Outline of the Project

1. Title

A lightweight approach to haptic-feedback for stroke rehabilitation.

2. Context

To date, robotic technology has been applied almost exclusively to devices that assist people with a disability to interact with the environment. Within the last few years, however, robots have been developed specifically for rehabilitation (e.g. the Motorika Reo http://www.motorika.com/REO/). Such specialised robots are versatile, but very expensive (costing upwards of USD 60K). This research program will investigate a "lightweight" approach to using force-feedback to assist rehabilitation of the arm after stroke. The host laboratory (http:// muves.unimelb.edu.au) has conducted preliminary development of targeted arm exercises with a device based on the commercially available Phantom haptic pen (http://www.sensable.com/products-haptic-devices.htm) and the project will pursue these ideas further, in collaboration with Professor Mary Galea, a clinical physiotherapist and Director of the Rehabilitation Sciences Research Centre at the University.
(http://www.physioth.unimelb.edu.au/about/school/people/mg.html)

3. Proposal

Research has shown that intensive task-specific training by a physiotherapist soon after the stroke leads to a significant improvement in the functional use of the affected arm. However, ongoing rehabilitation is required to optimise function. A robot can provide intensive, reproducible training. Preliminary reports indicate that such training results in substantial functional improvement, however there is insufficient evidence to warrant adoption of this technology into current rehabilitation practices. This project will develop software to support the interfacing of the Phantom with appropriately designed activities, with a target of rehabilitation therapy in chronic stroke patients with moderate to severe disability in the affected arm. A potential focus will be the development of new algorithms for personalisation of decision support based on tracked observations. This has the potential to allow the robot activity to adapt to an individual patent's needs over time. We anticipate there will be opportunity for some trialling of the implemented designs with selected patients.

4. Background

The national cost of health care for stroke survivors is substantial, with the lifetime costs of all first-ever stroke cases estimated to be $1.3 billion (Dewey et al. 2003). Stroke is the leading cause of long-term physical disability in Australia. Although most patients regain the ability to walk after stroke, a large proportion of stroke patients (30%-60%) never regain functional use of the arm and hand (Kwakkel et al. 1999). Reduced upper limb function after stroke is associated with poor health-related quality of life. Observational studies indicate that insufficient time is provided for rehabilitation of the affected upper limb, with just 10 minutes per day spent on upper limb activities (Goldie et al. 1992). Galea's own unpublished observations confirm these findings. The relative disparity between time given to mobility training (moving in bed, walking) and upper limb treatment in the rehabilitation setting reflects the necessity of preventing blockage of beds and the limited time of the treating therapists.

Converging evidence from both animal and human studies suggests that appropriate post-lesion training induces use-dependent patterns of neural activity that can selectively drive the reorganisation of the undamaged cortical areas and contribute to functional recovery (Xerri et al. 1998). Randomised controlled clinical trials have shown that intensive physiotherapy for the affected arm in the early period following stroke significantly improves upper limb function (e.g. Winstein et al. 2004). Other studies (e.g. Van der Lee 1999) have shown that intensive rehabilitation in the chronic period following stroke can also result in improvements in arm function. Primary efficacy measures of upper limb function can be measured by (a) the Motor Assessment Scale, a tool used routinely in Australian clinical practice, and (b) the ABILHAND, a Rasch-analysed person-centred measure of unimanual and bimanual ability in everyday activities. Secondary outcome measures can include the Stroke Impact Scale and the Assessment of Quality of Life scale.

Robots are a means of providing intensive, reproducible and task-specific training that can be adapted to address a wide range of treatment needs, and to the patient's available range of movement. These devices are extremely compliant to a person's attempts to move. Importantly they can also log the amount of practice and the patient's performance over time and therefore can further our understanding of the mechanisms that underlie motor recovery after stroke. Reports from the US indicate promising results from the use of robotic therapy in the rehabilitation setting (Aisen et al. 1997), however there has been only one study reporting the effectiveness of this methodology in chronic stroke patients (Lum et al. 2002). There is, as yet, insufficient evidence to warrant adoption of this technology into current rehabilitation practices.

5. References

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