12 March, 10:45 – 12:15
Session Title: “Step change results from FP7 projects”
Organizers: Cécile Huet, Bjoern Juretzki, Franco Mastroddi (EU Commission)

CYBERLEGs

Step change results from CYBERLEGs project

Nicola Vitiello, on behalf of the CYBERLEGs consortium

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

CYBERLEGs project

CYBERnetic **L**ow**E**r-Limb Co**G**nitive Ortho-prosthesi**s**

Scuola Superiore Sant'Anna – SSSA
Project Coordinator: Dr. Nicola Vitiello

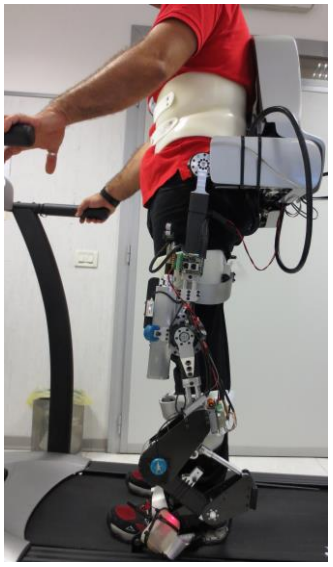
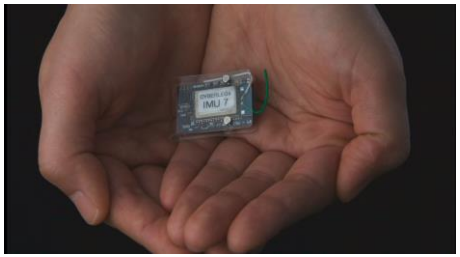
Universite catholique de Louvaine – UCL
Prof. Renaud Ronsse

Vrije Universiteit Brussel – VUB
Prof. Dirk Lefeber & Prof. Romain Meeusen

Univerza V Ljubljani – UL
Prof. Marko Munih

Fondazione Don Carlo Gnocchi - FDG
Dr. Raffaele Molino Lova

CYBERLEGs is an artificial cognitive **ortho-prosthesis** for dysvascular trans-femoral amputees lower-limb functional replacement and assistance in daily living activities

Duration: 3 years
Start date: February 1, 2012
Budget: 3,45 M€
EU Contribution: 2,54 M€
Project Coordinator: Nicola Vitiello
Leading institution: The BioRobotics Institute, Scuola Superiore Sant'Anna

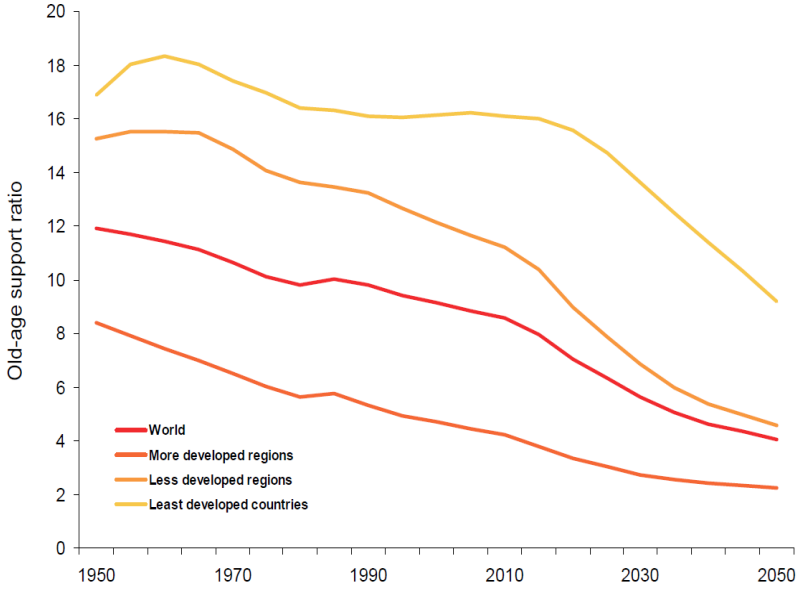
www.cyberlegs.eu

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

World population ageing

The proportion of those that require **support for active aging** or care to improve quality of life in their old age **is increasing**, while the proportion of those that are asked to provide this support is declining. In other words, **an ageing society leads to concrete problems** that could threaten the sustainability of our welfare and economic system.

Gait disorders lead elderly people to an **inactive life** that bring several major consequences, like **poor cardio-fit** and sometimes a cognitive impairment.



Number of working-age person (15-65 y) per older person (>65 y)

UN Ageing Report 2013:
http://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2013.pdf

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

Peripheral artery diseases lead to lower-limb amputations

Diabetes affects more than 285 million people **globally and that number is expected to grow by more than 50 percent in the next 20 years to 438 million people.**

- The most impairing comorbidity factor are dysvascular diseases that leads to **gait disorders** or even **amputation**.
- Difficulty and pain in walking brings to an inactive lifestyle that generates a **vicious circle** with the disease progression.

Global SHERPA: http://www.globalsherpa.org/nutrition-market-obesity-malnutrition
WIKIPEDIA: http://en.wikipedia.org/wiki/Stroke

- Lower-limb loss is a disabling condition
- Incidence of all-cause lower-limb amputations
  - 0.4 over 10,000 in Japan
  - 10 over 10,000 in Native American communities (e.g. Navajo Region, US)
- Vascular diseases are the main cause of lower-limb amputation: ~80% in US
  - ~60.000: new transfemoral amputees per year in US & EU28
- Ageing is a risk factor

Transfemoral amputation is challenge

- More energy, less speed: 40% of the speed, 2.5 times more energy
- Steps, Stairs and other ups & downs
- More “mental energy”, less gait stability

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

CYBERLEGs long-term vision

CYBERLEGs

Market needs

- energetic, cognitive and stability challenge are not fully overcome by any passive or active prosthesis
- most (around 80%) of dysvascular amputees do not use any prosthesis

- **GOAL**, a new set of wearable robotic (orthotic and prosthetic) technologies
  - to help amputees to recover a more efficient gait/locomotion
  - intuitive/user friendly (low cognitive load)

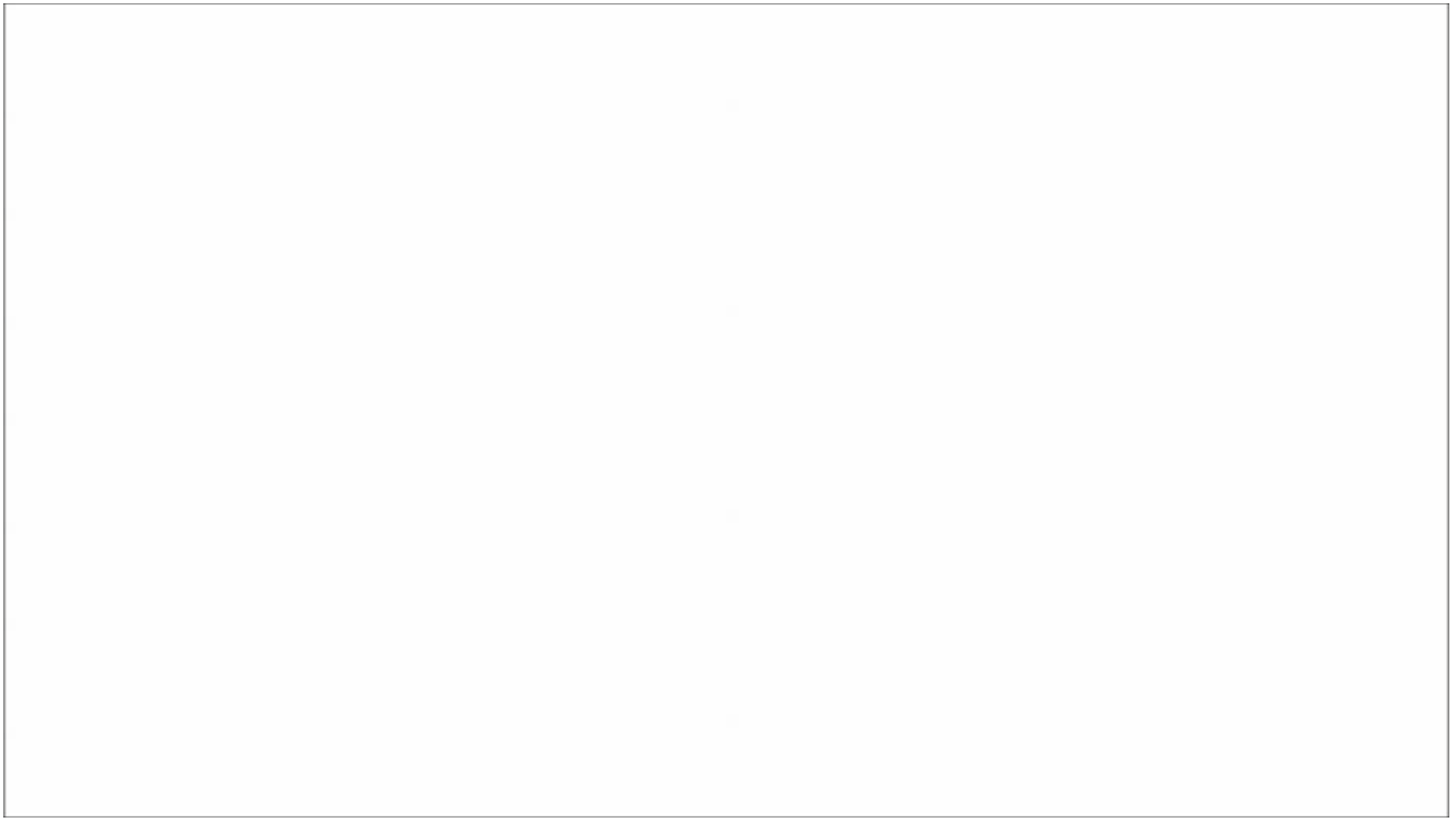
Patent pending

N. Vitiello, et al., “Technological aid for transfemoral amputees”, PCT/IB2013/055065, 2013.

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

3 years of project activities

Official video at: https://www.youtube.com/watch?v=a0BEv-wa36Q



CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

Case study #1: active pelvis orthosis (APO)

With reference to:
Robotics 2020 Multi-Annual Roadmap,
Release B 06/02/2015

Gait Assistant for
energy-efficient locomotion

Market need

- Safe & ergonomic interaction
- Adaptive control (user drives)
- Inter-subject/inter-day variability
- High-force/high transparency

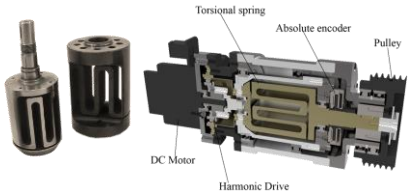
Requirements

Configurability Level 3	**Adapatability** Level 3: parameter Level 2: component	**Interaction ability** HRI: Level 2 HRI Safety: Level 7	**Dependability** Level 4
Run-time Self Configuration Intra-, inter-day change of the assistive strategy configuration	**Multiple-parameter adaptation** Assistance adapts following the user performance **Adaptation of individual component** Adaptive self-aligning mechanism	**Direct physical interaction** Control through physical interaction **Dynamic safety** Strong forces but recognizes risky conditions	**Graceful degradation** Recognise the impact of failures
(X) Level 1	**(√) Level 3** **(√) Level 2**	**(√) Level 2** **(x) Level 6**	**(x) Level 2**

Target abilities

Capabilities

Step change



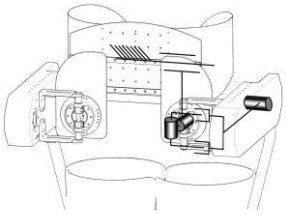
Weight: **~700 g**
Peak/cont torque: **22/12 N·m**
Paras. Stiff.: **~1 N·m/rad**
Patent App.:
PCT/IB2014/062735

Novel Series-Elastic Actuator (SEA)

"Ideal" torque source
New Actuator concept

Novel passive mechanism for ergonomic interaction

Basic pHRI architecture
Low-weight device
Adaptive control strategy



3-DOF passive chain
Collocated Abd/Add and Int/ext rotation
Patent App.: FI2015A00002

Mechatronics Actuators

Human-Robot Interaction

Technologies

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

Case study #2: active transfemoral prosthesis (ATP), whole-body awareness control (WBAC)

CYBERLEGs

With reference to:
Robotics 2020 Multi-Annual Roadmap,
Release B 06/02/2015

Above-knee prosthesis for human-like locomotion

Market need

- Safe & ergonomic interaction
- Adaptive control (user drives)
- Intuitive control (no training)
- Human-like movement (beyond passive mechanics)

Requirements

Configurability Level 3	**Adapatability** Level 3: parameter Level 2: component	**Interaction ability** HRI: Level 2 HRI Safety: Level 7	**Dependability** Level 4	**Cognitive ability** Level 3
Run-time Self Configuration Intra-, inter-day change of the control/assistive strategy configuration	**Multiple-parameter adaptation** Control/injected energy adapts following the user performance **Adaptation of individual component** Adaptive rest position of knee flexion spring	**Direct physical interaction** Control through physical interaction **Dynamic safety** Strong forces but recognizes risky conditions	**Graceful degradation** Recognise the impact of failures	**Sense driven action** Sensor-data fusion and action
(X) Level 1	(√) Level 3 (√) Level 2	(√) Level 2 (x) Level 2	(x) Level 2	(√) Level 3

Target abilities

Weight: **~5 kg**
2 powered DOFs
SEA for knee joint
VIA for ankle joint

Novel ATP

New actuator concept
Variable-impedance actuator

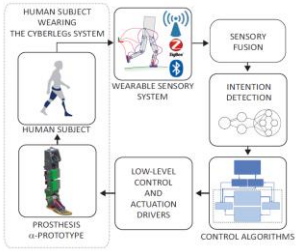
Mechatronics Actuators

Non-invasive WBAC-based HRI

Novel kinds of interfaces
Sensor data fusion to "propose" assistive activites to the user based on observed situation

Human-Robot Interaction

Capabilities



3 locomotion tasks
100% success rate in GLW
Ambrozic et al., IEEE RAM, 2014

Step change

Technologies

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

Impact on healthcare domain …and beyond healthcare

- CYBERLEGs technologies are ready to start an innovation process, addressing clear market needs
  - Rehabilitation and assistive needs
  - More than amputees: all lower-limb mild gait impairments
- Currently, this topic is being discussed with **Össur**, represented today by Freygarður Þorsteinsson

- A sector of the EU-27's non-financial economy which is **significantly affected by the ageing of the population and work force is the *construction sector***, (third largest workforce, some 15.0 million persons, and the third highest level of value added, about 600 B€) Eurostat yearbook 2012
  - construction is a physically demanding industry
  - construction is the sector most affected by fatal accidetents (13 workers per 100.000 against 5 for the all sector average)
  - compared with white-collar workers, construction workers experience increasing chronic health conditions over time, and
  - although older workers typically have a lower frequency of workplace injuries, their injury-related costs are higher than of younger workers (Shuford and Restrepo, 2005)
- Currently, this topic is being explored with colleagues from **ACCIONA Infraestructuras**, represented today by Manuel Palomino Garcia

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894

Thanks for the attention

…questions?

Contact: **n.vitiello@sssup.it**
http://www.cyberlegs.eu

CYBERLEGs Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 287894