Liberty Robotic Rehabilitation Platform

A novel robotic system for early whole-body rehabilitation

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Outline

- Current rehabilitation robotic systems
- Liberty Robotic Rehabilitation Platform: target functions
- Preliminary development: various leg movements
- Second prototype: synchronous arm-leg movements
- Conclusions and future work
Current Rehabilitation Robotic Systems
Exoskeleton-based Rehabilitation Robotic Systems

ArmeoPower, Hocoma AG

Lokomat, Hocoma AG
Neuro-Cardio-RehaRobot

IRPT Rehabilitation Robotics Lab, Burgdorf (MU110) Interlimb neural coupling

J. Fang and K. J. Hunt, "Mechanical design and control system development of a rehabilitation robotic system for walking with arm swing", accepted by *Frontiers in Rehabilitation Sciences* 2:720182, October 2021.
End-effector-based Rehabilitation Robotic System

IRPT Rehabilitation Robotics Lab, Burgdorf (MU110)

G-EO System, Reha Technology AG
Cable-driven Rehabilitation Robotic Systems

Diego, Tyromotion Austria

RoboWalk expander, h/p/cosmos
Robotic Systems for Early Rehabilitation

Erigo, Hocoma AG

First Mover, Reha Technology AG
Limitations in the Devices for Early Rehabilitation

- There is no device that provides whole-body rehabilitation.

- The movement pattern is different from that is required in daily activity.

- Interlimb neural coupling suggests that walking-like arm-leg training should be performed.

- Cable-driven robotic systems produce motion in a "more natural" way than traditional robots that use rigid metal structures.
Liberty Robotic Rehabilitation Platform

Target functions
Liberty Robotic Rehabilitation Platform (Liberty MedTech Sagl)

➢ Aim: to provide bed-based whole-body rehabilitation.

➢ Functions: posture change, position transfer, arm-leg movements.
Innosuisse Projects:

➢ In Silico Design and Analysis of the Liberty Robotic Rehabilitation Platform (1.9.2018 – 31.8.2019, CHF 190’971)

Preliminary Development

Various leg movements
Preliminary Prototype

In collaboration with Siemens Schweiz AG.
Control System

Control unit

Motors and controllers

Software: TIA Portal

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Production of Supine Stepping

Two motors, belt actuation for the thigh and shank segments

https://youtu.be/5N1NSrWfS0A  https://youtu.be/S9q7Epk3iso
Movement Control

Teach and replay training

Side-lying stepping

https://youtu.be/bnv3-l4aGwM

https://youtu.be/2n6SLdeEWck
Evaluation with Test Persons

The belts should be actively controlled.

https://youtu.be/eEtC_DLwlSo
https://youtu.be/TFCgzcJdcvl

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New Idea from the RoboWalk System

Impedance & force-controlled robotic system: four motors produce well-controlled walking movement in the sagittal plane.


https://youtu.be/rOKvnBY6MO4
Second Prototype

Synchronous arm-leg movements
Mechanical Model

Only six cables are shown below to produce 3-D movement of one leg.
Mechanical Model

12 motors: arm-leg movement (side-lying).
16 motors: arm-leg movement of both sides (supine-lying).
Latest Development

Two controller boxes were mounted for 3-D leg movement. More controller boxes are to be used to provide whole-body rehabilitation.
Control System

Multi-axis controller, MiniMACS

Industrial PC, Beckhoff

Cable-driven units

Software: TwinCAT 3

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Conclusions and Future Work
Conclusions and Future Work

- Liberty Robotic Rehabilitation Platform aims to provide early whole-body rehabilitation for severely impaired patients.

- A preliminary prototype was developed for producing various leg movements.

- The structure and control algorithms for the second prototype have been determined for generation of various arm-leg movements.

- Future work will focus on movement control and biofeedback development.
Clinical Evaluation
Thank you for your attention.