Research & Development of Rehabilitation Technology in Singapore

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Assistive Technology

Technologists / Engineers  \rightarrow \text{AT}  \rightarrow \text{PWD & Caregivers}

\text{Healthcare Professionals}

\text{Market: End-users / PWD}
Rehabilitation Technology

Technologists / Engineers → Healthcare Professionals → PWD

Market: Healthcare Professionals
Rehabilitation Robots

Upper Limb Robot

Lower Limb Robot

MIT Manus

Lokomat
Brain-Computer Interface (BCI) & Functional Electrical Stimulations (FES)

G. Pfurtscheller, et al, Austria, 2000
Mixed Reality Rehabilitation

REAL ENVIRONMENT

AUGMENTED REALITY (AR)

AUGMENTED VIRTUALITY (AV)

VIRTUAL ENVIRONMENT

Interactive Rehabilitation and EXercise system (IREX)

Wii-Hab
Rehabilitation R&D Partnerships

Clinicians
- Rehab Physicians
- Therapists
- Nurses

Scientists
- Clinician Scientists
- Neuroscientists
- Motor Control Scientists

Technologists
- Engineers (ME, EE, BioE, IT)
- Computer Scientists
Rehabilitation R&D Project Types

Rehabilitation Practice

- Principal Investigator
  - Usually Clinicians (MBBS, MD, PhD)
- Scope
  - Validate new treatment/protocol with existing technology
  - Clinical trials (Phase 0-2)
- Outcome
  - Publications
  - New treatments, new protocols

Rehabilitation Technology

- Principal Investigator
  - Technologists (PhD) & Clinicians
- Scope
  - New gadget, equipment, system
  - Healthy subject trials
  - Clinical trials (Phase 0)
- Outcome
  - Publications, patents
  - New systems, products, etc.
Rehabilitation R&D Project Types

Clinicians ↔ Scientists ↔ Technologists

- **Principal Investigator**
  - Clinician or Scientist
  - May not involve technologist

- **Scope**
  - Validate new theories, test hypotheses
  - May use off the shelf technologies, e.g. motion capture system
  - Clinical trials

- **Outcome**
  - Publications, new models

- **Principal Investigator**
  - Usually Scientist

- **Scope**
  - Validate new theories, test hypotheses
  - Use new or customized technologies for experiments
  - Healthy subject trials
  - Clinical trials

- **Outcome**
  - Publications, new technological systems, new models
RT R&D Activities in Singapore

- RT Research
- Basic
- Translational
- Development
- Design
- Modification
- Universities
- Research Institutions
- Polytechnics
- Hospital & Community Rehab

Nanyang Technological University
RT R&D Activities in Singapore

**Need / Problem/Qn**
- Healthcare Clinicians
- Clinician Scientists
- Neuroscientists

**Technologies**
- Engineers
- Computer Scientists

**Funding Agencies**
- National Medical Research Council (Ministry of Health)
- A*STAR Science & Engineering Research Council (Min. of Trade & Ind)
  - National Research Foundation (PM Office)
- Academic Research Funding (Min. of Education)
  - Spring Singapore (MTI)
- Institution Internal Funding (MOE/MOH/Reserve)
  - Tote Board / Foundations
Brain Computer Interface

• To use Electroencephalography (EEG) or brain-wave to control devices via a computer

• Synchronous BCI
  – P300: a spike in EEG signal 300ms after an anticipated event occurs
  – Choices are displayed on a computer screen one after another, once a spike in EEG is detected, the choice displayed 300ms ago would be the intended target
Asynchronous BCI

- Movement / imagination of limb movements will invoke self-induced variations of EEG over the motor cortex
- EEG power in the $\mu$ (8-14 Hz) band will attenuate during movement ➔ This change can be used to control a BCI
BCI Research Projects in Singapore

Attention Deficit & Hyperactivity Disorder
RT Innovation Projects in Singapore

Upper limb tracking with MS Kinect + accelerometers with augmented reality game interface

sEMG-driven continuous passive motion (CPM) machine

Wearable Sensors

Pro-Balance™ Balance training & screening machine
RT Research Programme for Stroke Neuro-Rehabilitation

- Joint proposal by Nanyang Technological University, Tan Tock Seng Hospital & Rehabilitation Institute of Chicago, USA
- S$10M, 5 years
- Tripartite research partnership
  - Technologists: NTU
  - Clinicians: TTSH
  - Neuroscientists: RIC
RT Research Programme for Stroke Neuro-Rehabilitation

• Scope: Upper Limb
• Target group: sub-acute stroke patients
• To address key gaps in assessment & intervention for stroke motor recovery / relearning
  – To take a technological approach
  – To be backed empirical evidence & scientific basis
RT Research Programme for Stroke Neuro-Rehabilitation

• Assessment
  – Technology enhanced objective assessment
    • To supplement or replace current assessment scales (Functional outcome scales, e.g. FIM, BI; Neurological deficit scales, e.g. Fugl-Meyer, NIH Stroke Scale)
    • Goals: objectivity, higher resolution, better representation/estimate of true recovery
    • Parameters to measure & study: kinematic parameters, dynamic behaviours in presence of disturbance, compensation strategy
RT Research Programme for Stroke Neuro-Rehabilitation

• Assessment
  – Motor Synergies: adaptability & clinical significance
    • To study how CNS uses redundancy in motor synergies
    • To study the motor synergies and adaptability of stroke subjects when mobility (redundancy) is reduced
    • Quantitative assessment of motor synergies to provide diagnostic and prognostic indicators
RT Research Programme for Stroke Neuro-Rehabilitation

• Intervention
  – Adaptive interface
    • To go beyond games to encourage motivations and engagement of stroke patients
    • To keep patients involved in tasks at the neural level (even with motor inability)
    • To implement adaptive multi-agent interactions (patient, therapist, machines) in relation to the cognitive capacities of patients
    • Use of mixed reality interface & mobile devices
RT Research Programme for Stroke Neuro-Rehabilitation

• Intervention
  – Cognitive Robotic Assistant Therapist
    • UL exoskeleton with modular attachment
    • Adaptable to the dynamics of the patient and will learn from the therapist, to provide ‘assist-as-needed’ therapy tailored to patient-specific needs
    • To use inputs from new assessment methods for adaptation basis
QUESTIONS OR COMMENTS?