PROJECT DESCRIPTION:

Introduction
Two critical issues in Physical Medicine are vital to its effectiveness:
1. An accurate and objective assessment method to quantify motor recovery and effectiveness of rehabilitation is needed and long overdue. Current clinical assessment methods suffer from inter- and intra-assessor inconsistencies and lack the grading resolution and scientific rigor to accurately quantify motor performance.
2. The need to engage and motivate patients to participate actively and positively in their rehabilitation programmes. Rehabilitation is usually laborious, time consuming and sees slow progress. A successful rehabilitation has as much to do with the art to encourage perseverance of the patient.
This project proposes to address these two issues with technology based solutions.

Objectives
The main objective is to develop an interactive system for post stroke rehabilitation of the upper extremities.

This project proposes to integrate advanced techniques in complex system modeling, sensing, interactive digital media and human factors engineering, with rehabilitation medicine, neuroscience, and biomechanics to achieve the following specific aims:
1. To develop an interactive rehabilitation system to engage and motivate stroke patients to participate actively in rehabilitation;
2. To develop an objective and consistent technology-based motor function assessment and functional task performance evaluation system to quantify stroke motor recovery;
3. With specific aims (i) & (ii) as the bases, we shall test the hypothesis that active engagement and motivation of stroke patients in the process of rehabilitation yield a more effective motor recovery.

Methodology
Physical rehabilitations of stroke patients using virtual reality or mixed reality have been implemented with differing degree of success in recent years and demonstrated the following advantages:
1. Safe practice environment for potentially dangerous real life tasks such as boiling water;
2. Choice to include gaming factors to enhance motivation;
3. Tasks’ level of difficulty can be controlled within a virtual environment;
4. Increase rehabilitation opportunities and time when used as tele-rehabilitation system;
5. Enables real-time objective feedback of the patient’s performance;
6. Transfer of training to “real” world.
Most importantly, virtual reality based rehabilitations have been shown to improve motor movement and induce cortical reorganization and associated locomotor recovery. Hence, a mixed reality system...
will be created and integrated into our proposed system to provide objective feedback and facilitate learning by action observation.

The call for an objective assessment system in rehabilitation is long overdue. Common scales used in assessing rehabilitation outcome such as Fugl-Meyer, Barthel Index, Functional Independence Measure, Postural Assessment Scale for Stroke Patients, etc are either fully or partially subjective measures. Such subjective and discrete scales focus on completion of functional tasks and fail to account for an improvement in movement quality that may not necessarily be accompanied by task completion. In this way, such scales are incapable of capturing the true effects of rehabilitation. This will jeopardize the prescription of correct therapies and also de-motivate the patients. This project aims to develop a proof of concept interactive mixed reality system for upper extremities stroke rehabilitation to deliver the three abovementioned objectives.

Rehabilitation of the upper extremities is performed in a mixed reality environment where the images of a patient is captured and integrated into a virtual environment. The patient is able to interact with on-screen objects to participate in game-like rehabilitative activities. These virtual activities are specially designed based on human factors theory and psychology of stroke patients to provide them with fun and motivating experience.

Instead of the classical clinical outcome based approach, this project adopts a system science methodology to quantify motor performance. Precise kinematic and kinetic measurements of the upper extremities performing rehabilitation tasks are measured by a suite of sensors with different sensing modalities (optical sensing, accelerometry and surface electromyography). With these measurements and biomechanical models as scientific bases, a novel objective and accurate assessment method for upper extremity motor recovery will be proposed. The method may also be used to evaluate existing rehabilitation approaches and possibly explore new rehabilitation approaches.

Equipped with more information of the patient’s motor performance and a mixed reality system that allows fine tuning of training parameters to adapt to the progress and subtlety of each patient, medical practitioners are able to have more control over the entire rehabilitation process. We hypothesize that the proposed system will result in better upper extremities rehabilitation outcome than conventional stroke therapy.

The proposed system will have the following important features:
1. A 3D mixed reality interactive environment capable of providing fun and variety through game-like activities to engage and motivate the patient to participate more actively in their prescribed rehabilitation regimes.
2. A collection of scalable low level motor skill exercises and higher level functional tasks in the mixed reality environment with adjustable level of difficulties to customize in accordance to the motor ability of the patients. This gives the therapists more control over the rehabilitation program of the patients. Another advantage is to enable a patient to practice and gain confidence on tasks that are otherwise too difficult or daunting to perform in real life. For example, to practice pouring of water from a jug to a cup. The system captures and displays the images of patient holding a real jug and a real cup in the mixed reality environment, and allows him to practise pouring of virtual water from the jug to the cup without the fear of real spillage.
Virtual spillage of water can be displayed both on the screen and the projection table as a feedback to the user.

3. An objective assessment of the motor performance and motor recovery of the patients. Recorded assessment history of the patients will allow the therapist and doctor to monitor the progress of the patient. A progress report is also an important source of motivation for the patients.

The overall system in the proposed scenario will be based on existing device technologies. One important criterion of the system is to keep the implementation costs affordable for hospitals and community rehabilitation centres.

While this project targets upper extremity stroke rehabilitation, the same methodology may be extended for the lower extremities and other rehabilitation scenarios in the future.

**GRANT:**
$200,000, NTU Peaks of Excellence Initiative Grant, 1 Apr 2011 – 31 Mar 2013.

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**PUBLICATIONS:**

**Refereed Journal (Published/In Press):** Nil.

**Refereed Conference (Published/In Press):** Nil.

**Refereed Conference Poster:** Nil.