Robotic systems for training and assistance of walking

Jan Veneman. Danijela Ristic-Durrant. Carlos Rodriguez Guerrero and Edwin Van Asseldonk.

- Human cooperative control strategies in robotic systems for training and assistance of walking.
- Training and assistance of natural-like walking including balance (training protocols and development of control strategies)
- Actuator designs for human cooperative behaviour in robotic systems for training and assistance of walking
- New conceptual approaches in robotic systems for training and assistance of walking

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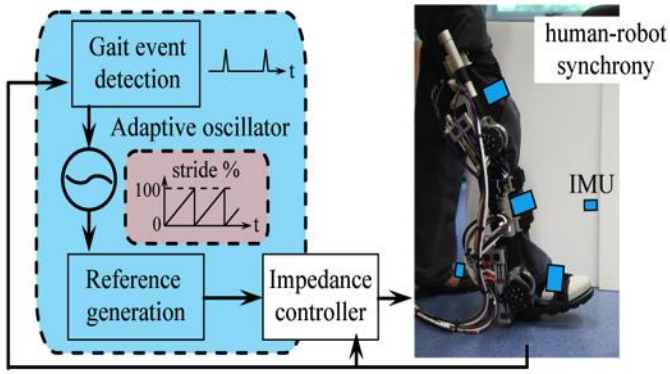
- Yu Haoyong: National University of Singapore
- Santiago Focke University of Bremen
- Thomas Sugar Arizona State University.

Adaptive-Oscillator-Based Control Strategy for Gait Rehabilitation Robots

Haoyong Yu
Department of Biomedical Engineering,
National University of Singapore

- A novel method to achieve human robot synchronization
- Gait phase is detected with wearable sensors
- Adaptive oscillator synchronize the robot motion with human gait
- Method is validated on an exoskeleton robot

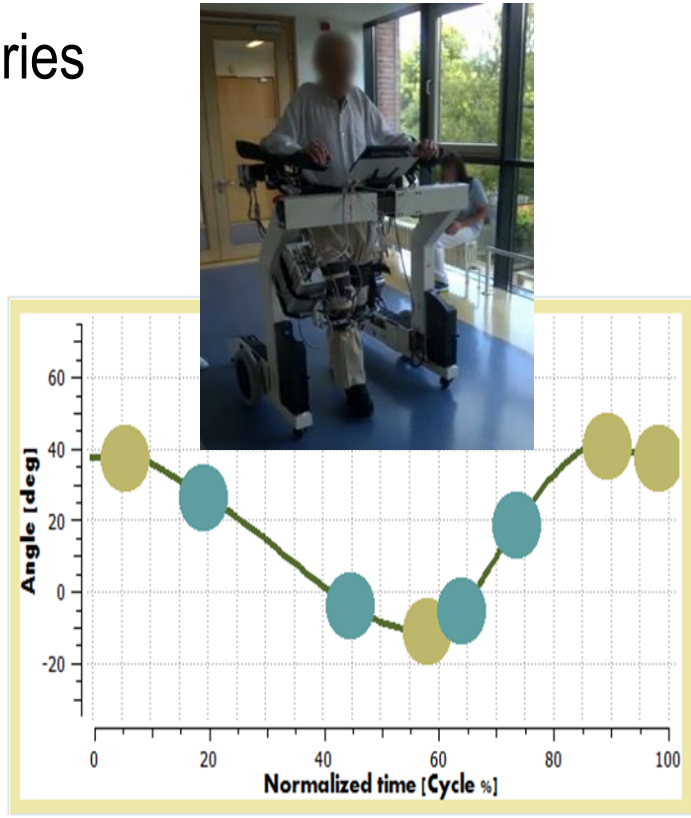


Gait-event-based synchronization method using an adaptive oscillator.

Individualization of Gait Therapy Through Patient-tailored Trajectory Generation

Santiago Focke Martinez, Olena Kuzmicheva,
Danijela Ristić-Durrant and Axel Graeser
Institute of Automation, University of Bremen, Germany

- Generation and adaptation of reference trajectories for hip and knee joints via characteristic points.
- Initial implementation and clinical trials with *MOPASS*: a robot-based system for over-ground gait rehabilitation.
- Estimation of healthy-like joint trajectories.
- Automatic online adjustment of reference joint trajectories when the therapist changes the walking speed during the exercise.



Bioinspired Controller Based on a Phase Oscillator

Thomas G. Sugar and Sangram Redkar
The Polytechnic School, Arizona State University, USA

- Oscillatory behavior is important for tasks such as walking and running
- We are developing methods to add energy to assist the oscillatory movement based on phase angles
- We use a forcing function based on the sine and the cosine of the phase angle
- We can adjust the frequency and amplitude of the oscillation

Primitive Terms	
$\sin(\phi) = \frac{\dot{\theta}/\omega}{\sqrt{(\dot{\theta}/\omega)^2 + \theta^2}}$	Positive – Bounded, negative damping term
	Negative – Increase the damping of the system
$\cos(\phi) = \frac{\theta}{\sqrt{(\dot{\theta}/\omega)^2 + \theta^2}}$	Positive – Decrease the frequency of oscillation
	Negative – Increase the frequency of oscillation

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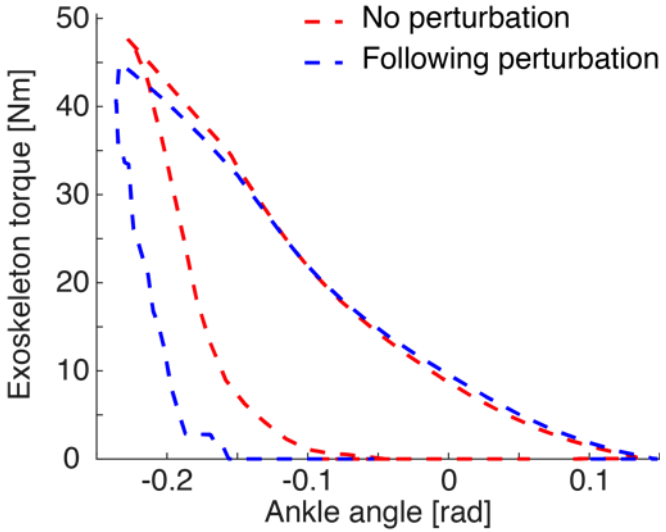
- Edwin Van Asseldonk: University of Twente
- Zlatko Matjačić: University rehabilitation institute

Control strategy for ankle exoskeleton to assist in balance recovery

Edwin van Asseldonk, Diego González,
Mark Vlutters and Herman van der Kooij
Department of Biomechanical Engineering, University of Twente,
the Netherlands

- Human modulate their ankle torque and work to counteract anteroposterior perturbations
- We developed a controller to adjust the ankle torque and work based on perturbation-induced changes of the Center of Mass velocity
- This controller was evaluated in healthy subjects to evaluate whether balance was recovered faster and/or with less human effort



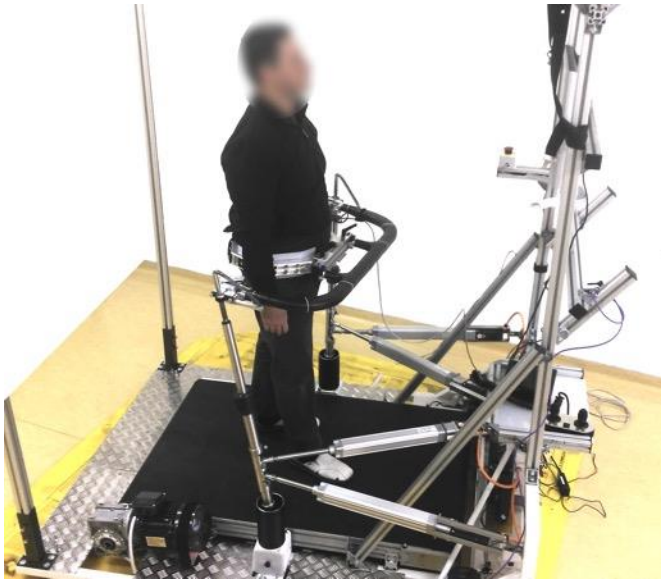
Modulation of ankle angle-torque profile to assist in balance recovery

Dynamic balance assessment during pathological bipedal walking

Zlatko Matjačić, Matjaž Zadravec, Nika Goljar and Andrej Olenšek
University rehabilitation institute,Ljubljana, Slovenia

- 6 DOF Balance assessment robot (BAR) for use on instrumented treadmill was developed
- Balance responses following pushes to the pelvis were assessed in healthy and post-stroke subjects during treadmill walking
- Balance responses in stroke population are subject-specific
- Efficient balance training program must also be individualized and subject-specific

Univerzitetni rehabilitacijski inštitut
Republike Slovenije - Soča



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- Actuator designs for human cooperative behaviour in robotic systems for training and assistance of walking

- Dirk Lefeber: *Vrije Universiteit Brussel*
- Nicola Vittiello: *Scuola Superiore Sant ‘Anna*

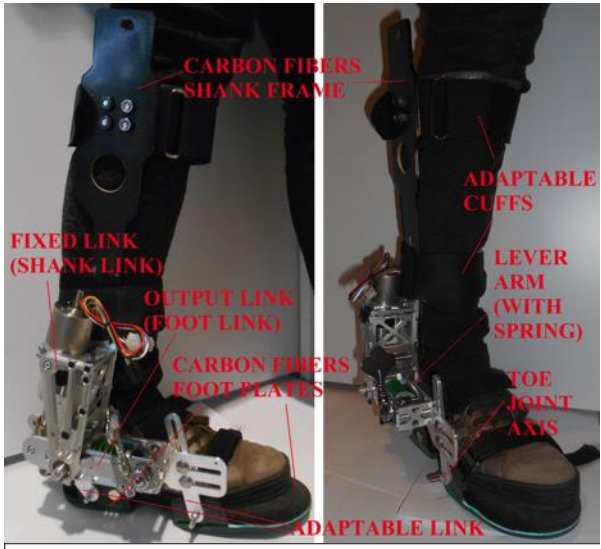
Compliant Lightweight Actuator Designs for Robotic Assistance and Rehabilitation Exoskeletons

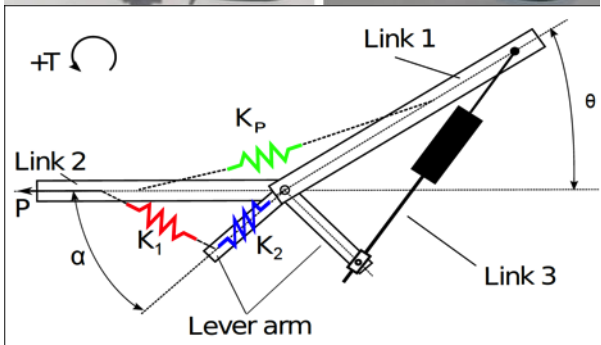
Dirk Lefeber, Marta Moltedo, Tomislav Bacek, Kevin Langlois, Karen Junius, Bram Vanderborght

Department of Mechanical Engineering, R&MM Research Group, Vrije Universiteit Brussel (VUB)

- torque-controlled, variable stiffness actuator
- lightweight ankle actuator (1.7kg including electronics and excluding batteries).
- Knee : energy efficient quasi-passive on/off mechanism
- Spring inside lever arm

- This work is supported by the European Commission's 7th Framework Program as part of the project BioMot (Grant Agreement number IFP7-ICT-2013-10-611695), by the Flemish agency for Innovation by Science and Technology as part of the project MIRAD (IWT-SBO 120057) and by the FWO grant (no.G026214N)



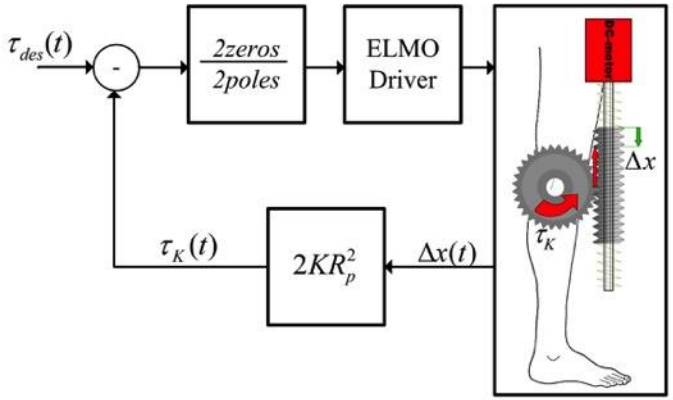


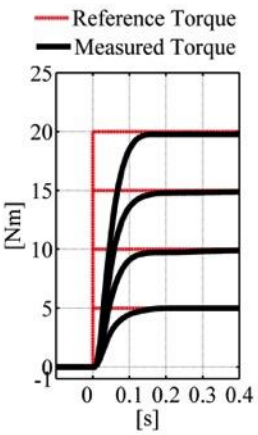
An active compliant knee joint for gait assistance: design and characterization

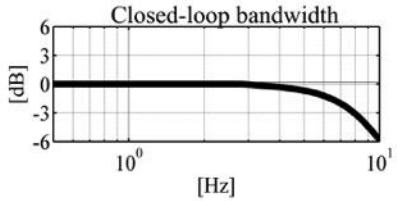
Matteo Fantozzi, Andrea Parri, Francesco Giovacchini, Tingfang Yan, Silvia Manca, Mario Cortese and Nicola Vitiello

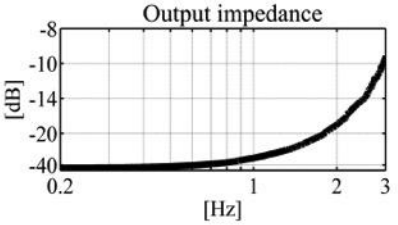
The BioRobotics Institute, Scuola Superiore Sant'Anna, Pontedera, Pisa, Italy

- Linear Series Elastic Actuator for an active compliant knee joint for a lower-limb wearable assistive orthosis
- Joint stiffness of ≈ 95 N·m/rad and maximum output torque of 30 N·m
- Accurate closed-loop torque control with a -3dB closed-loop bandwidth of 8 Hz
- Minimum output impedance under zero-torque control: 1.2 N·m/rad @1 Hz corresponding to an output resistive torque of ≈ 2 N·m









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- Conor Walsh: Harvard University

Soft exosuit design

Connor Walsh
Harvard University