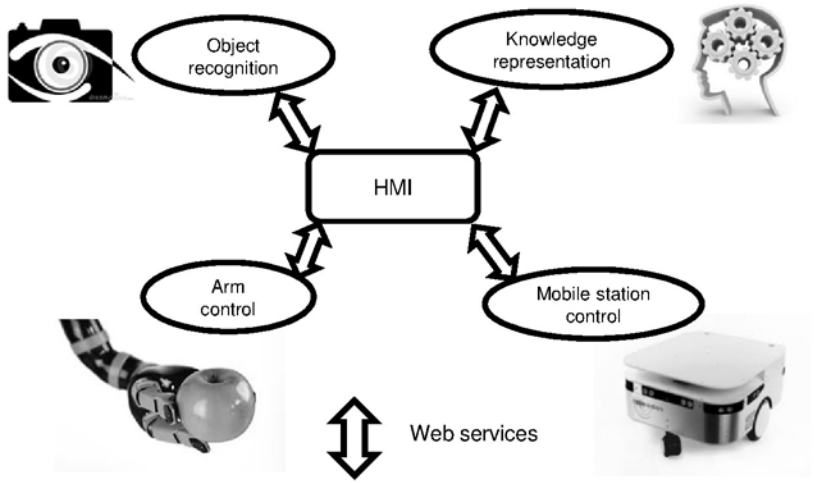
ARMEN PROJECT : BRING INTUITIVE SERVICES TO ASSISTIVE ROBOT SAM

SAM robot :

- *Robulab10 mobile base :*
  - Up to 4m/s
  - Bring 8 hours autonomy to the whole system
- *JACO robotics arm :*
  - Visual servoing control
  - Able to carry up to 1.5kg
- *Easy installation procedure* :
  - no need to define a geometric model of the area nor of the objects to grasp



Previous clinical evaluation of SAM with quadriplegic and elderly people let us reshape services and SAM overall aspect

Web services oriented devices:

- Interoperability
- Platform independent
- Ambient robotics oriented

Devices:

- *Object recognition* : to automatically recognize object in a scene
- *Arm control* : to control low level of the manipulator and enable automatic object grasping
- *Knowledge representation* : to semantically represent the context (through objects in the environment, robot and user)
- *Mobile station control* : to control low level of the mobile base

Intuitive HMI:

- Developed with support of occupational therapists

Usability Test of KNRC Self-Feeder

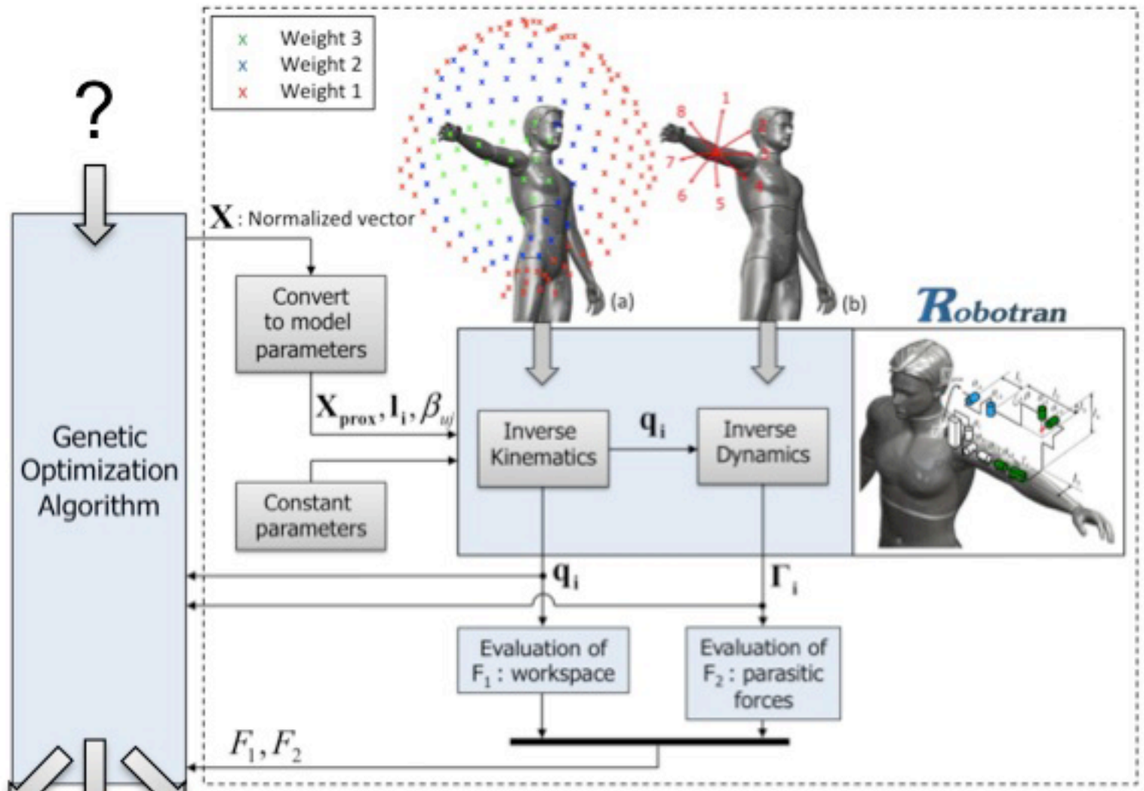
W-K Song, W-J Song, Y Kim, and J Kim: National Rehabilitation Center, Korea

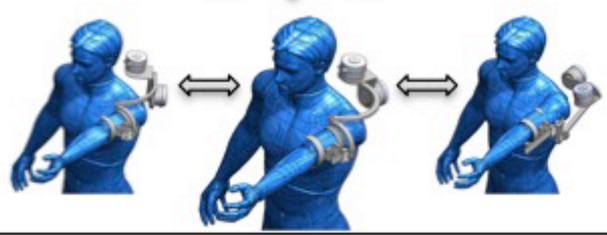
- We present three versions of a novel self-feeding robot (KNRC self-feeding robot), which is suitable for use with Korean food, including sticky rice.
- People with disabilities participated in comparative tests between the KNRC self-feeding robot and a commercialized product.
- The KNRC self-feeding robot showed positive results in relation to satisfaction and performance.

Optimal Design of an Alignment-Free Two-DOF Rehabilitation Robot for the Shoulder Complex

D Galinski, J Sapin, B Dehez: Centre for Research in Mechatronics,
Université catholique de Louvain, Belgium (UCL)

- A model of an alignment-free robot has been used in an optimization process intended to find the best parameters maximizing objective functions
- Three most promising candidates has been selected and compared
- The best candidate outperforms existing designs of alignment-free exoskeleton





Model-Based Safety Analysis of Human-Robot Interactions: the MIRAS Walking Assistance Robot

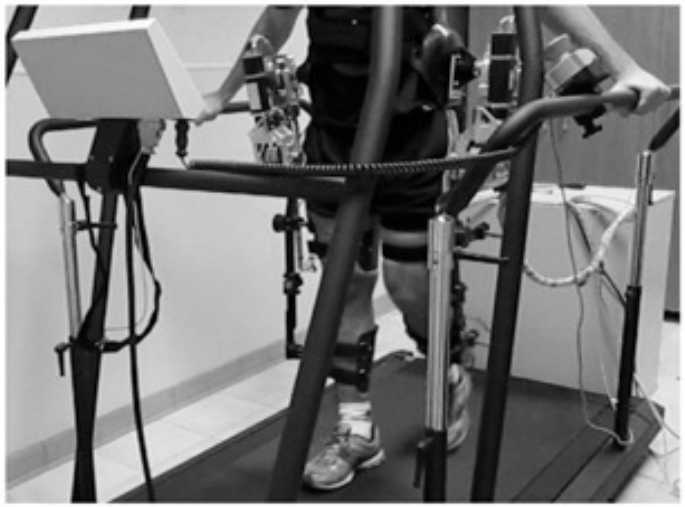
Jérémie GUIOCHET, Quynh Anh DO HOANG,
Mohamed KAANICHE and David POWELL
LAAS-CNRS, Université de Toulouse, France

- Assistive robot for standing up, sitting down and walking, and also capable of health-state monitoring of the patients
- Pragmatic approach to apply risk analysis and build a safety argumentation for certification
- Complete use case from system modeling to clinical trial testing (with agreement of the French regulatory authority)

Human-Robot Interaction Tests on a Novel Robot for Gait Assistance

N L Tagliamonte, G Carpino, D Accoto, E Guglielmelli: Università Campus Bio-Medico di Roma, Italy
F Sergi: Rice University, Texas

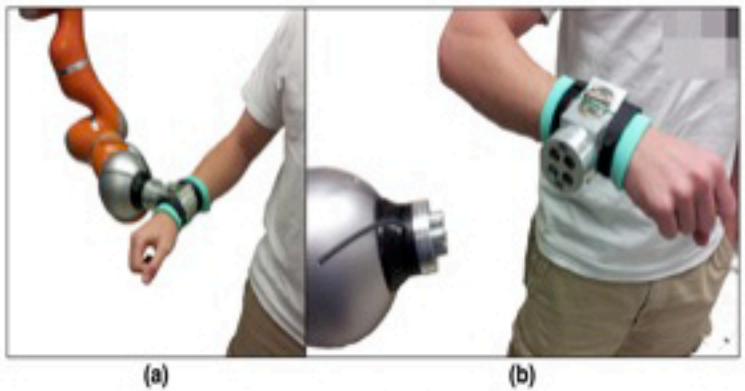
- Tests on a treadmill-based non-anthropomorphic robot for gait assistance were performed
- A healthy young subject walked with the robot unpowered and in assistance mode
- High intrinsic backdrivability was found and the capability of providing adaptive assistance was proved

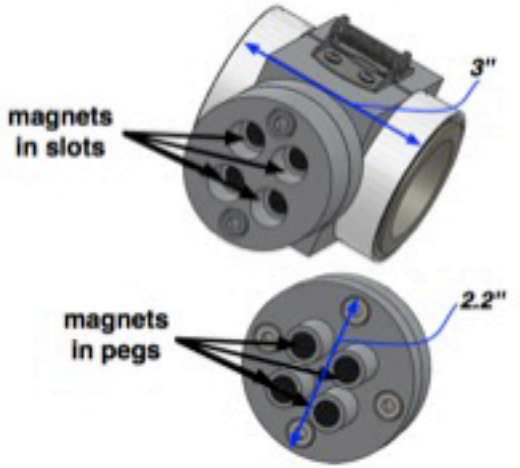


An intrinsically safe mechanism for physically coupling humans with robots

Gerald O'Neill, Harshil Patel and Panagiotis Artemiadis
Arizona State University

- We present the design and verification of a novel mechanism for physically coupling humans and robots.
- The proposed device is intrinsically safe.
- Its re-configurable nature allows for easy and consistent adjustment of the decoupling force.
- Its applicable to a wide range of human-robot coupling applications, ranging from low-force rehabilitation-therapy scenarios to high-force augmentation cases.

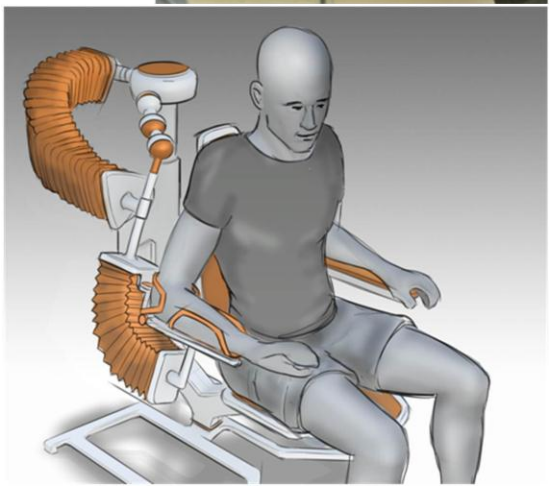




Adaptive Model-Based Assistive Control for Pneumatic Direct Driven Soft Rehabilitation Robots

André Wilkening and Oleg Ivlev: Friedrich-Wilhelm-Bessel-Institute Research Company (FWBI) and University of Bremen, Institute of Automation (IAT), Germany

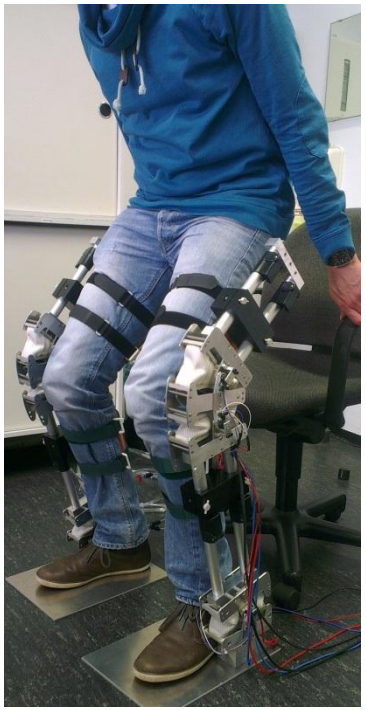
- Soft pneumatic REC-actuators are very suitable to develop assistive direct driven soft rehabilitation robots.
- For such robots two adaptive model-based assistive controllers without using force/torque sensors have been developed and tested.
- Advantages and disadvantages of both controllers are compared for healthy subjects using a prototype of soft-robot for elbow training.



Human-Robot-Interaction Control for Orthoses with Pneumatic Soft-Actuators – Concept an Initial Trials

D Baiden: FWBI Research Institute and University of Bremen, Germany
O Ivlev: FWBI Research Institute and University of Bremen, Germany

- A concept for human-robot-interaction control for robots with soft-actuators has been developed for hemiplegic stoke patients
- Using a 2 DOF exoskeleton robot the control strategy has been implemented on example of sit-to-stand training and tested with several able-bodied subjects
- Preliminary results illustrate the potential of safe and supportive interaction



Development of an orthosis for walking assistance using pneumatic artificial muscle

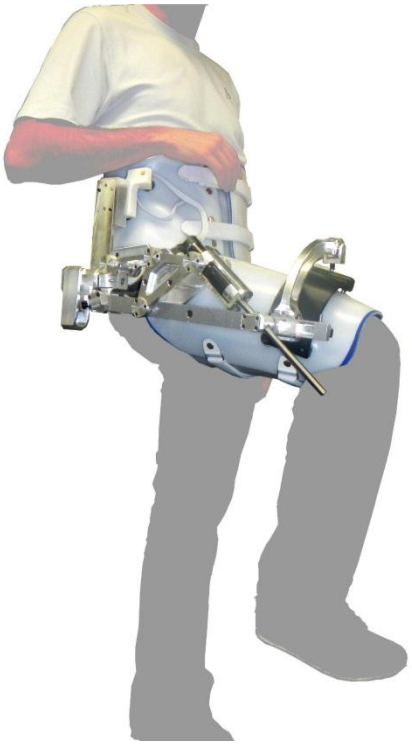
Takuma Kawamura, K. Takanaka,
T. Nakamura and H. Osumi: Chuo University, Japan

- This orthosis encourage people with a slight gait disorder to walk with expanded step length and improve their walking abilities
- Straight-fiber pneumatic artificial muscle performs flexible assistance with simple configuration
- Experiment with healthy subject shows increased step length and declined some EMG by the assistance

Development of an Assistive Motorized Hip Orthosis

J Olivier, M Bouri, A Ortlieb, H Bleuler, R Clavel:
Swiss Federal Institute of Technology Lausanne, Switzerland (EPFL)

- A motorized hip orthosis has been developed to help elderly people walking and/or standing up
- A mechanism inspired by excavator enables a varying transmission ratio in order to fit walking and sit-to-stand transitions requirements
- Preliminary results validate the capabilities of the device



A New Powered Orthosis with Hip and Ankle Linkage for Paraplegics Walking

Chikara Nagai, Shinnosuke Hisada, Goro Obinata
: Graduate School of Engineering, Nagoya University, Japan
Eiichi Genda: Orthopaedics, Minami Seikyo Hospital, Nagoya, Japan

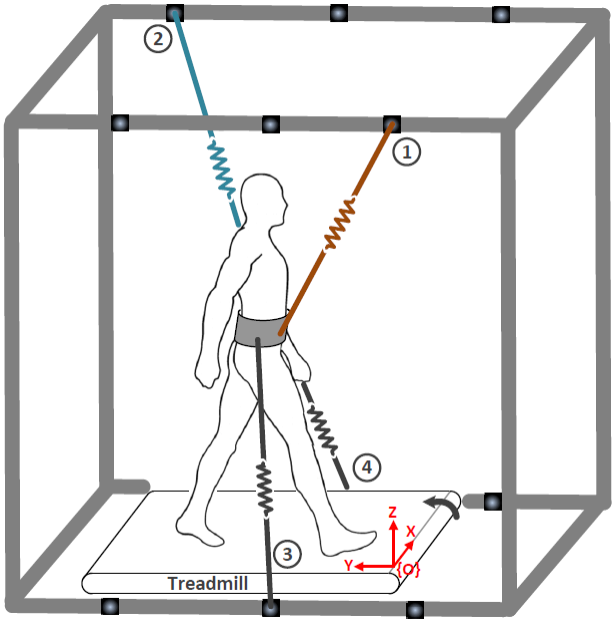
- Standing and walking provide much benefit for paraplegics.
- Hip and ankle linked orthosis (HALO) is one of compact orthoses, which seeks to achieve energy efficient walking and user friendliness on its don/doff.
- Introduce a power assistive idea into the HALO to achieve more energy efficient walking.
- Preliminary results showed the smoother movements of walking were achieved and the reduction of consumption energy can be expected.

Power assisted HALO system

Asymmetric Adaptation in Human Walking using the Tethered Pelvic Assist Device (TPAD)

V Vashista, S.K. Agrawal: Columbia University, USA
D.S. Reisman: University of Delaware, USA

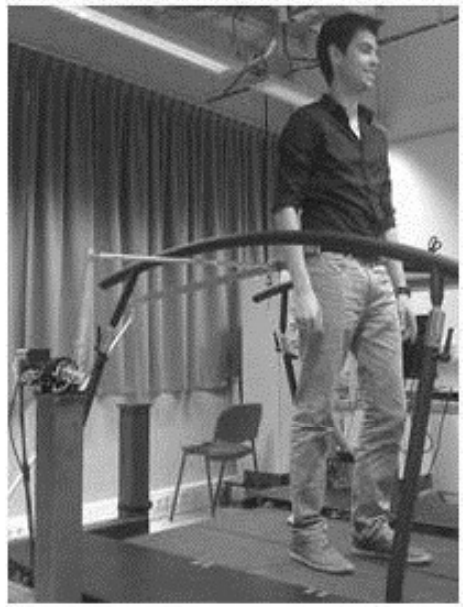
- An experimental paradigm has been developed to study the asymmetric adaptation in healthy humans.
- The Tethered Pelvic Assist Device (TPAD) was used to induce gait asymmetry by applying asymmetric forces on the human pelvis.
- TPAD can address subject specific gait needs by applying force and moment on the pelvis both in magnitude and direction.
- Results showed that the subjects adapted their gait parameters to distribute the anterior-posterior force component more symmetrically over the gait cycle.



Lateral balance control for robotic gait training.

B. Koopman, J.H. Meuleman, E.H.F. van Asseldonk, H van der Kooij
University of Twente

- Lateral balance support based on deviation from a healthy reference pelvis movement
- Direct control of the extrapolated center of mass

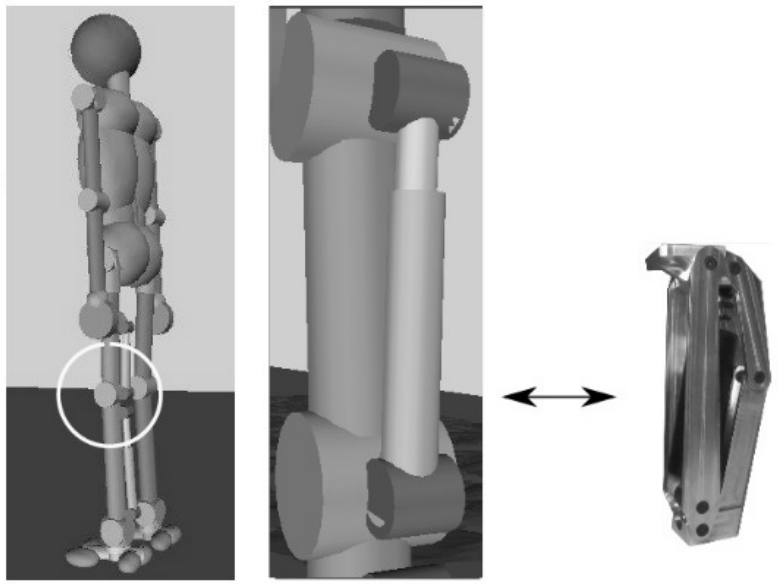


- Lateral balance support reduces step width
- Lateral balance support reduces step width variability

Design of Variable-Damping Control for Prosthetic Knee based on a Simulated Biped

Jie Zhao, Karsten Berns : TU Kaiserslautern, Germany
Roberto S. Baptista, Antonio P.L. Bó: Universidade de Brasilia, Brazil

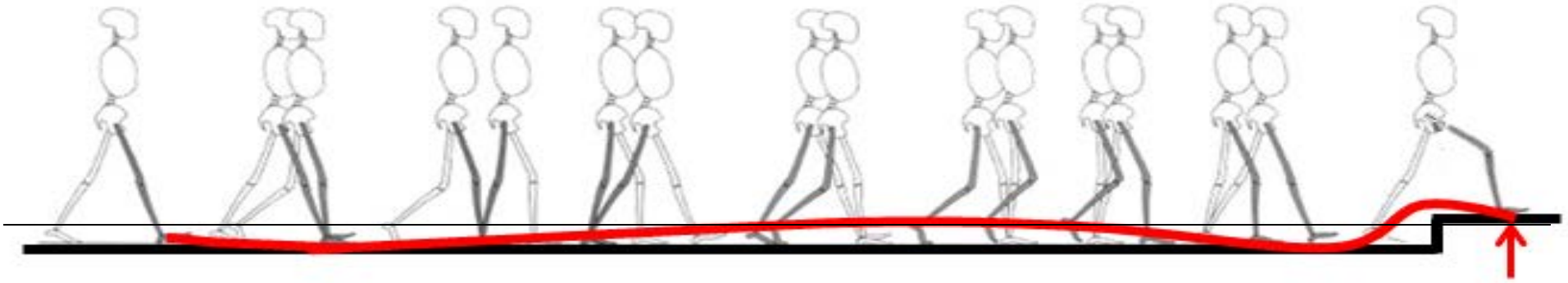
- Simulated Biped with human-like features, used for biomechanical analysis and damping profile extraction.
- Two versions: one represents a healthy subject, the other a prosthesis user.
- Simulation in different scenarios: flat surface and rough terrain, indicate positve performance of the variable-damping controller for the prosthesis.



Gait Mode Recognition and Control for a Portable-Powered Ankle-Foot Orthosis

Yifan David Li : University of Illinois at Urbana Champaign
Elizabeth Hsiao-Wecksler: University of Illinois at Urbana Champaign

- An IMU based 3D motion tracking algorithm was developed to track the position of the PPAFO during level, stair and ramp walking activities
- Actuation was controlled based on the functional needs of different gait modes
- Results showed the proper actuation control with gait mode recognition can better restore the kinematic and kinetic patterns compared to normal people

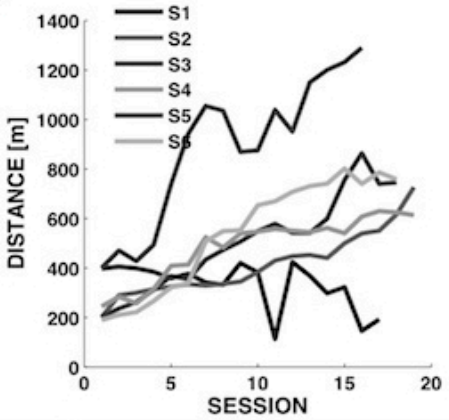


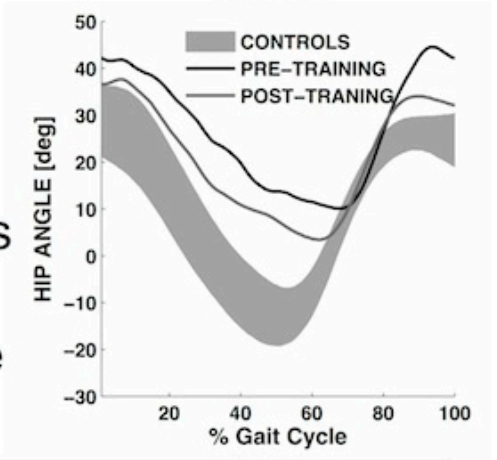
Functional Evaluation of Robot End-point Assisted Gait re-Education in Chronic Stroke Survivors

A. De Luca, C. Lentino, H. Vernetti, Robotics Rehabilitation Team, and G. A. Checchia,
Santa Corona Hospital, ASL 2, Pietra Ligure, Italy
P. Giannoni, ART Rehabilitation Center, Genova, Italy
P. Morasso, RBCS, Istituto Italino di Tecnologia, Genova, Italy
M. Casadio, DIBRIS, Università di Genova, Genova, Italy

We trained 6 chronic stroke survivors for up to 20 session with an-endpoint robot, progressively increasing the exercise difficulty. By using instrumented gait analysis, we found the following outcomes:

- self placed walking speed increases, with an improvement of both length and duration of the stride
- balance increases during standing and walking
- the non-affected side (see bottom figure) becomes less involved in attempting to correct for the deficiencies of the affected side, thus reducing the importance of compensatory strategies

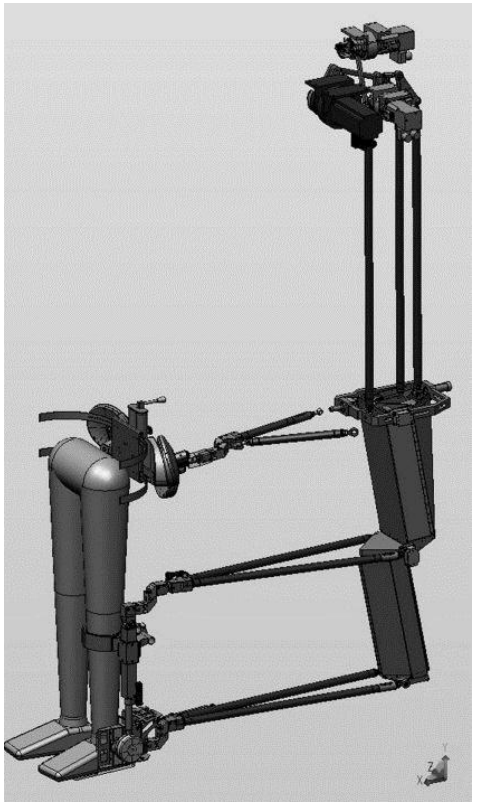




Novel actuation design of a gait trainer with shadow leg approach

J osMeuleman: Moog B.V. The Netherlands
Jos Meuleman, Edwin H.F. van Asseldonk, Herman van der Kooij
Department of Biomechanical Engineering
University of Twente

- A gait trainer has been developed that requires minimum adjustment and alignment and allows for arm swing
- Actuators are on thigh and shank, safety stops on knee extension
- Nonlinear kinematics between joints and actuators have been calculated
- Normal gait is possible for patients various stature lengths



Brief Biomechanical Analysis on the Walking of Spinal Cord Injury Patients with a Lower Limb Exoskeleton Robot

J. Y. Jung, H. Park: Korea Institute of Industrial Technology, Korea (KITECH)
H. D. Yang, M. G. Chae, University of Science and Technology, Korea (UST)

- The result of a brief biomechanical analysis on the walking of SCI patients with a lower limb exoskeleton robot is presented
- There are several differences on the walking of SCI patients with ROBIN-P1 comparing to the walking of normal.
- Exact analysis about the result of functional replacement by a lower limb exoskeleton robot is helpful to improve the walking of SCI patients.

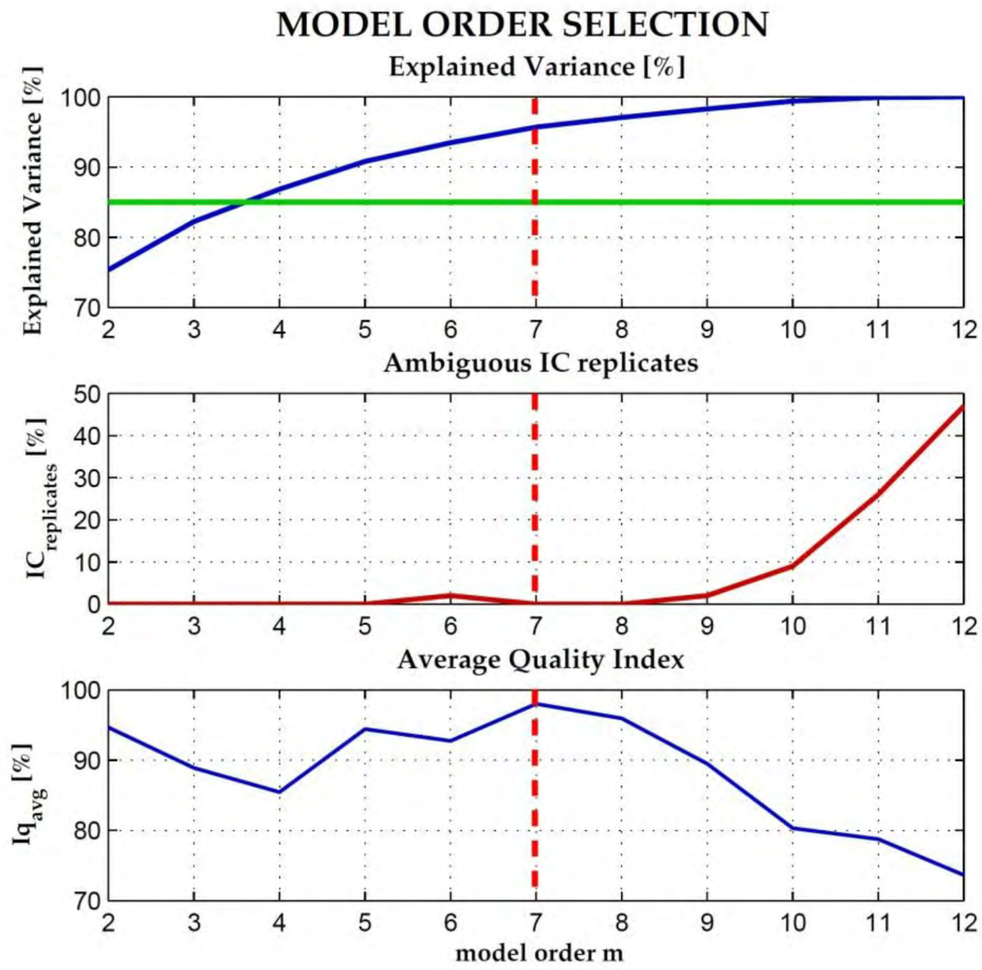
<ROBIN-P1>

Selecting the best number of synergies in gait: preliminary results on young and elderly people

- A new set of criteria, based on Independent Component Analysis, was developed to determine the number of synergies to extract from a multivariate EMG dataset.

- The methods have been applied on EMG signals acquired from 12 leg muscles during walking at different cadences (40, 60, ..., 140 strides per minute) in young and elderly subjects to study whether aging and cadence modify the number of underlying synergies

- Caution on the preprocessing is advised as it alters the number of synergies. The results suggest that the walking pattern is more stable at central cadences. The criteria proposed are not always conclusive but are robust to noise and can be used with other factorization algorithms

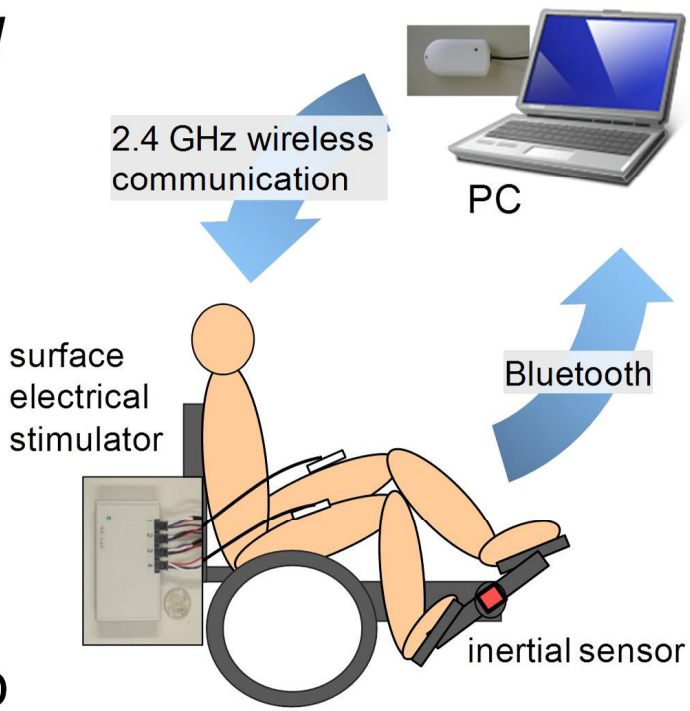


- The proposed method could serve as a guideline to scientists in the evaluation of walking performance.

Preliminary Tests of a Prototype FES Control System for Cycling Wheelchair Rehabilitation

T Watanabe, T Murakami: Grad. Sch. Biomed. Eng., Tohoku University, Japan
Y Handa: Tohoku University Grad. Sch. Medicine, Japan

- A prototype FES control system for *Cycling Wheelchair rehabilitation* was developed and tested with healthy subjects
- Stimulation pattern using the quadriceps and the gluteus maximus was effective to propel the *Profhand*
- It was suggested that stimulation timing considering delay in muscle response and cycling speed would be effective in order to improve FES cycling



cycling wheelchair "Profhand"

Dynamic arm supports

Overview and categorization of dynamic arm supports for people with decreased arm function

Loek van der Heide: Zuyd University of Applied Sciences (The Netherlands)

- Assistive devices that facilitate arm function in daily life.
- 70 years of development
- We found 97 devices
- We categorized them
- Robotics: 1/6 commercially available

Design of a perfect balance system for active upper-extremity exoskeletons

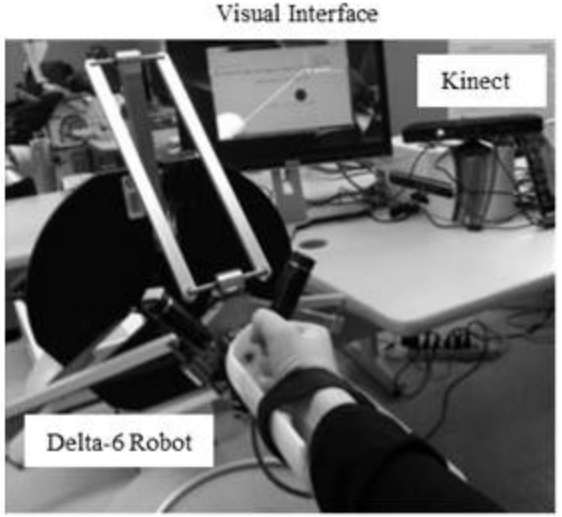
Richard L. Smith, Joan Lobo-Prat, Herman van der Kooij and Arno H.A. Stienen
Dept. Biomechanical Engineering, University of Twente, The Netherlands (UT)

- Passive methods for gravity compensation offer considerable advantages over conventional active methods
- The proposed passive system is well suited for providing compensation forces to support the combined weight of the robot and of the patient's arm.
- The mechanism follows the natural rotations of the human arm.

Using the Kinect to Limit Abnormal Kinematics and Compensation Strategies During Therapy with End Effector Robots

EB Brokaw: The University of Pittsburgh, USA
PS Lum: The Catholic University of America and National Rehabilitation Hospital, USA
RA Cooper: The Department of Veteran Affairs and The University of Pittsburgh, USA
BR Brewer: The University of Pittsburgh, USA

- Commonly used training methods with end effector robots allow abnormal kinematics and compensation strategies that may limit recovery.
- Limb and trunk measurements from the Kinect can be used to control path progression and provide joint space haptic feedback.
- This provides a cost effective solution to improve the quality of training movements with end effector robots.



Performance based upper extremity training: a pilot study evaluation with the GENTLE/A rehabilitation system

R Chemuturi, F Amirabdollahian, K Dautenhahn,
Adaptive Systems Research Group, University of Hertfordshire, UK

- A performance based adaptive training algorithm implemented on the GENTLE/A rehabilitation system was tested with healthy participants.
- The algorithm alters the task difficulty level based on the performance of the user.
- Pilot study results show that the system indeed tuned the task difficulty level based on user's performance and deserves further investigations with greater number of participants.

University of Hertfordshire

Electrical Stimulation and Iterative Learning Control for Functional Recovery in the Upper Limb Post-Stroke

K Meadmore, T Exell, E Hallewell, C Freeman, A-M Hughes, M Kutlu, J Burridge, and E Rogers

- A stroke rehabilitation system for the upper limb
- Electrical stimulation system assists performance of goal-orientated tasks
- Advanced ‘iterative learning control’ algorithms mediate the electrical stimulation provided to improve performance
- Improvements in performance and reduction in motor impairment demonstrate the potential of this system for stroke rehabilitation.

Passive-type Rehabilitation System for Upper Limbs Which Can Display the Exact Resistance Force in the Orientation Opposite to Hand Motion

Makoto Haraguchi, Junji Furusho: Fukui University of Technology, Japan

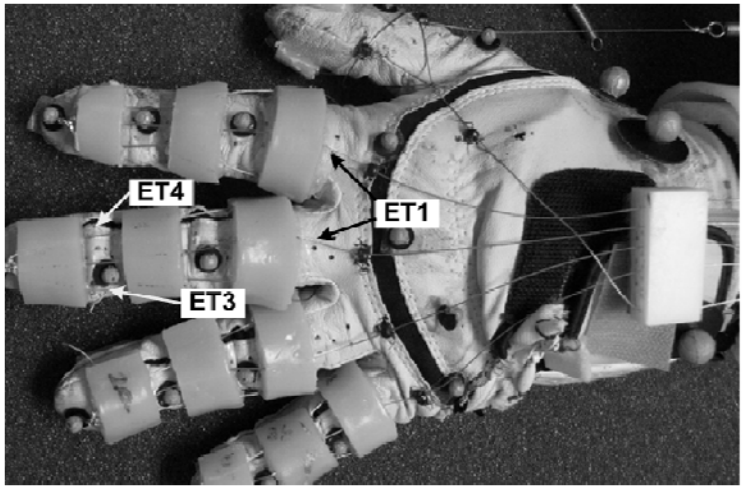
- We have developed a passive-type (unactuated) rehabilitation system for upper limbs.
- This system can display the resistance force in the orientation opposite to operator's motion.
- We have also developed training software in order to improve coordination of movement with this system.

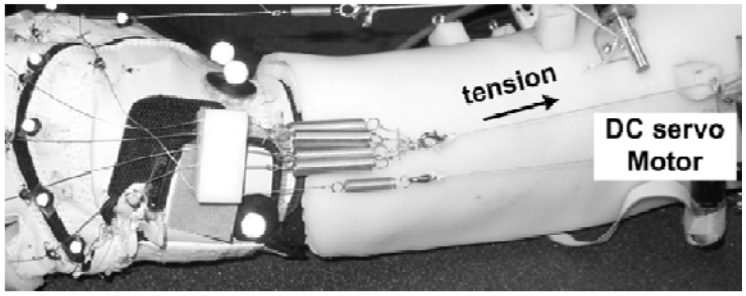
BIOMimetic Hand Exotendon Device (BIOMHED) for Functional Hand Rehabilitation in Stroke

SW Lee, K Landers: Catholic University of America, USA (CUA)
H-S Park: National Institutes of Health, USA (NIH)

- A biomimetic hand rehabilitation device that enables functional hand movements (e.g.: power grip and pinch)
- Fingers are driven by exotendons actuated by remotely located actuators

  (not being bulky at hand)
- Fingers are moved by four exotendons that mimics major intrinsic/extrinsic muscle tendons at the hand.
- Preliminary results illustrate that the device enables functional task-oriented training during hand rehabilitation.





THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Fine Finger Motor Skill Training with Exoskeleton Robotic Hand in Chronic Stroke

Corinna Ockenfeld, Raymond K.Y. Tong*, Evan .A. Susanto, Sze-Kit Ho and Xiao-ling Hu
Interdisciplinary Division of Biomedical Engineering, Hong Kong Polytechnic University, Hong Kong
*Corresponding author's email: k.y.tong@polyu.edu.hk

Training Design

- **Individual Finger Flexion and Extension**
- **Finger Coordination**
- **Natural Grasping Functions**
- **Task Specific Training**

20 Sessions of

- **Full-Hand-Grasping**
- **Three-Finger-Pinch**
- **Pincer-Grip**

→ **20mins**

- **Physical Therapy Training**

→ **25mins**

Outcomes

- **Reduce Muscle Co-Contraction**
- **Increase Isolation of Individual Fingers**
- **Improve Motor Function (Fugl-Meyer, ARAT)**
- **Increase Motor Strength**