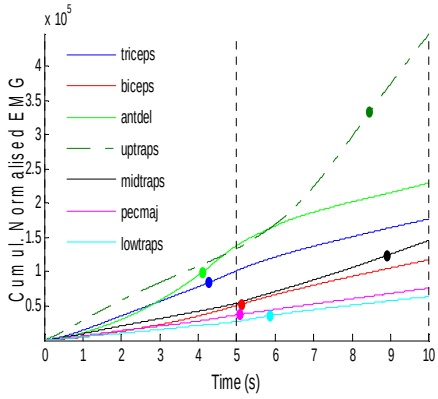

Figure 3: Cumulative normalised EMG during one reach and return task ('●' at peak rate).

Conclusion

The gradient of the cumulative normalised EMG graph represents the rate of increase of EMG activity. The '●' symbol indicates the centre of the 2 second interval in which the muscle was most active. The end point amplitude of each muscle corresponds with its total contribution to the completion of the task. Cumulative EMG graphs have been drawn for each trajectory to enable a simple characterisation to be constructed of muscle activation patterns in unimpaired subjects.

Future Work

- To investigate the muscle activation patterns of stroke patients when completing the same tasks.
- To identify whether stroke subjects can use voluntary activation assisted by ILC mediated by FES to accurately track a trajectory.
- If successful, the concept could be applied to other neurological conditions, such as cerebral palsy and incomplete spinal cord injury.

References:

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