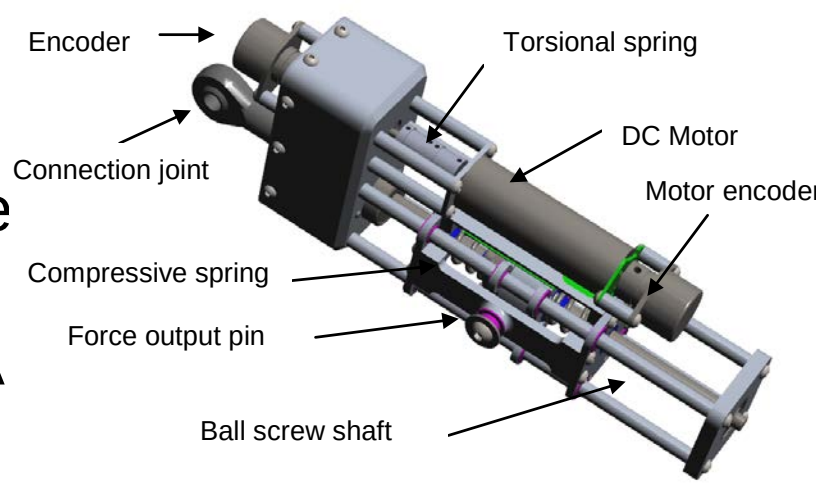
A Novel Compact Compliant Actuator Design for Rehabilitation Robots

H.Yu, S. Huang,N. Thakor, G.Chen, S.L. Toh: National University of Singapore (NUS)
M. STA Cruz, HOPE Technik Pte.Ltd, Singapore
Y. Ghorbel, University of Stuttgart, Germany
C. Zhu, Maebashi Institute of Technology, Japan

- A novel compact compliant actuator design most suitable for rehabilitation robots has been developed
- The actuator achieved both high force control fidelity and high bandwidth, overcoming limitations of current SEA design
- A compact knee ankle robot has been developed with this actuator design

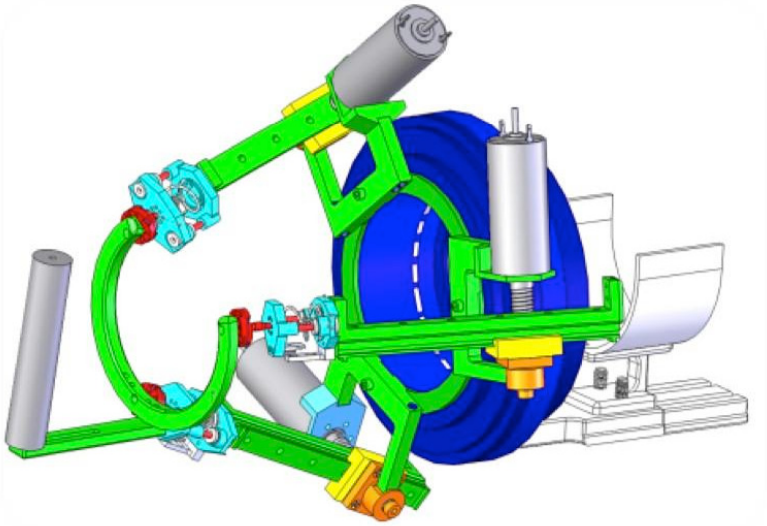


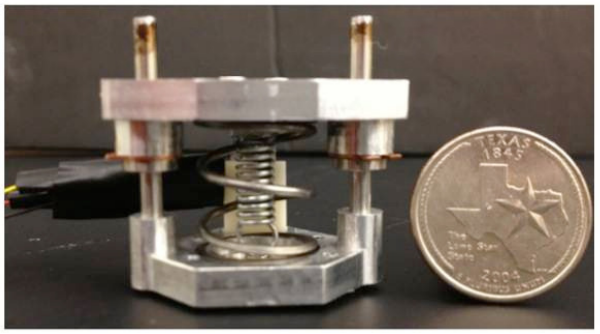
Poster B1

Design of a series elastic actuator for a compliant parallel wrist rehabilitation robot

Fabrizio Sergi, Melissa M. Lee, Marcia K. O'Malley

- Linear series elastic actuator designed to match requirements for wrist rehabilitation robot:
  - Backdriveability
  - Intrinsic compliance
  - Force control
- A force sensing scheme involving a Hall effect sensor shows a 4.5% max nonlinearity and hysteresis
- Accurate and passive force control can be obtained up to 8 Hz.



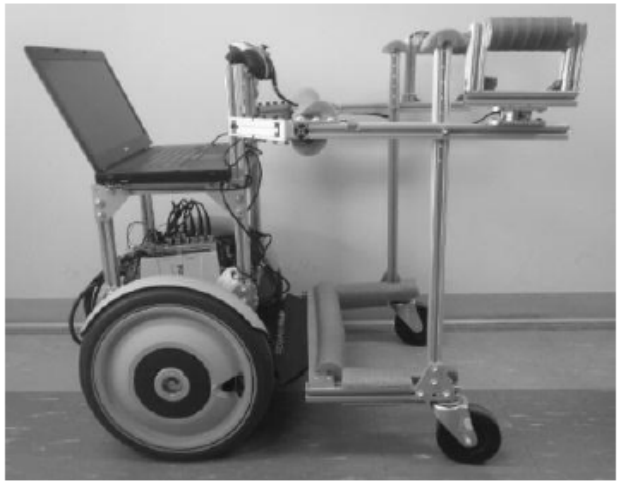


Poster B2

Intelligent Control of a Smart Walker and its Performance Evaluation

Simon L. Grondin and Qingguo Li
Department of Mechanical and Materials Engineering, Queen's University
K7L 3N6, Kingston ON, Canada

- An intuitive rule-based control system for a smart walker was developed and evaluated.
- The novel control system aimed to minimize the interaction force required to operate the smart walker while still accommodating perturbations in force input.
- 10 healthy young adult subjects walked a set course at 1m/s without aid, with a rollator, and with a smart walker controlled by the novel rule-based control system and a well known admittance-based control system.
- The new controller is comparable to the admittance-based controller in the areas of user experience, speed control, interaction force variation, and metabolic requirements.



Smart walker used to evaluate the rule-based control system.

Poster B3

Development and Control of a Lower Extremity Assistive Device (LEAD) for Gait Rehabilitation

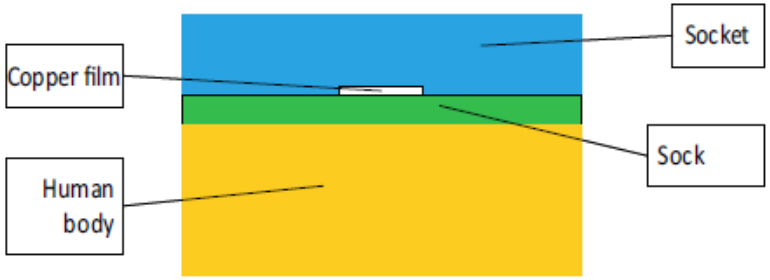
- Developed a wearable lower extremity assistive device.
- Finite state machine controller to drive joints in accordance with user.
- Sub-division of Walking state based on mechanical goals and function
- iEMG shows significantly less muscle effort with assistance.

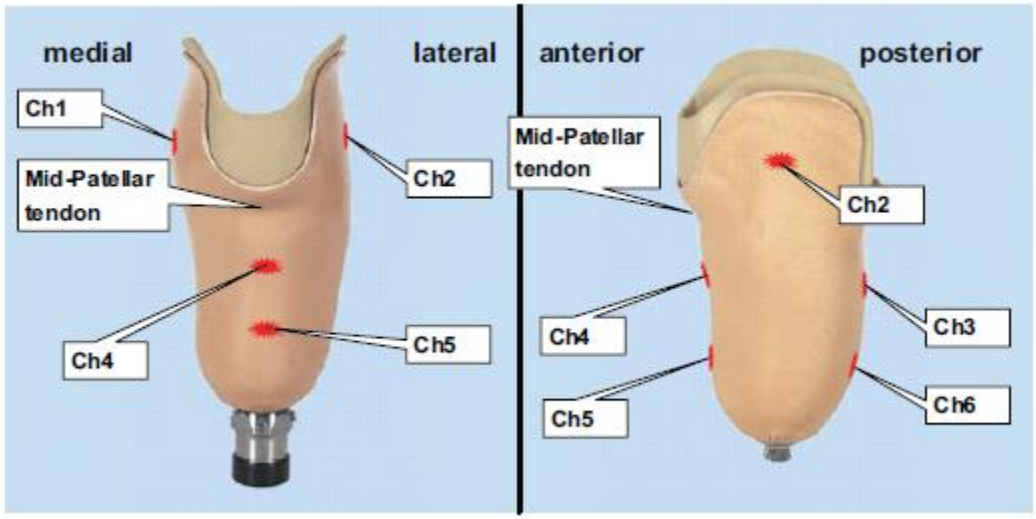
Poster B4

Non-Contact Capacitance Sensing for Continuous Locomotion Mode Recognition: Design Specifications and Experiments with An Amputee

Enhao Zheng, Long Wang, Yimin Luo, Kunlin Wei and Qining Wang
Intelligent Control Laboratory, College of Engineering, Peking University, China
qiningwang@pku.edu.cn

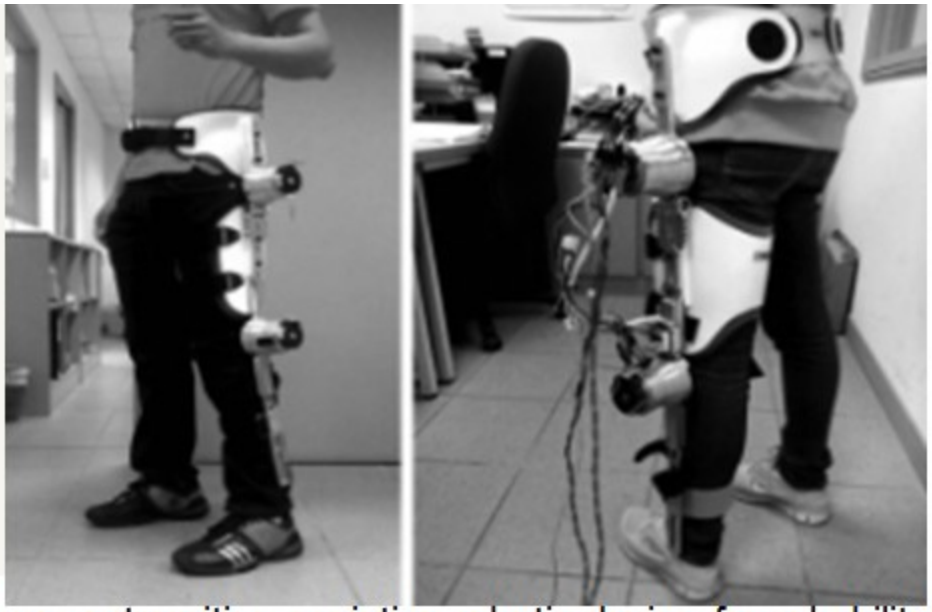
- This paper presents a non-contact capacitance sensing system (C-Sens) to measure the interfacial signals between the residual limb and the prosthetic socket.
- With the continuous phase dependent classification method and the quadratic discriminant analysis (QDA) classifier, the average recognition accuracies are 93.8% and 95.0% for the stance phase and the swing phase respectively.
- The results show the potential of the proposed system for the control of powered lower-limb prostheses.





Poster B5

Muscle Force Estimation Method with Surface EMG for a Lower Extremities Rehabilitation Device

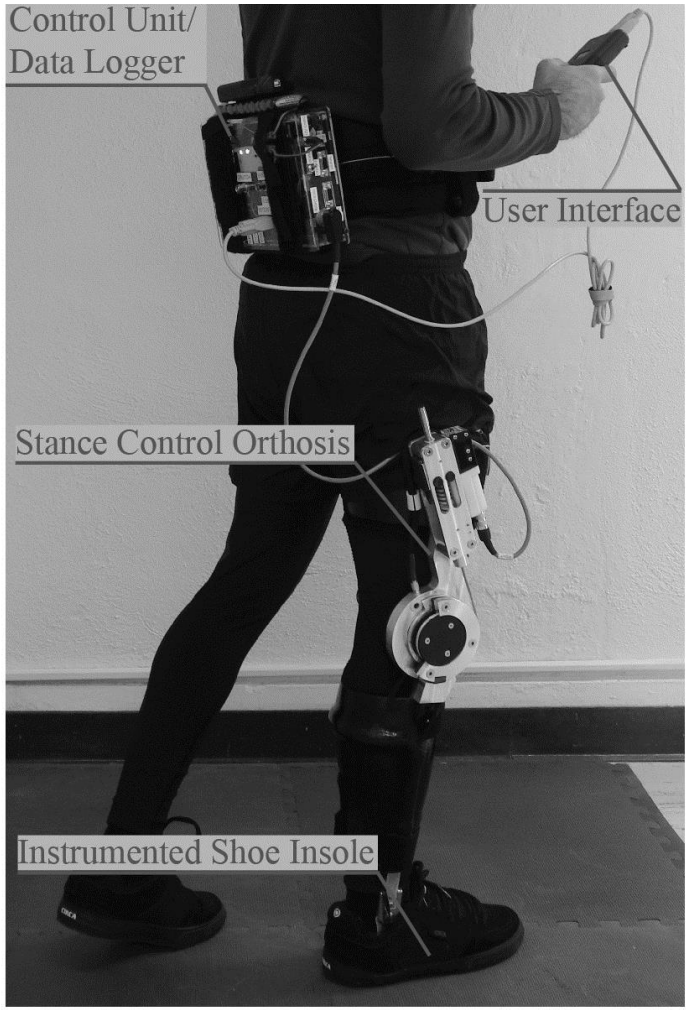


- A new wearable lower extremities assistive robotic device for rehabilitation was developed to provide assistive torque by detecting the user's intention.
- EMG signals were recorded from 10 subjects' hamstring and quadriceps femoris for off-line signal processing.
- The human intention and muscle force/torque were estimated with the proposed CWT-based algorithm. Preliminary force estimation results show high implementation feasibility for the assistive device.
- Implementation on the rehabilitation device and online tests.

Poster B6

A Quasi-Passive Compliant Stance Control Knee-Ankle-Foot Orthosis

- Design and Control of a Quasi-Passive Stance Control Knee-Ankle-Foot Orthosis
- Knee Behaves Close to a Linear Torsional Spring in Stance Phase
- Implement a Spring in Parallel with an Impaired Knee in Stance to Stabilize It
- Allow for Free Motion in the Rest of the Gait
- Size the Spring Based on the User's Stature and Gait Speed



Poster B7

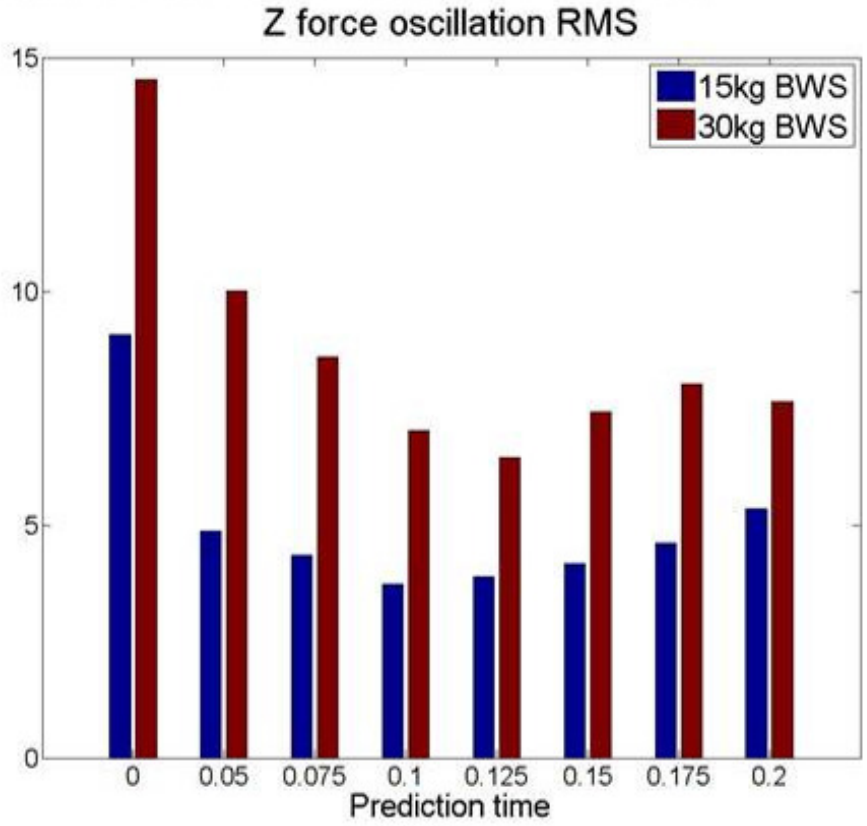

An Egocentric Vision based
Assistive Co-robot
Get what you can see
Human in the loop
Anything is Wireless

Poster B8

Adaptive Position Anticipation in a Support Robot for Overground Gait Training Enhances Transparency

Ch. Everarts, R. Ronsse: Université catholique de Louvain (UCL), Belgium
H.Vallery: ETH Zurich, Switzerland
M.Bolliger: Balgrist University Hospital, University of Zurich, Switzerland

- Transparency of a support robot for overground training was improved by predicting the robot trajectory.
- Robot trajectory was learned with an adaptive oscillator in order to estimate its future evolution.
- Preliminary results illustrate that the method decreased the undesired oscillations of the BWS force by a factor 2.

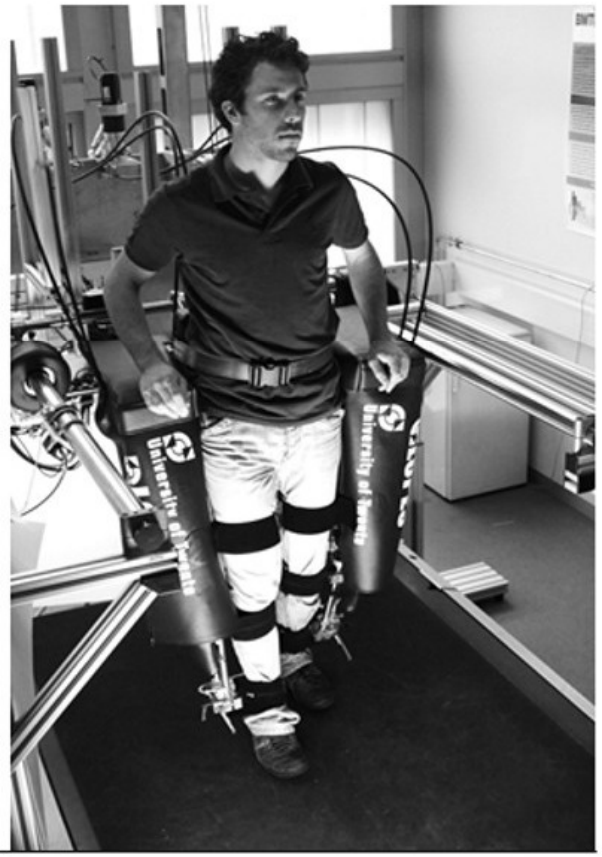


Poster B9

Improving the transparency of a rehabilitation robot by exploiting the cyclic behaviour of walking

W. van Dijk*: Delft University of Technology
B. Koopman*, E.H.F. van Asseldonk, H. van der Kooij: University of Twente
**equal contributors*

- An improved transparent mode for the Lopes rehabilitation robot
- A general framework of adaptive frequency oscillators and kernel based non-linear filters
- Improved tracking by 52%
- Improved transparency: Reduction of undesired human-robot interaction forces by 40%



Poster B10

A Novel Body Weight Support System Extension: Initial Concept and Simulation Study

- Conventional body weight support systems develop lateral forces in the supporting cables.
- These stabilise the human subject and make balance control less challenging.
- A new device is proposed which reduces lateral force development and minimises disturbances to the main body weight support mechanism.
- Simulation results demonstrate that lateral forces are reduced by a factor of eight.

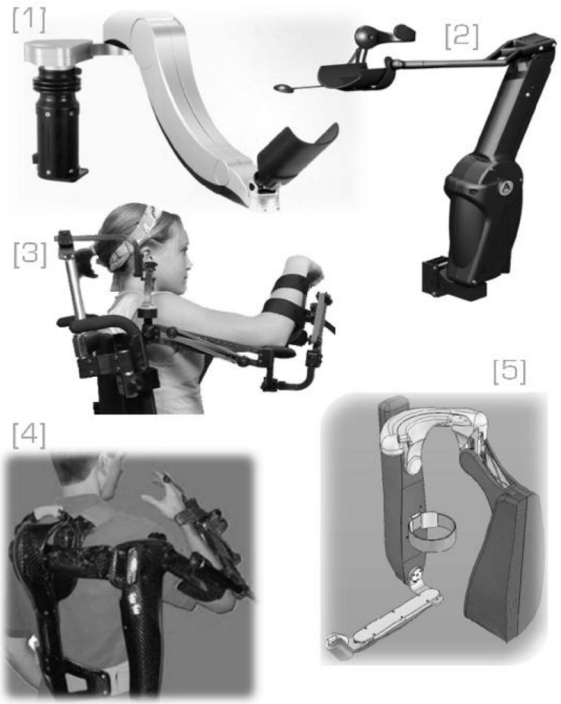
Poster B11

A review of assistive devices for arm balancing

What does the arm support of the future look like?

A.G. Dunning, J.L. Herder: Delft University of Technology, NL

- The wearability and inconspicuousness of passive and wearable active assistive devices were investigated with respect to three evaluation metrics: 1) the interface points with the body, 2) the volume, and 3) the workspace.
- 4 out of 23 devices were wearable and have a relative small amount of volume outside a stated reference volume close to the body; only one is passive.
- To design a passive, wearable, inconspicuous device, do we need an **Evolution** or a **Revolution**?



[1] Darwing, [2] Armon Ayura, [3] WREX, [4] Rupert III, [5] ABLE.

TU Delft Delft University of Technology

FLEXTENSION ORTHOTICS AND INNOVATION

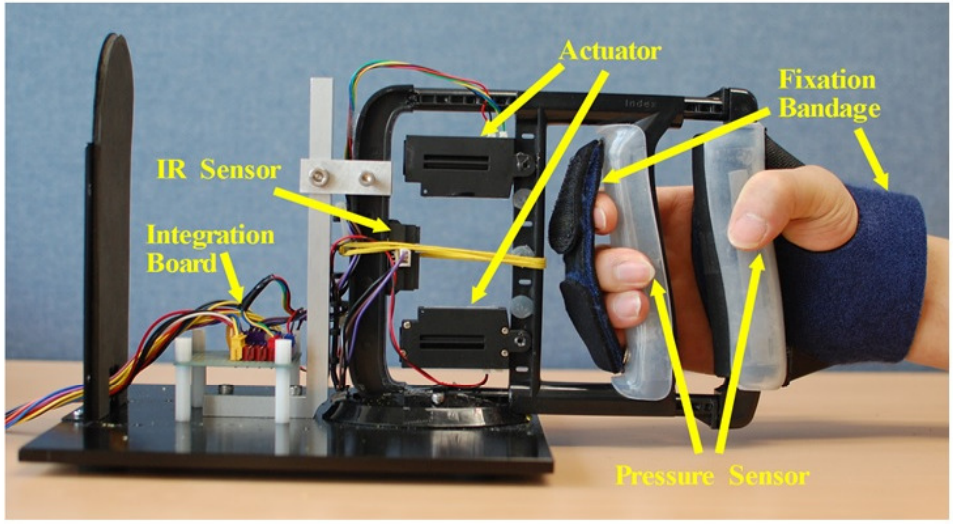
STW Enabling new technology

Poster B12

A Rehabilitation Device to Improve Hand Grasp Function of Stroke Patients using Patient-driven Approach

Wanjoo Park[1,2], Wookjin Jeong[1], Gyu-Hyun Kwon[1], Yun-Hee Kim[3] and Laehyun Kim[1]

[1] Center for Bionics, Korea Institute of Science and Technology, Seoul, Korea
[2] Department of Brain and Cognitive Engineering, Korea University, Seoul, Korea
[3] Department of Physical and Rehabilitation Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea



- The device is designed for stroke patients to train and recover their hand grasp function for activities of daily living (ADL).
- Once the system detects patient's intention by pressure sensor, it triggers the robotic device to move the patient's hand to make the normal grasping behavior.
- Patient-driven mode gives the patients motivation of rehabilitation training and it can be effective in preventing malfunctioned active movement.

Poster B13

Towards Extended Virtual Presence of the Therapist in Stroke Rehabilitation

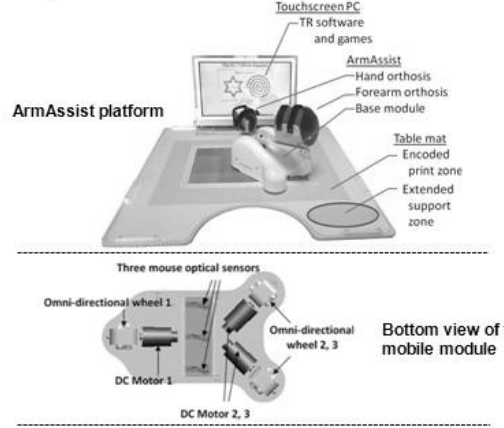
- The concept of 'extended virtual presence' is proposed to extend the therapists' service to remotely located patients.
- A single subject case study is performed to study the feasibility of the concept.
- Results indicate that the therapist is able to gain sufficient proficiency in teleoperating a robot, prescribing well-balanced and challenging tasks/ targets, which is well accepted by the patient and the spouse.

Poster B14

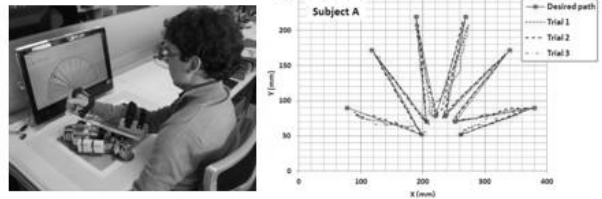
Development of a powered mobile module for the ArmAssist home-based telerehabilitation platform

Je Hyung Jung, David B. Valencia, Cristina Rodríguez-de-Pablo,
Thierry Keller, Joel C. Perry
Rehabilitation Area, Health Division, TECNALIA

- ArmAssist: a system for at-home telerehabilitation of post-stroke arm impairments developed by TECNALIA.
- Motorized ArmAssist mobile module developed, employing 3 DC motors and a position controller.
- Tested in experiments with different load conditions and two unimpaired subjects.
- Result: Acceptable position tracking performance for reaching movement training.



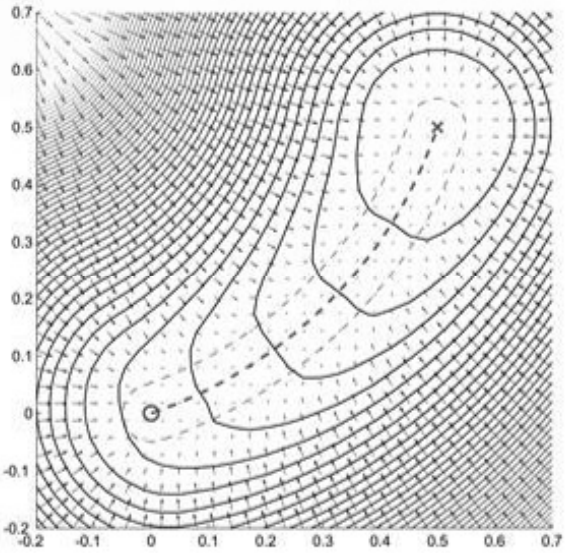
Test result



Poster B15

Assist-as-needed path control for the PASCAL rehabilitation robot

U Keller, G Rauter, R Riener: ETH & University Hospital Zürich, Switzerland



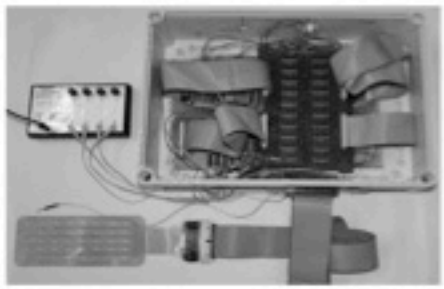
- PASCAL is an end-effector-based robot for combined rehabilitation of arm and legs in children with neurological disorders.
- An assist-as-needed path controller is introduced that supports the arm during reaching movements in space.
- The controller can be adapted to the patient and covers a range from complete guidance to free movement along the path.

Poster B16

Goal Orientated Stroke Rehabilitation Utilising Electrical Stimulation, Iterative Learning and Microsoft Kinect

T Exell, C Freeman, K Meadmore, A-M Hughes, E Hallewell, M Kutlu, J Burridge and E Rogers: University of Southampton, UK

- A rehabilitation system has been developed to improve upper-limb function
- Functional electrical stimulation applied to three muscle groups during reaching tasks
- Microsoft Kinect® incorporated to collect movement data
- Iterative learning control used to update stimulation automatically for each trial
- Initial results indicate performance improvements when using the system

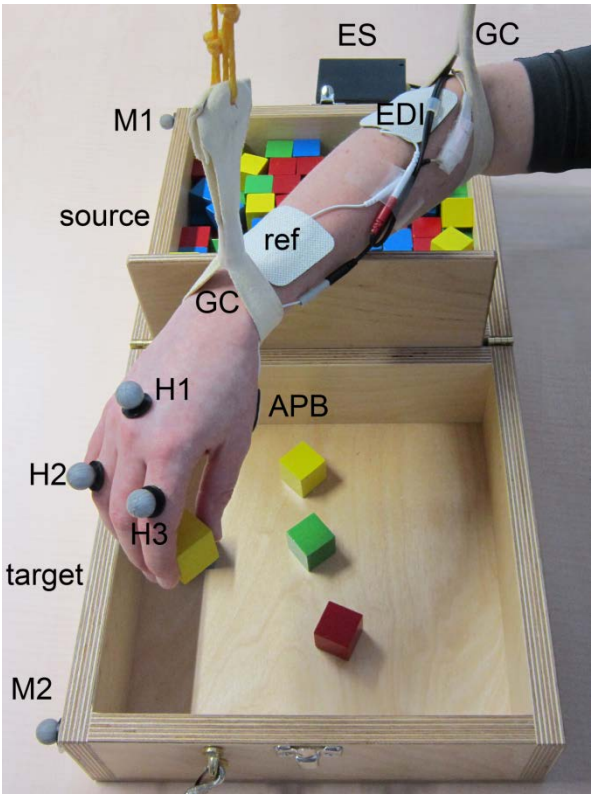


Poster B17

A feasibility study of the effect of multichannel electrical stimulation and gravity compensation on hand function in stroke patients: a pilot study

T. Krabben, MSc; J.H. Buurke, PhD; G.B. Prange, PhD; J.S Rietman, PhD, MD

- A new therapeutic device for post stroke arm/hand training is being developed.
- Effect of gravity compensation (GC) and electrical stimulation (ES) on dexterity was evaluated with Box and Blocks Test.
- Possible to induce sufficient hand opening but no instantaneous improvement of dexterity due to GC and ES.
- More specific and sophisticated control algorithms are needed.



Poster B18

Pulsed assistance: a new paradigm of robot training

D De Santis, L Masia, P Morasso, V Squeri, J Zenzeri: Robotics, Brain and Cognitive Sciences Dept.
Istituto Italiano di Tecnologia Genoa, Italy
M Casadio: DIBRIS, University of Genoa
P Giannoni ART - Education and Rehabilitation Center
A Riva SI4LIFE - Innovation hub for elderly and disabled people Genoa, Italy

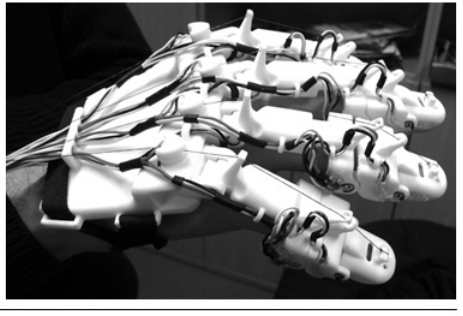
- In this preliminary study we compare continuous with pulsed robot assistance in stroke survivors with the aim of promoting volitional effort and reducing assistance during a reaching task.
- The minimal assistance level is evaluated automatically via the measurement of the average holding force.
- Moreover, we introduce a novel kinematic-based measure to assess voluntary participation of subjects during the rehabilitation task, which is only applicable with pulsed assistance.
- Results show that pulsed assistance allows subjects to reach similar performance levels as compared to continuous assistance after a single training session, in spite of being about half the continuous assistive force level.

Poster B19

Towards a Parameterizable Exoskeleton for Training of Hand Function After Stroke

P Weiss, L Heyer, T Münte, M Heldmann, A Schweikard, E Maehle:
University of Lübeck, Germany

- A novel approach of an actuated exoskeleton for virtual therapy and adaptive motor training after stroke is described
- 3D printing technology allows parameterization of dimensions to adapt the exoskeleton to the patient's hand and prevent misalignment
- The accuracy of Hall effect based angle sensors in the joints and a current limiting circuit for force control are evaluated

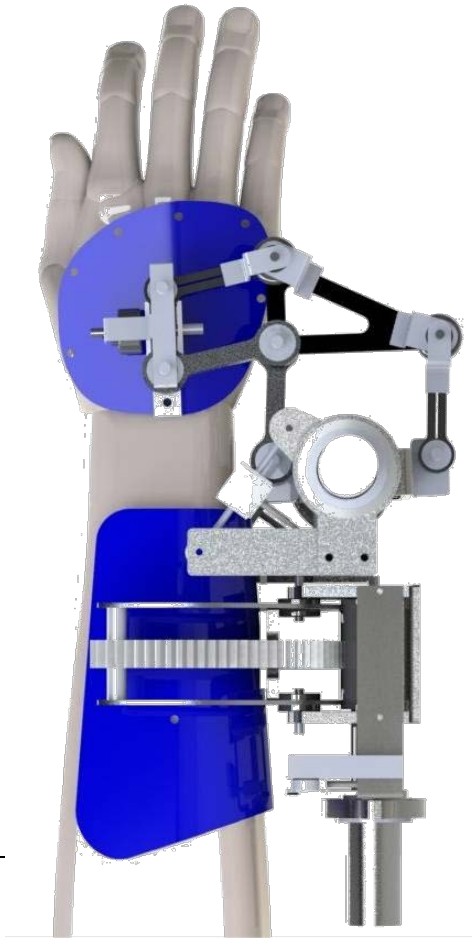


Poster B20

Design of a self-aligning 3-DOF actuated exoskeleton for diagnosis and training of wrist and forearm after stroke

J. Houdijn Beekhuis*, Ard J. Westerveld*, Herman van der Kooij*†, and Arno H.A. Stienen*‡
*Laboratory of Biomechanical Engineering, University of Twente, Enschede, NL
†Biomechanical Engineering, TU Delft, NL
‡Physical Therapy and Human Movement Sciences, Northwestern University, Chicago (IL), USA
Corresponding author: arnostienen@gmail.com

- A novel exoskeleton for wrist and forearm to help post-stroke survivors recover hand function has been developed
- Decoupling of rotations and translations makes the device self-aligning to the wrist's axes
- The device can provide training and diagnostics in the full ROM of Flexion/Extension, Radial/Ulnar-deviation and Pronation/Supination while hand and fingers remain free
- CAD design has been completed and a prototype will provide real-world validation of mechanical and functional properties

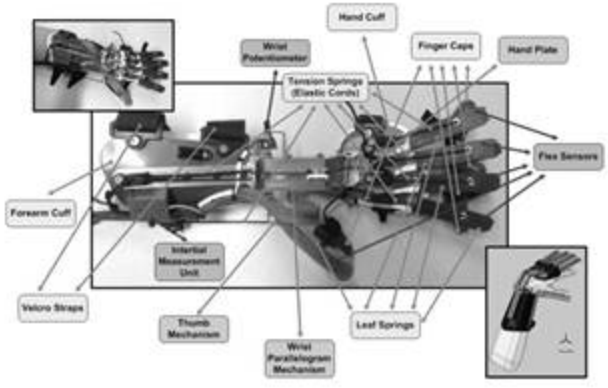


Poster B21

SCRIPT Passive Orthosis: Design and Technical Evaluation of the Wrist and Hand Orthosis for Rehabilitation Training at Home

S Ates, J Lobo-Prat, H Kooij, A Stienen: Univ. of Twente, The Netherlands (UT)
P Lammertse: MOOG B. V., The Netherlands (MOOG)
H Kooij: Delft University of Technology, The Netherlands, (TU Delft)

- A new hand and wrist exoskeleton design, SCRIPT Passive Orthosis (SPO), for the rehabilitation after stroke
- Exercises with the *SPO* train opening/closing of the hand, as well as flexion/extention of the wrist
- Design, technical evaluation and validation of *SPO* which are fulfilling the user requirements are completed.

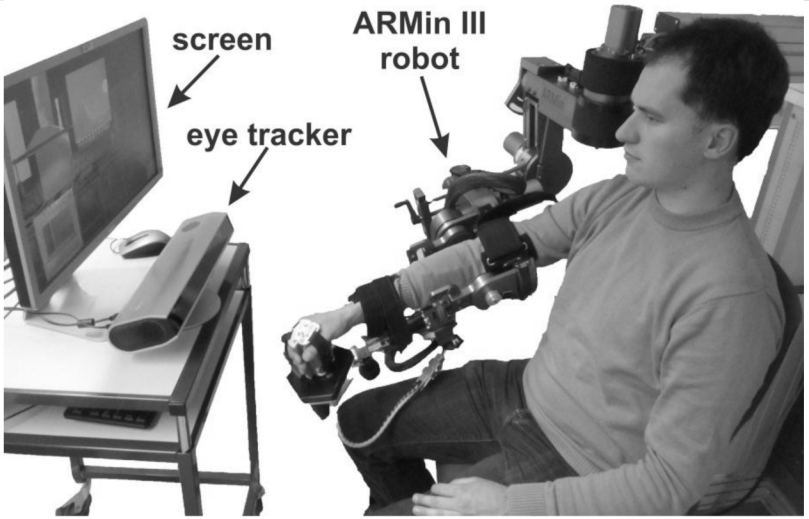


Poster B22

Enhancing Patient Freedom in Rehabilitation Robotics using Gaze-Based Intention Detection

D Novak, R Riener: ETH Zurich, Switzerland

- A ‚virtual kitchen' scenario with many possible patient actions has been developed for the ARMin III robot
- Scenario combined with eye tracker that detects intended action and triggers appropriate robotic support
- Technical feasibility shown, though potential benefits (e.g. increased freedom improving motivation) not yet proven

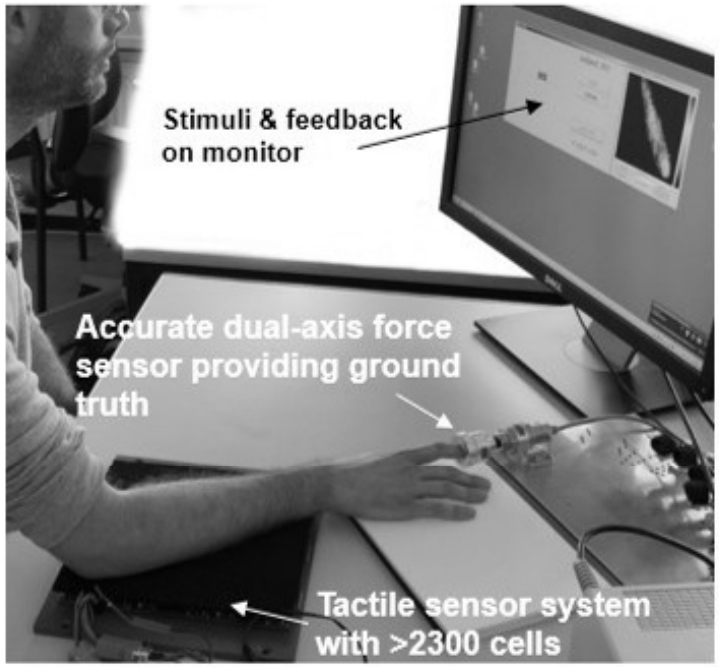


Poster B23

Using a high spatial resolution tactile sensor for intention detection

Claudio Castellini: DLR - German Aerospace Center, Germany
Risto Kõiva: Bielefeld University, Germany

- A new HMI, with the potential to be better than electromyography.
- Our goal is to reliably and naturally enable the disabled to control a robot/computer.
- We investigate the use of a high-resolution tactile sensor to predict finger forces from muscle bulges.
- Experimental results show an average prediction accuracy >98%.



Experimental setup to validate our approach

Poster B24

Whole-arm Tactile Sensing for Beneficial and Acceptable Contact During Robotic Assistance

Phillip M. Grice[1], Marc D. Killpack[1], Advait Jain[2], Sarvagya Vaish[1], Jeffrey Hawke[1], Charles C. Kemp[1]

1. Healthcare Robotics Lab, Georgia Institute of Technology
2. Redwood Robotics

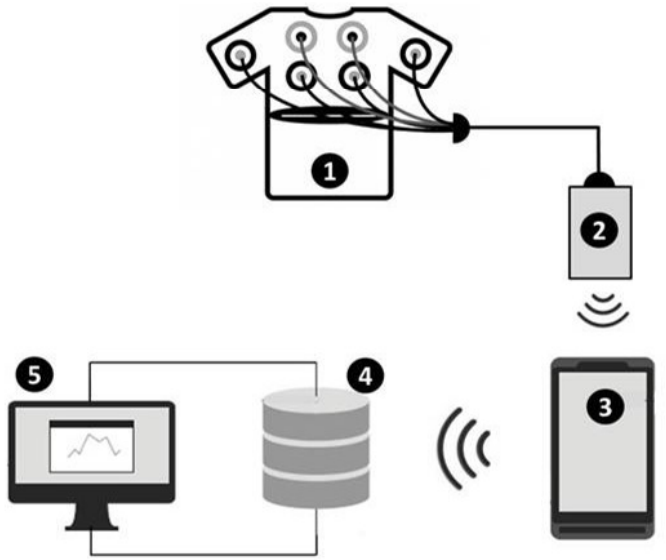
- Avoiding contact through safety margins significantly reduces the reachable workspace of an assistive robot.
- Whole-arm tactile sensing can improve task performance and limit contact forces during assistive tasks.
- Able-bodied users controlling an assistive robot to perform a task around their bodies find physical contact by the robot acceptable.

Poster B25

SQUID: Sensorized Shirt with Smartphone Interface for Exercise Monitoring and Home Rehabilitation

Amir B. Farjadian, Mark L. Sivak, Constantinos Mavroidis
Biomedical Mechatronics Laboratory, Department of Mechanical and Industrial Engineering, College of Engineering, Northeastern University, Boston MA

- Smart shirt to automate home rehabilitation and increase exercise effectiveness,
- Muscle and cardiac activity monitoring,
- Real-time haptic/audiovisual biofeedback,
- Investigating strength/coordination across different muscle groups,
- Proof of the concept experimental results is provided.



Poster B26

Design of a Robotic Mobility System to Promote Socialization in Children

Xi Chen, Christina Ragonesi, James C. Galloway, University of Delaware, USA
Sunil K. Agrawal, Columbia University, USA

- A robotic mobility system has been developed to track multiple moving targets and plan a path to the goal while avoiding moving obstacles.
- Use force-feedback to train children to join the peers in a ball chasing game.
- Results show that all modules functioned well and the system is promising in promoting socialization in children.

Poster B27

A Haptically Enhanced Painting as a Tool for Neurorehabilitation

HH Le, RCV Loureiro, A Zivanovic, MJ Loomes: Middlesex University, UK
F Dussopt: Florian Dussopt Design Studio, UK
N Phillips : Nick Phillips Design Studio, UK

- A new form of interaction combining haptic and sonic exploration with static visual information from a real painting
- Preliminary results suggest approach might be of value to neurorehabilitation by exploring concepts of augmented art works with technology (haptics + sound), promoting social integration and potential use in public spaces.

Poster B28