A United Front for the UK Assistive and Rehabilitation Robotics Research

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Today’s Presentation

- Brief Introduction to THINKlab & Centre for Rehabilitation and Human Performance
- Example Research Project, GENTLE/S
- Why do we need a united front for assistive and rehabilitation robotics research?
THINK lab – space for innovative research
Centre for Rehabilitation & Human Performance
Facilities: Gait & Human Performance Lab

Mary Seacole Building

This is our principal gait and human performance laboratory and offers a large space (30m x 12m) within which a wide range of activities can be supported.

The lab can also be divided into three separate sections to support parallel activities.

The central area is designed for walking studies and general motion capture. The lab also has isokinetic, ultrasound imaging, treadmill, cycle and rowing facilities plus gas analysis and other human performance measures.

In addition, there is a 30m running track surface along the length of one side of the lab.
The aim of this study is to develop a clinician and patient friendly measurement device that measures posture of post-stroke patients in a clinical environment. The final product will be portable, easy and convenient to use, and suitable for a wide range of patient. Inertial sensors will measure orientation of the head, trunk and pelvis in three dimensions, while a lightweight force plate will measure weight distribution through the buttocks and feet in sitting and standing. Pattern analysis techniques will be used to present results that can be used immediately for clinical decision making.
Healthy Aims, an EU Framework VI project securing over 16M Euro of funding over 4 years for the 26M Euro project. There are 26 partners, including 6 SMEs, across 9 EU countries. These partners have developed a range of medical implants to help the aging population and those with disabilities.

Our role was to develop an FES for the upper limb device to aid reach, grasp & release tasks for post-stroke patients. Salford has been collaborating with Finetech Medical and Odstock Medical to develop and validate software for the control of upper limb FES.
Our team at Salford collaborated with a team in Sheffield to develop a multi-channel, electrode-array based stimulator that addresses the problems with the current single channel technology. The stimulator is to aid walking for post-stroke patients with drop foot.

- We have investigated the effect of the properties of the hydrogel layer that interfaces between the electrode array and the skin, on stimulation selectivity and sensation. We identified that a high resistivity layer improves both stimulation selectivity and reduces sensation felt by the user during stimulation.
- We are developing a technique for rapid searching of the electrode array to identify the optimal virtual electrode (active subset of 64 electrode array) that when stimulated results in appropriate foot motion at low current.
Example Research Project to rationalise the need for a national united front

GENTLE/S Robot Mediated Upper Limb Neuro-rehabilitation system
Living Pulse, Discovery Channel
The Gentle/s consortium

- **Partners**
  - University of Reading, UK - Research and coordination
  - Zenon, Greece - Industrial
  - Trinity College Dublin, Ireland - Clinical
  - TNO Institute of Applied Physics, Netherlands - Research
  - Newcastle University, UK - Research
  - University of Ljubljana, Slovenia - Research
  - Rehab Robotics Ltd, UK - Industrial
  - Virgo, Greece - Industrial
  - Staffordshire University, UK - Research

- **Subcontractors**: Royal Berkshire Hospital, UK - Clinical
Funded by the EU
Framework 5, Quality of Life
KEY ACTION 6: The Ageing Population and disabilities
2.6 M€

A project to evaluate robot mediated therapy in stroke rehabilitation for elderly
Different disciplines and expertise involved

- **User groups**
  - Trial patients, advisory groups, patients’ families
- **Clinicians**
  - Consultants, physiotherapists, occupational therapists
- **Engineers**
  - Control, Mechanics, Biomechanics, Robotics, Design
- **Computer Science and VR experts**
- **Statisticians**
- **Commercialisation experts**
Initial thoughts
First Prototype

- PER-Force 6DOF Robot Manipulator
User requirements

- Workshop with Staffordshire young stroke group, clinicians & engineers

Figures Courtesy of TNO-TPD, Delft, the Netherlands
The system has two chairs for left and right arm patient treatment, which move at the same time on a linear slide. The 1st monitor on a swinging arm is positioned on either side of the patient activity table, for left or right arm treatment by the therapist.

Figure Courtesy of Staffordshire University and RehabRobotic
Gimbal end-effector

GENTLE/S Gimbal Design, courtesy of University of Reading
Royal Berkshire Hospital system, Prototype 2.1
Dublin System, Prototype 2.2
Exercise environments
Pre-Commercial reincarnation
Immersion and motivation

Developments by Virgo, Greece
Interactive and engaging environments
GENTLE/S trial

- 31 hemiplegic subjects, 3+ month past stroke
- 26 to 28 sessions
- Three phases per patient
  - A – Baseline
  - B – Robot (9 sessions)
  - C – Sling suspension (9 sessions)
- Patients were randomised into ABC or ACB groups
Fugl-Meyer outcome measure for one patient in ABC group

Analysis of one subject, Farshid Amirabdollahian
### Summary of results

**Centre** | **Patient** | **Is RMT Slope Greater than SS Slope (RMT>SS)? (1=True;0=False)** | **FM-Approaches** | **MAS** | **Total** | **Month post-stroke**
---|---|---|---|---|---|
| Fl Fl | Fl Ex | Sh Fl | Sh Abd | Sh ExR |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 8 |
| 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 3 | 8 |
| 3 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 5 | 5 |
| 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 4 |
| 5 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 8 |
| 6 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 5 | 4 |
| 7 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 5 |
| 8 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 8 |
| 9 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | 3 |
| 10 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 6 |
| 11 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 5 | 26 |

**Subtotal** | **4** | **4** | **4** | **3** | **3** | **8** | **7** | **1** | **5**

| 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 4 | 5 |
| 2 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 3 | 3 |
| 3 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 3 | 6 |
| 4 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 16 |
| 5 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 6 | 13 |
| 6 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 5 | 10 |
| 7 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 5 | 24 |
| 8 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 33 |
| 9 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 11 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 16 |
| 12 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 16 |
| 13 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 16 |
| 14 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 16 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 16 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 18 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 16 |
| 19 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 16 |
| 20 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 5 | 75 |

**Subtotal** | **13** | **7** | **15** | **10** | **6** | **7** | **0** | **0** | **5**

**Total** | **17** | **11** | **19** | **13** | **10** | **8** | **7** | **1** | **14**

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Results summary, Farshid Amirabdollahian.

Special thanks to GENTLE/S Clinical Partners in Dublin and Reading for providing clinical measurements for this study.
What was learned from it?

- GENTLE/S seems to be able to contribute to recovery 3 months post stroke

Areas for improvement:

- Larger number of patients, improve statistical power
- Early intervention
- Longer exposure
- More function oriented therapies
- Involvement of hand and grasping
- More bio-feedback on how a patient does during a session
- 1 and 2 month post trial assessment
- Double blinding during clinical assessment
- Better design for the study (carry over effects can not be eliminated due to lack of stable baseline)
Wish list continues

- Shaping and motivational therapies
- Device for use at home
- Real-time analysis of the performance
Now the main topic: why a united front?

EPSRC NETWORK FOR ASSISTIVE & REHABILITATION ROBOTICS
Why a network?

- Slow rate of progress
  
  Although safety, robustness and flexibility are improved, price is still a major barrier
- We need to convince industries and users
- Paradox:
  
  Lack of adequate evidence for usefulness => relatively small demand => little funding => lack of adequate evidence
- Multidisciplinary nature of the problem and lack of sufficient linking between different disciplines
- Weak dissemination => inadequate public awareness (industries, governmental bodies, other Universities, international collaborators, users)
Possible solutions

- Stronger multidisciplinary links
- Strong successive chain of usefulness evidence
- Strong dissemination
- Stronger commercialisation

Core members with 300 peer reviewed papers, £16M funding and 48 PhD students, perhaps a more coordinated approach can make the evidence more powerful.
Current Network Members

- University of Salford, Dr Farshid Amirbdollahian (PI), Prof David Howard, Dr Laurence Kenney, Dr Sarah Tyson
- The University of Reading, the Human Robot Interface lab (THRIL) – Prof William Harwin & Mr Rui Loureiro
- The University of Newcastle, Centre for Rehabilitation and Robotics Studies (CREST) - Prof Garth Johnson
- Queen Margaret University – Dr Frederike van Wijck
- Keele University - Dr Anand Pandyan
- NHS Grampian, Aberdeen - Dr Alastair Cozens
- University of Leeds - Prof Bipinchandra Bhakta & Prof Martin Levesly
- University of Bath, Bath Institute of Medical Engineering - Dr Michael Hillman & Prof Roger Orpwood
- Imperial College London - Dr Anthony Bull & Dr Etienne Burdet
- University of East London – Prof Duncan Turner
- Sheffield Hallam University – Prof Gail Mountain
- Southampton University – Dr Jane Burridge, Ann-Marie Hughes, Eric Rogers, Christopher Freeman, Paul Lewin and Paul Chappell
- University of Bristol and University of West of England – Prof Chris Melhuish, Dr Anthony Pipe, Dr Ravi Vaidyanathan, Dr Kevin Foreman & Dr Ailie Turton
- Prof Yu from Staffordshire University on external advisory role
Network Objectives

- A. A united front for the UK’s assistive and rehabilitation robotics research
- B. Website and dissemination
- C. National and international meetings, workshops and conferences
- D. Interdisciplinary project proposals
- E. Resource exchanges
- F. Knowledge transfer
- G. Link with industries, existing networks and initiatives
Network Activities

- 1. Preparation of a short-term and long-term research roadmap
- 2. Production of a website (http://rehabilitationrobotics.net)
- 3. Preparation of at least 4 flagship project proposals during the life of the network
- 4. Organising regular meetings/workshops
- 5. Session sponsorship at ICORR2009 conference
- 6. Visiting scholar programme
- 7. Publication of a series of White Papers
- 8. Attracting new members
- 9. Links with existing networks and initiatives
- 10. Link with existing industries
Establishing these links:

• Linking with HAM UK-Japan network
• Link with FAST-UK
• Link with National Stroke Association, CP and other
• Link with SMART and SMART 2 consortia
• Link with NHS Technology HUB

• Links with regional medical physics groups, teaching hospitals and other clinical entities near each member institute
Thanks for inviting me
Thanks for listening
Any questions?

Special Thanks to Prof Harwin and Dr Nester for providing permission to include this content on the web.