Rehabilitation robots on the rise

International ERC & Bejczy Day 2017

March 3, 2017
Budapest, Hungary

Jan Veneman

IISART
International Industry Society in Advanced Rehabilitation Technology

BALANCE
Balance Augmentation in Locomotion, through Anticipative, Natural and Cooperative control of Exoskeletons.

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TECNALIA is a non-profit Research and Technology Organization (RTO)

- leading private R+D+i entity in Spain
- 5th largest in Europe
- More than 1,400 employees
- Annual turnover of approximately 110 million Euros and over 4.000 clients.
- Large activity in FP7&H2020

Link research to business

Organised in 7 Divisions

1. SUSTAINABLE CONSTRUCTION
2. ENERGY AND ENVIRONMENT
3. INNOVATION STRATEGIES
4. ICT-EUROPEAN SOFTWARE INSTITUTE
5. INDUSTRY AND TRANSPORT
6. HEALTH
7. TECHNOLOGICAL SERVICES

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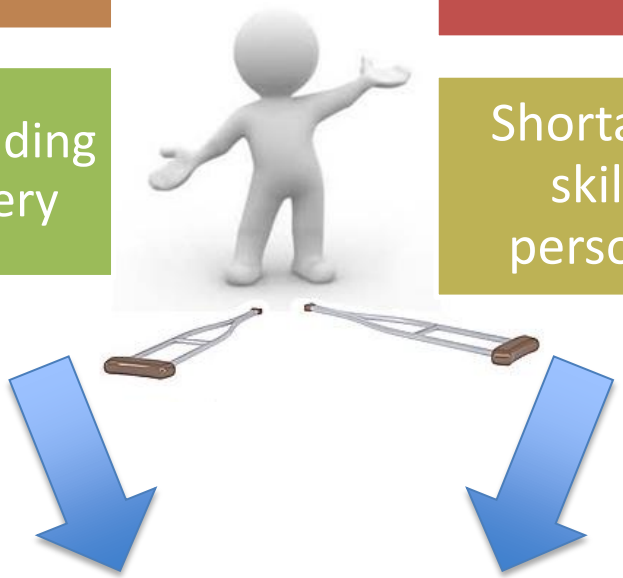
Drivers for new technologies

Developments in Technology and Science

- Sensors
- Robot technology
- Machine ‘intelligence’
- Understanding of recovery

Clinical needs

- Budget pressure
- Aging
- Shortage of skilled personnel
- Efficiency



Opportunity for new technologies in neurorehabilitation

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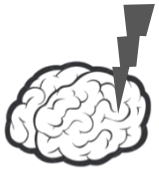
Trend towards advanced technologies

Demographic change



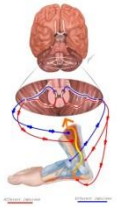
Increase of neurological diseases

Increase of healthcare costs

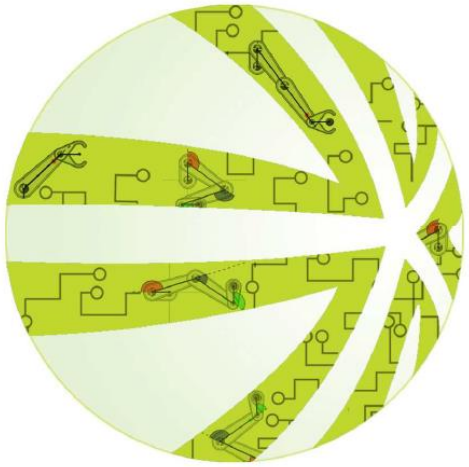
vs.

Lack of resources for therapy

Efficient and effective use of advanced technologies



Clinical Evidence (Motor Learning)



IISART

INTERNATIONAL INDUSTRY SOCIETY IN ADVANCED REHABILITATION TECHNOLOGY

IISART: International Industry Society in Advanced Rehabilitation Technology

Company-Members:

ARETECH, ARGO Medical Technologies Ltd., ekso BIONICS, HDT GLOBAL, REHA TECHNOLOGY FOR A BETTER LIFE, tyromotion, Hocoma, MOOG, MOTEK MEDICAL, motorika, HASOMED HARD- UND SOFTWARE FÜR DIE MEDIZIN, myomo my own motion, b·kin TECHNOLOGIES, SWORTEC, tecnalia Corporación Tecnológica

IISART European Company Members

Associated Members:

cost Action TD1006, ICORR, ifess, ISVR International Society for Virtual Rehabilitation, WFNR World Federation for NeuroRehabilitation

Tech trends shaping the future of medicine I

Rehabilitation robotics

Rehabilitation robotics support an **effective and efficient** way to treat patients through a state-of-art **therapy**.

Therapeutic electrical stimulation

Use of **electrical energy** as a medical treatment

Gamifying health

Combining fun and games into healthcare can **motivate the patient** and **collect data** needed to make informed decisions on daily activities that contribute to one's health.

Tech trends shaping the future of medicine II

Empowered patients

The Internet has led to many people **researching their symptoms** and **diagnosing** and **treating themselves**.

Telemedicine and remote care

Home healthcare services and innovative technology will allow for **doctor-patient connectivity**.

Re–thinking the medical curriculum

Medical schools will **prepare future physicians** for a world full of **e-patients** and **technology**.

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Tech trends shaping the future of medicine III

Surgical and service robots

Robots will become much **more integrated** into **healthcare** as already established in the area of radiotherapy.

Genomics and truly personalized medicine

DNA analysis will become a standard step when **prescribing medicine** or **treatment**, to ensure it is **personalized** and **optimized** for that particular patient's metabolic background.

Body sensors

Technology is allowing us to **measure** critical **health parameters** in convenient and inexpensive ways.

Medical tricorders and portable diagnostics

Diagnostic procedures are shifting towards **devices** that are **portable** and able to be performed **from home**.

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Tech trends shaping the future of medicine IV

Do-It-Yourself (DIY) biotechnology

Cheaper technology and a DIY spirit are generating a new generation of scientists and engineers who see no limitations in research. Community biology labs are popping up around the world - the resulting innovation in biotech has the potential for disruptive solutions that will further change the way medicine is practiced.

The 3D printing revolution

3D printers can **manufacture** medical equipment, prostheses, or even drugs.

Iron Man: powered exoskeletons and prosthetics

Exoskeleton suits have enabled partially-paralyzed individuals to walk again.

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New technologies in neurorehabilitation

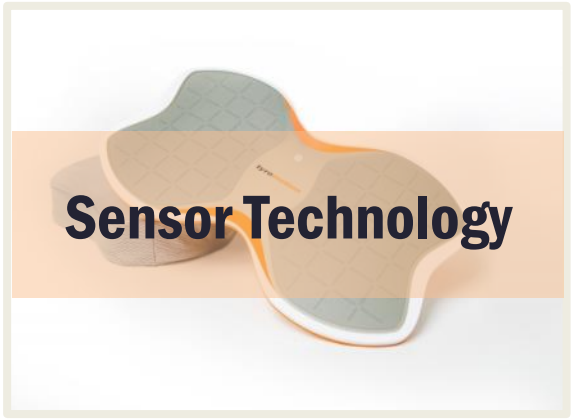
Application of robotic devices to assist, enhance and intensify therapy

Use of motor-less devices such as body weight support systems to facilitate rehabilitation

Application of electrical stimulation to create functional movements and improve recovery

New technologies in neurorehabilitation

Use of virtual reality and environments for enhancing movement therapy



Use of sensors (motion, force etc.) for assessing and enhancing therapy

Application of stimulation to the brain for enhancing recovery

Advantages of new technologies

Repetitions

Larger number of repetitions

- automated administration
- assistance for impaired patients

Duration

Increased practice time

- high motivation
- lesser need for supervision
- home-based practice

Motivation

Increased motivation

- immersion through gamification
- encouraging feedback
- goal-setting
- success through assistance

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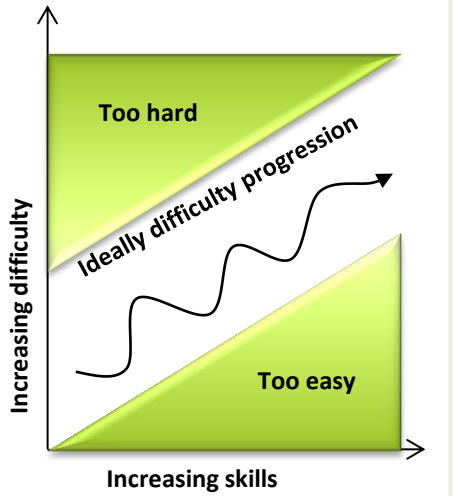
Linkage to Neural Principles and Learning

Motivation



- Motivation is needed to repetitively carry out task

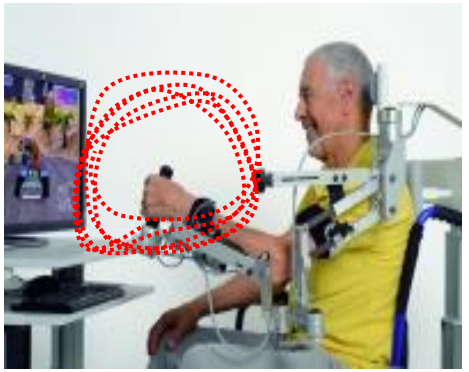
+

Feedback

- Learning process must be reinforced by feedback
- Feedback links patient's performance to successful task outcome

=

Repetitions



- Repetitions are important to promote motor learning and cortical plasticity

Robotics in neuro-rehabilitation

- Training devices: to provide motor therapy
  - Manipulation (arm and hand function)
  - Gait training (leg function)
  - Posture training (balance)

  → physical and occupational therapy with less therapist effort

- Assistive devices: to support functions
  - Mobility (exoskeleton/wheelchair)
  - Eating
  - Grasping

  → better functional performance of disabled people

Also: diagnosis, assessment, *cognitive rehabilitation*

Safety viewpoint: existing framework for assistive technologies

RACA: Rehabilitation, Assessment, Compensation, Alleviation

Actuated Applied Part -

Clinical Evidence Robot-Assisted Therapy: Upper Extremity

Proximal Improvements

Significant effect on **motor function** of shoulder and elbow, **muscle strength** and **pain reduction**

(Veerbeek et al. 2014)

Transfer to Daily Life

Improves generic **activities of daily living** and **arm function**

(Mehrholz et al. 2012)

Distal Improvements

Elbow and wrist training **enhances motor function** and **muscle strength**

(Veerbeek et al. 2014)

Risk

No increased risk of **injury** with intensive training

(Mehrholz et al. 2012)

Recovery Time

Robotic therapy **improves motor function** in a **shorter time** than physiotherapy

(Sale et al. 2014)

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Clinical Evidence Robot-Assisted Therapy: Lower Extremity

Walking improvements

Positive effect on **gait speed**, **walking distance** and **basic activities** of daily living

Rehabilitation Time

Non-ambulatory patients in **early rehabilitation profit most** from robot-assisted therapy

Dependency

Every **fifth dependency** in walking **could be avoided** using robotic-assisted training

Effectiveness

Robotic therapy in combination with conventional therapy is **more effective than physiotherapy** alone

(Mehrholz et al. 2013)

Where are we?

- 600 Million people require neurorehabilitation, only 1/3 receive it in some form
- Robot mediated rehabilitation is currently available in highly developed countries
- Considered as tool to overcome demographic challenge in rehab

Rehabilitation robotics market

- Emerging market, many small companies, the largest are in Europe, 2-digit growth rates, no consolidation yet

Current research results and evidence

- First evidence shown on repetitive robot mediated training in lower and upper extremities: therapy frequency matters

Examples of robotics

Some examples of robotic devices for neuro-rehabilitation physical therapy

- Arm function: rehabilitation of manipulation
- Leg function: rehabilitation of walking

Robots for arm training

Product

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Hocoma

Research

ArmAssist

by tecnalia

THE NEW GENERATION

Cost-effective, comprehensive upper-limb robotic device for neurorehabilitation

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The second generation of **ArmAssist** allows passive, assisted and active training of the arm and hand, allowing the treatment of **most stroke patients**.

The improved software platform allows remote patient progress assessment and management of the therapy based on serious games, which motivate patients to actively participate in their rehabilitation and **maximize the outcome**.

Robots for training of walking

tecr

Hocoma

Robots for training of walking

Product

- Re Ambulator, Autoambulator (Motorika)
- Gait Trainer (Reha-Stim)
- Gait system, G-EO-System (Reha Technologies)
- LokoHelp (LokoHelp Group)
- Walkbot (P& S Mechanics)
- Robogait

Robots for training of walking

tecn

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Robots for training of walking

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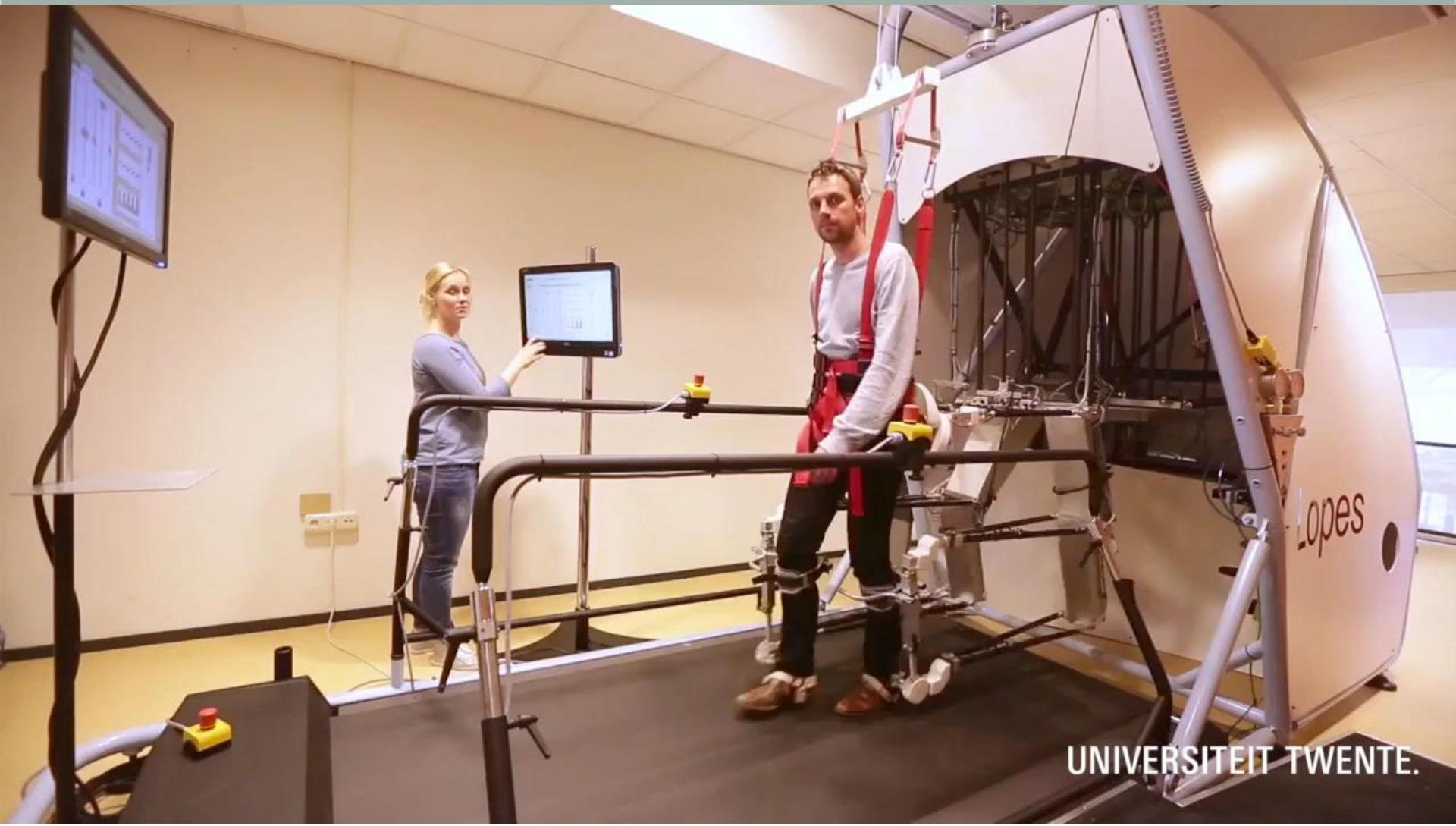
Robots for training of walking



Robots for training of walking

Robotic platform for walking support, based on springs

Product

Research

medica
MEDIZINTECHNIK GMBH

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Robots for training of walking

Product

Hocoma

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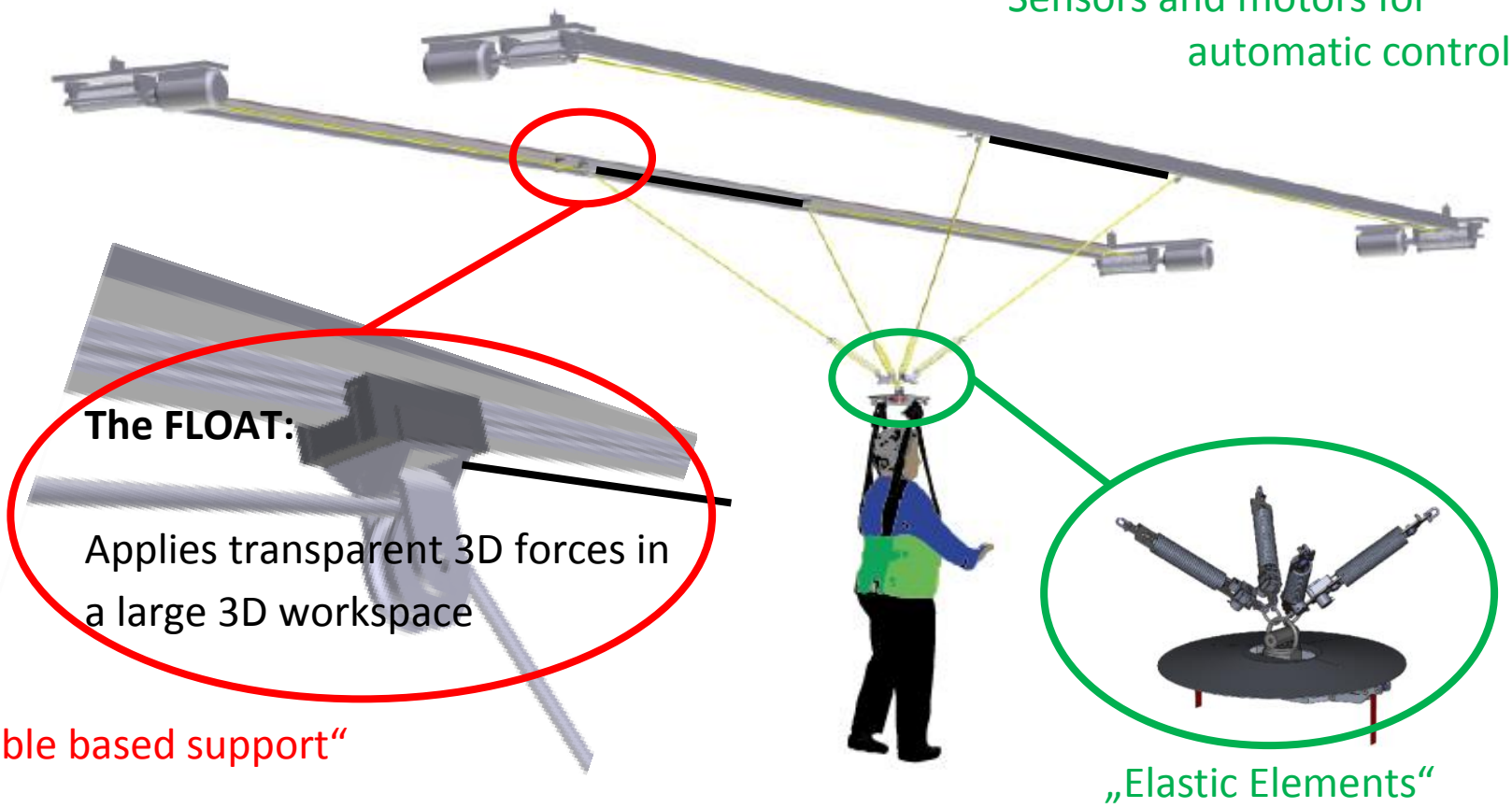
Robots for training of walking

Product

HDT Global - Kineassist MX

Robots for training of walking

THE FLOAT — *F*ree *L*evitation for *O*verground *A*ctive *T*raining



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Vallery & Lutz: Apparatus for unloading a user's body weight. *European Patent Application EP12154778.0,* 2012

Research

THE FLOAT

University of Zurich[UZH] ETH Zürich

LUTZ MEDICAL ENGINEERING

[TeleZüri, Checkup]

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Vallery et al: Multidirectional Transparent Support for Overground Gait Training. *ICORR 2013.*

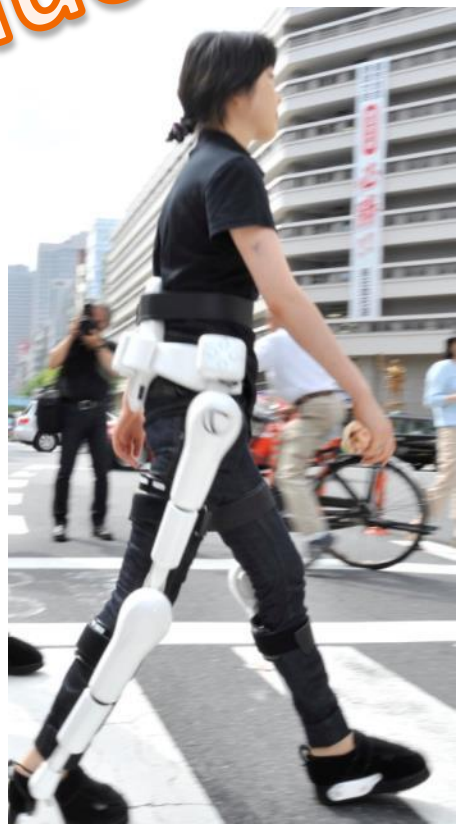
Robots for training of walking

Fully wearable exoskeleton robotics

Product

Ekso legs, Ekso Bionics

Product

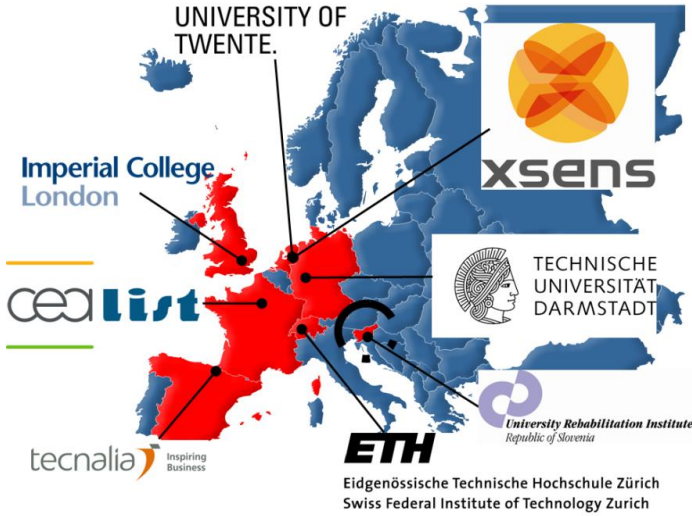


HAL, Cyberdyne

BALANCE

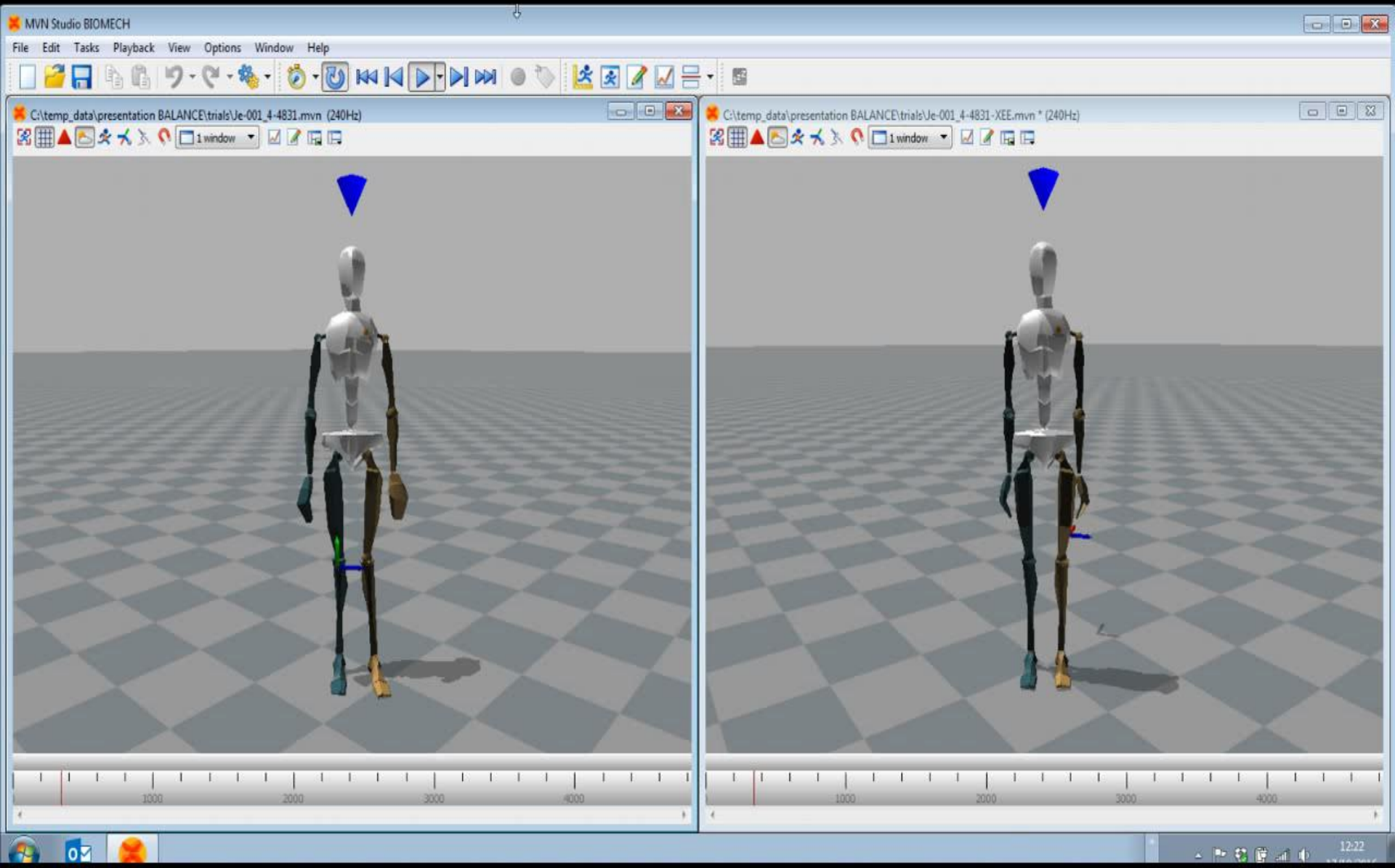
Balance Augmentation in Locomotion, through Anticipative, Natural and Cooperative control of Exoskeletons.

New developments in Wearable Robots (exoskeletons):



- Improve control
  - Control of balance → balance-fp7.eu
  - Improved safety
  - Improved training
- Improve hardware
  - Easy to put on
  - Light weight
  - Ergonomics
  - Operative range
- Reduce cost
- Make feasible for home use, as assistive device outside the clinic
- COST Action CA16116: **Wearable Robots for Augmentation, Assistance or Substitution of Human Motor Functions http://www.cost.eu/COST_Actions/ca/CA16116?**

Walking with Pelvic robot
in transparent mode


MVN Studio BIOMECH
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Real-time audio feedback based on stability condition

Imperial College London

UNIVERSITY OF TWENTE.

Robot Assistance for Balance Recovery

EU FP7 project BALANCE

Balance Augmentation in Locomotion through Anticipative, Natural and Cooperative control of Exoskeletons

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SEVENTH FRAMEWORK PROGRAMME

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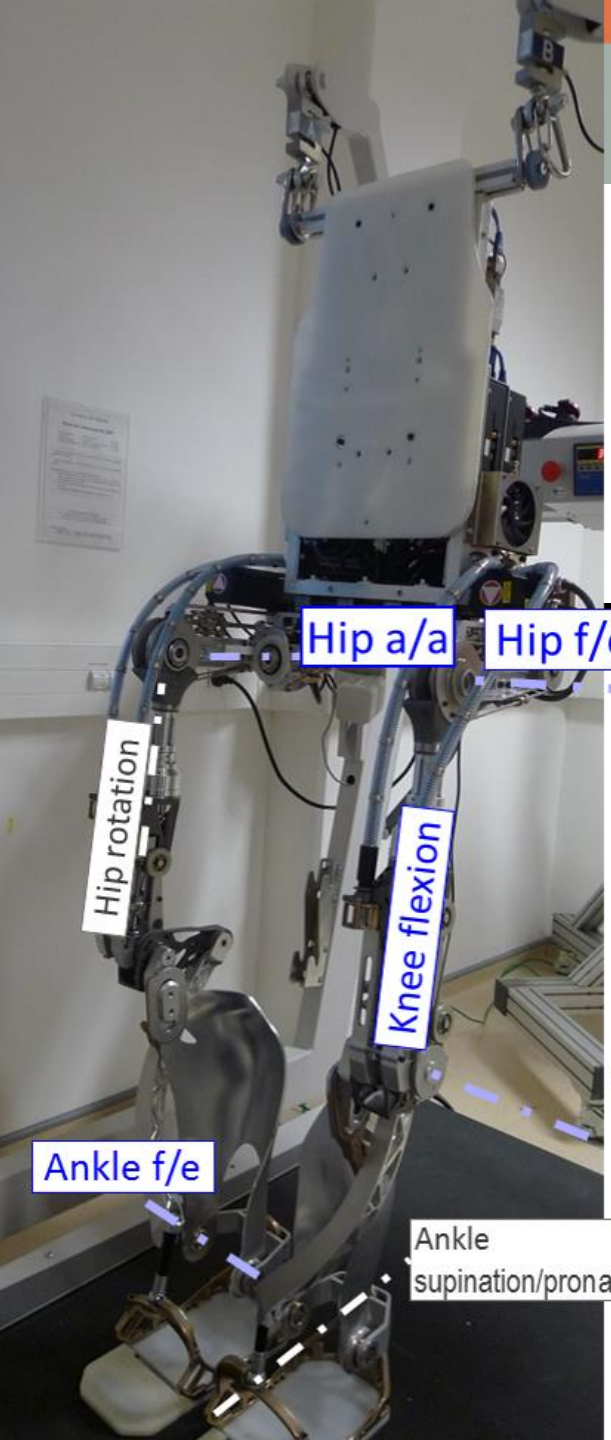
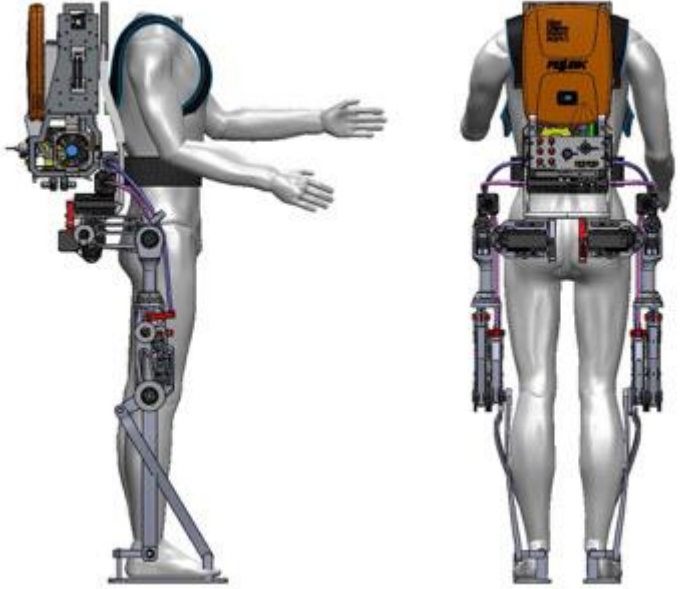
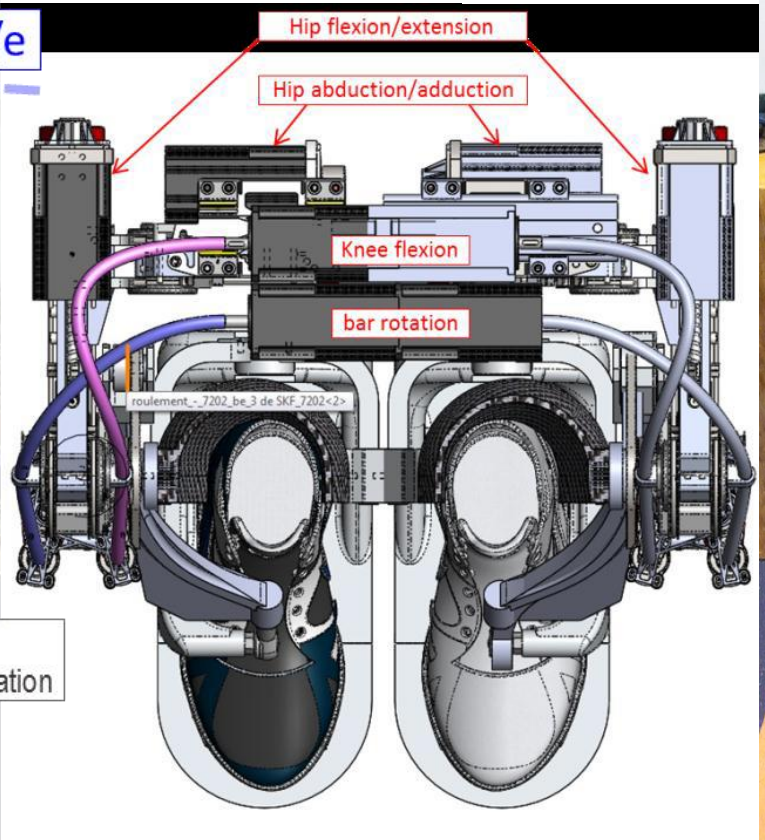

Hip a/a
Hip f/e
Hip rotation
Knee flexion
Ankle f/e
Ankle
supination/pronation




Hip flexion/extension
Hip abduction/adduction
Knee flexion
bar rotation
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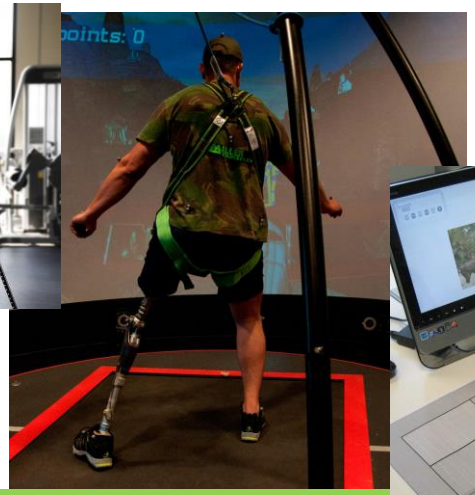
Where is the field heading?



Maturation of rehabilitation technology sector requires efforts on **broader education**, **unified** (EU wide) **regulation and reimbursement policies** to face societal challenges and risks

Research: Dose response and efficacy studies, combinational therapies, improved biomarkers, assessments, and selection of responders

Technology: Combination of assistive and training; lower cost devices for home use wearable technologies, combination of technologies

Society: Rehabilitation needs to be understood as continuum and not as intervention, access to technologies needs to be simplified

Policy: European medical device policy that allows a consumer product like deployment, facilitation of broad use, maintain safety aspects

IEC/ISO 60601-2-78 safety standard

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