Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Liberty Robotic Rehabilitation Platform

A novel robotic system for early whole-body rehabilitation

researchXchange on 05.11.2021

Dr. Juan Fang, Tenure-Track assistant professor

Institute for Rehabilitation and Performance Technology IRPT
http://irpt.ti.bfh.ch/

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.

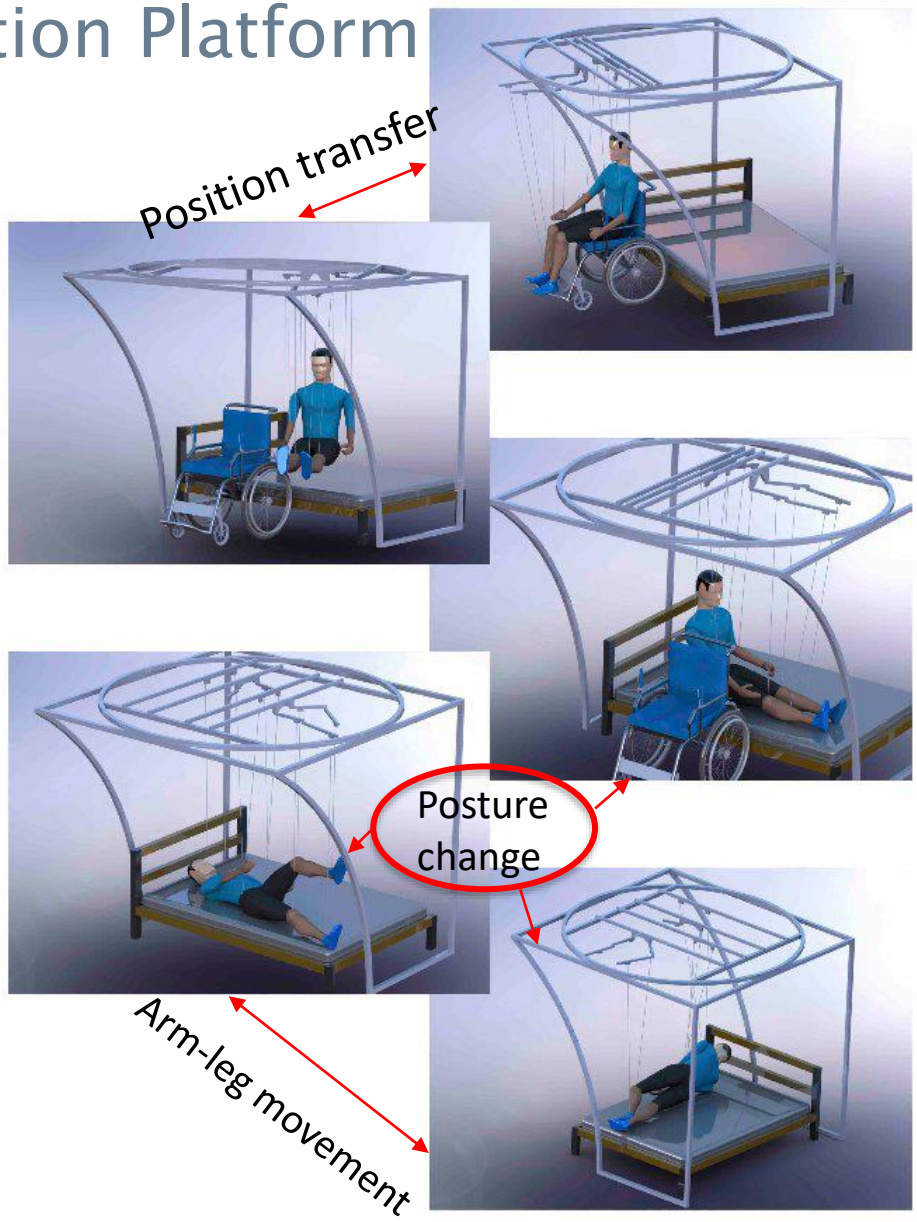
Liberty Robotic Rehabilitation Platform

Target functions

Liberty Robotic Rehabilitation Platform (Liberty MedTech Sagl)

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

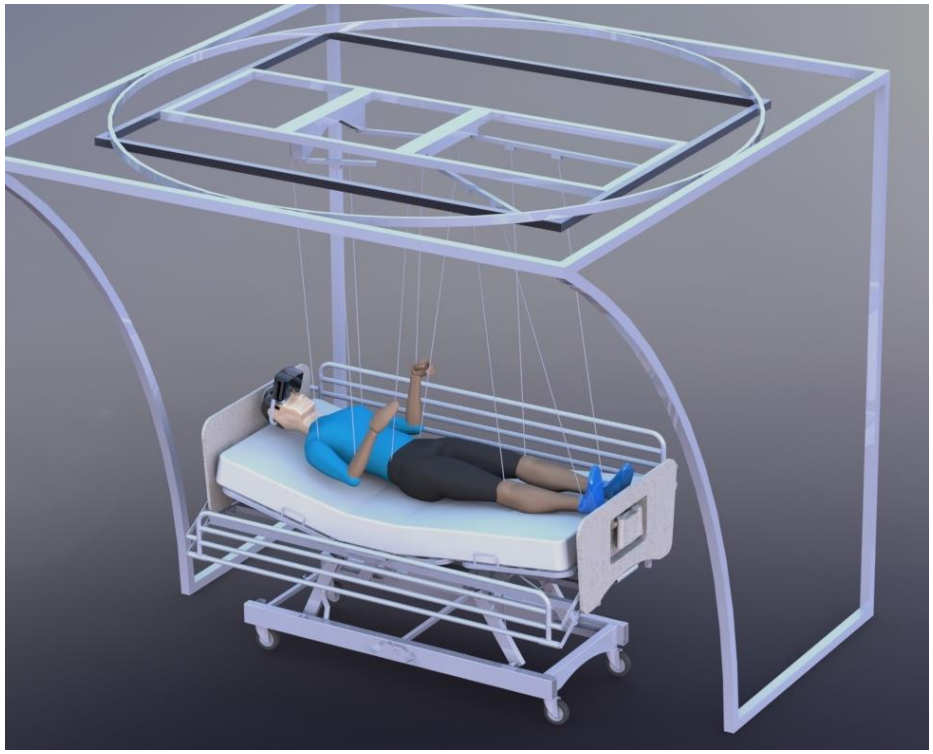
- Functions: posture change
  position transfer
  arm-leg movements



Innosuisse Projects:

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

- Design and Technical Evaluation of the Liberty Robotic Rehabilitation Platform (01.01.2021 – 31.12.2022, CHF 411‘556)

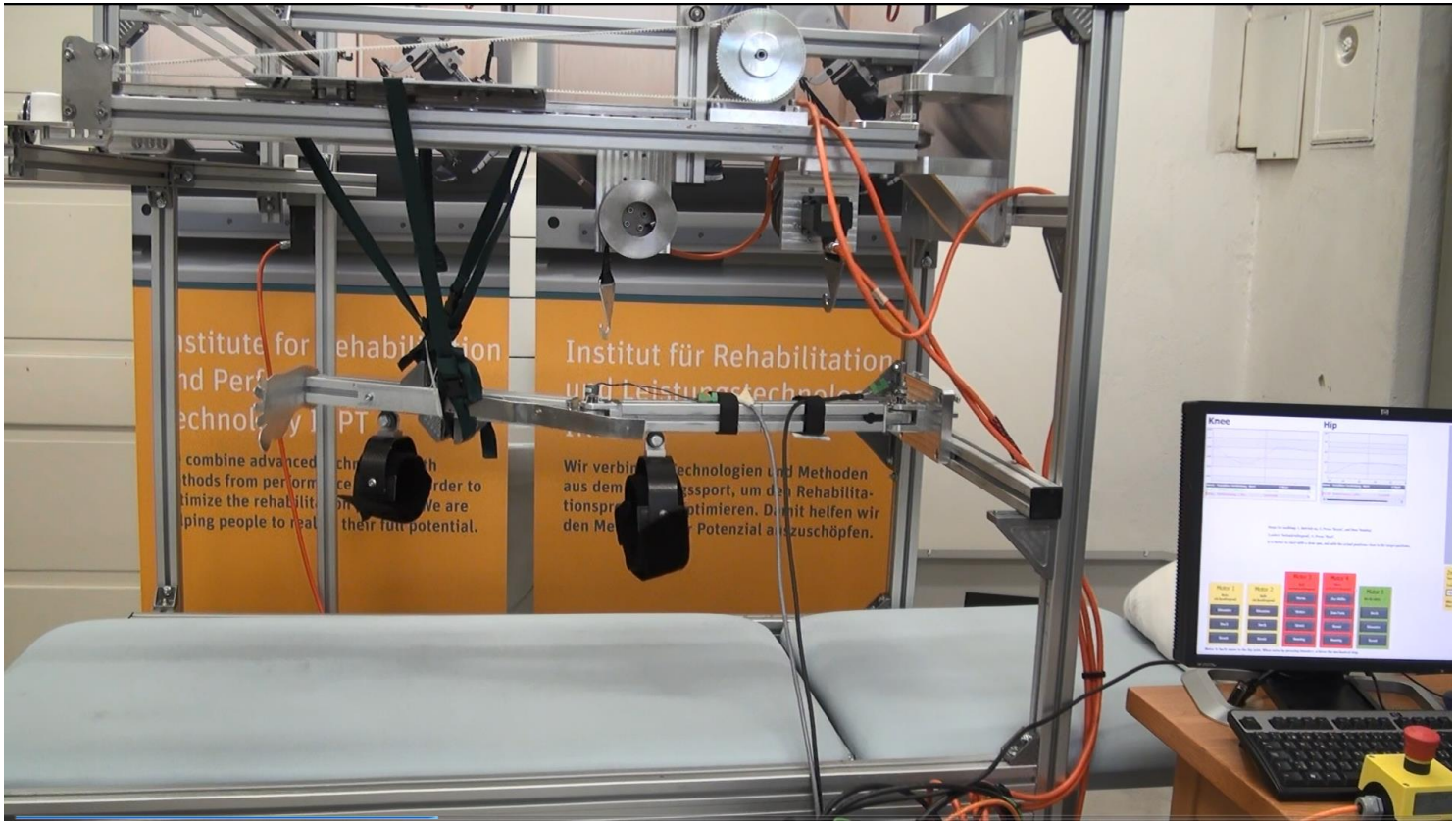


Preliminary Development

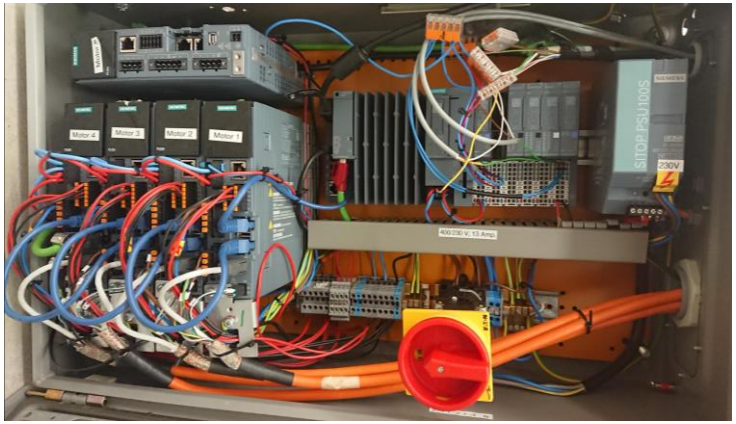
Various leg movements

Preliminary Prototype

In collaboration with Siemens Schweiz AG.

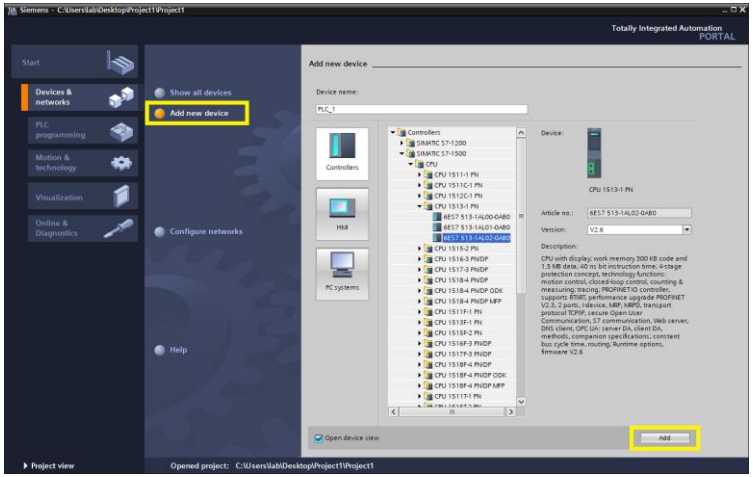


Control System



Control unit

Motors and controllers



Software: TIA Portal

Industrial PC

Production of Supine Stepping

Two motors, belt actuation for the thigh and shank segments

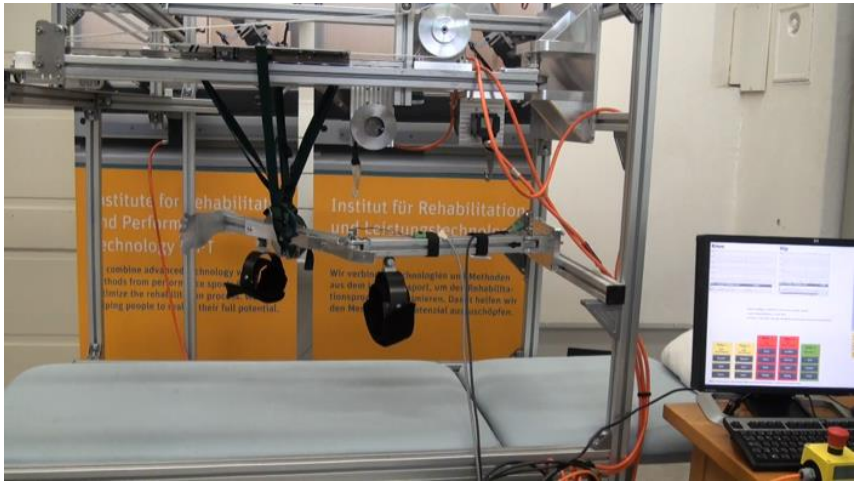
https://youtu.be/5N1NSrWfS0A

https://youtu.be/S9q7Epk3iso

Movement Control

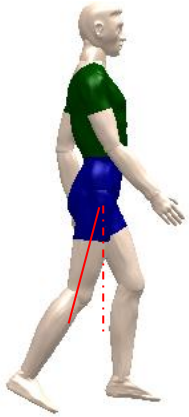
Teach and replay training

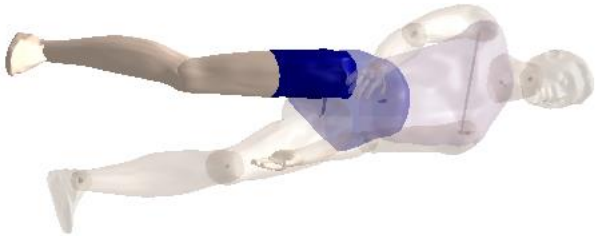
Side-lying stepping



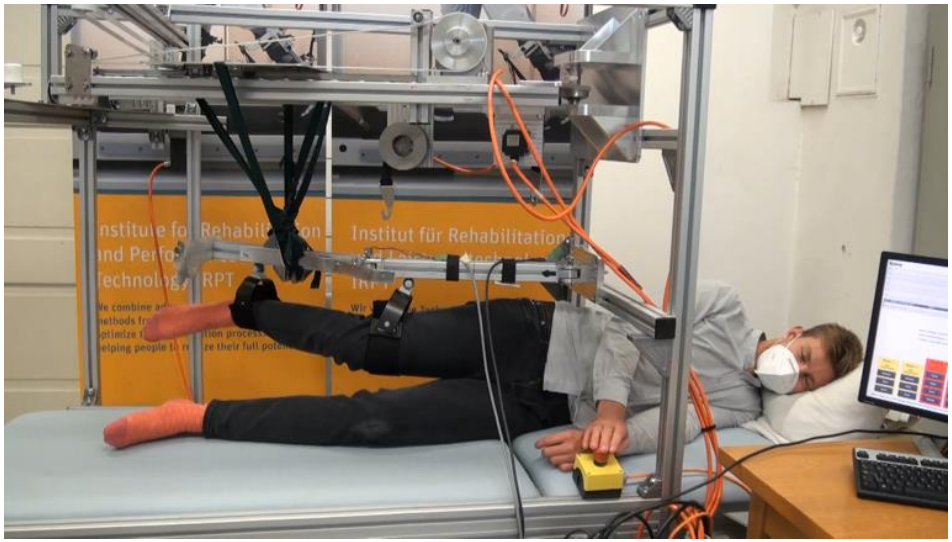
https://youtu.be/bnv3-I4aGwM

https://youtu.be/2n6SLdeEWck

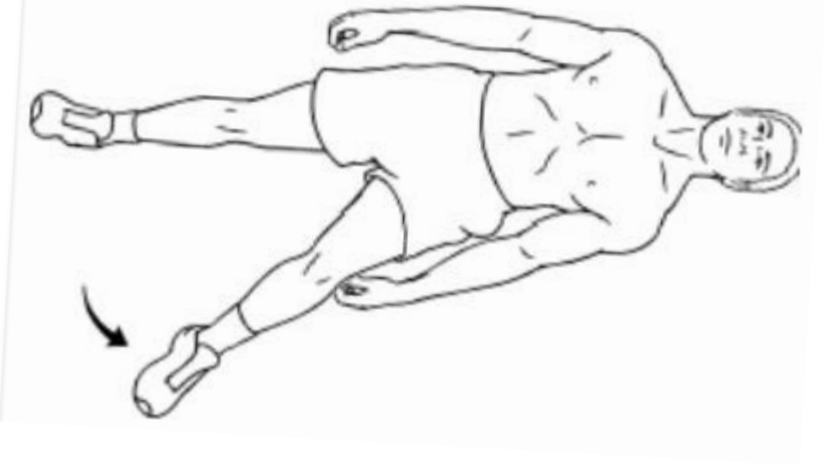


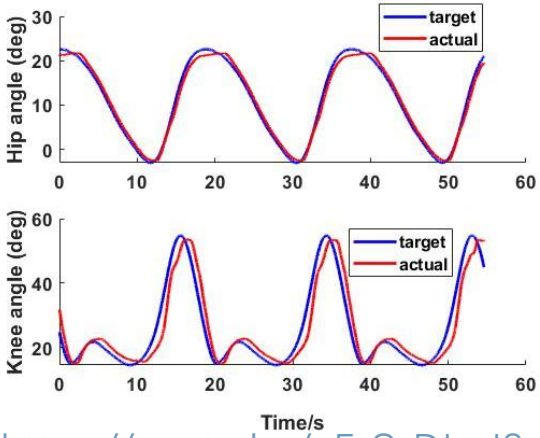


Evaluation with Test Persons



The belts should be actively controlled.



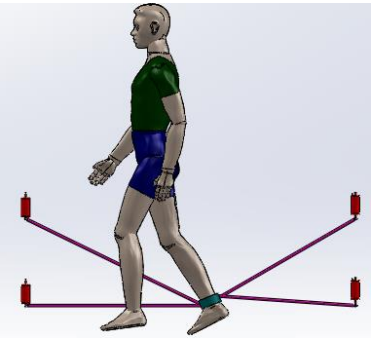


https://youtu.be/eEtC_DLwlSo

https://youtu.be/TFCgzcJdcvI

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

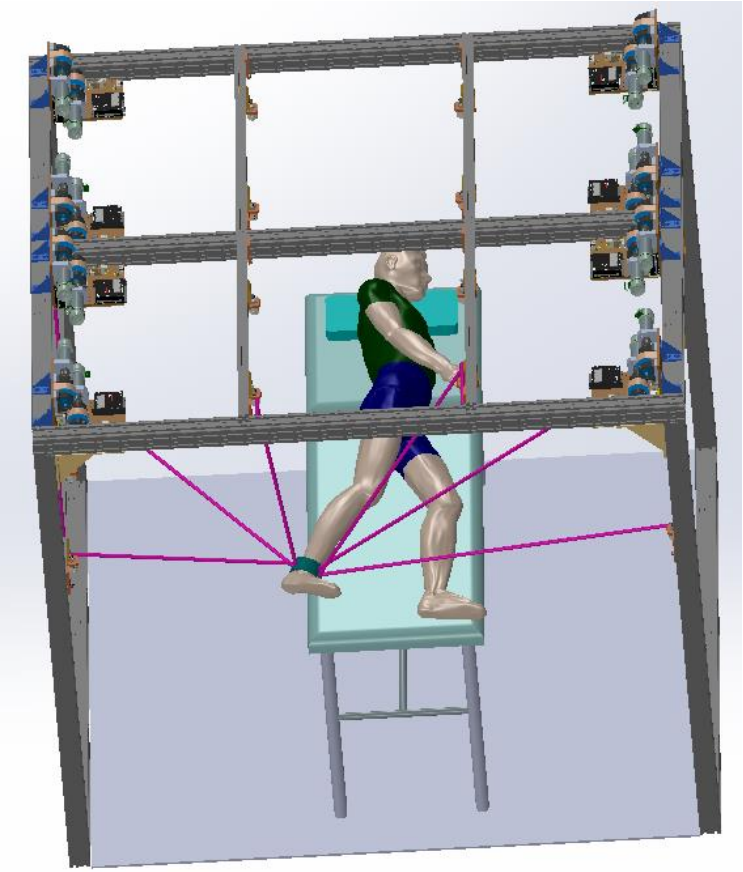
J. Fang, M. Haldimann, L. Marchal-Crespo, and K. J. Hunt, "Development of an active cable-driven, force-controlled robotic system for walking rehabilitation," *Frontiers in Neurorobotics,* vol. 15, 2021.

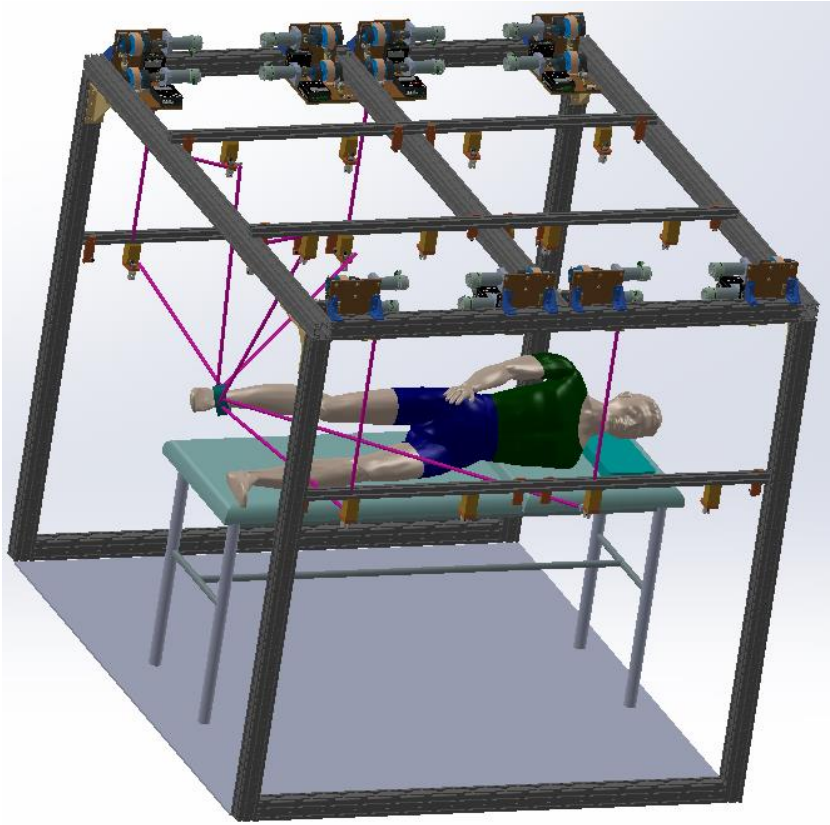
Second Prototype

Synchronous arm-leg movements

Mechanical Model

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

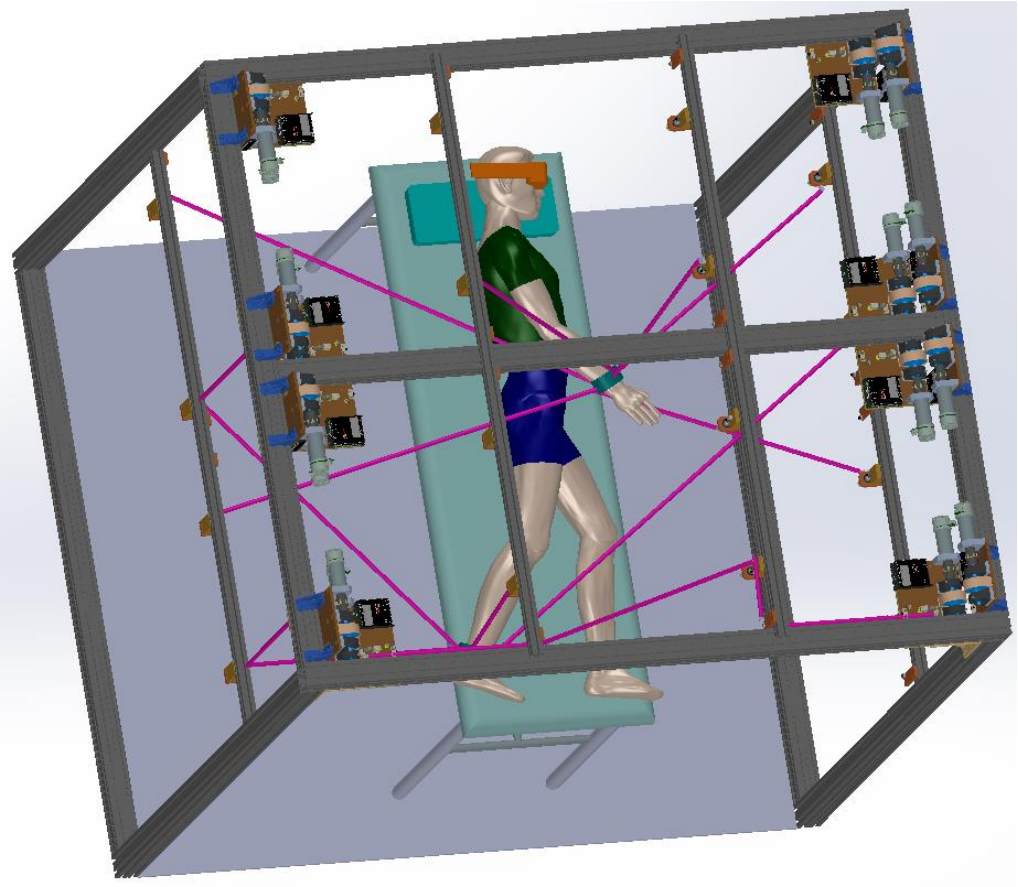




Mechanical Model

12 motors: arm-leg movement (side-lying).

16 motors: arm-leg movement of both sides (supine-lying).

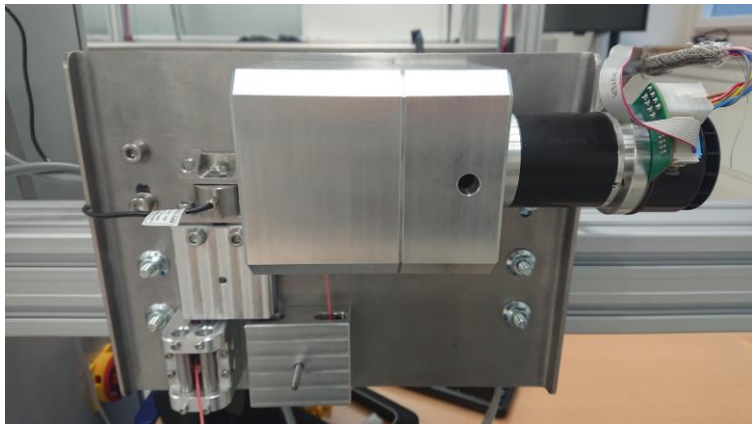


Latest Development

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

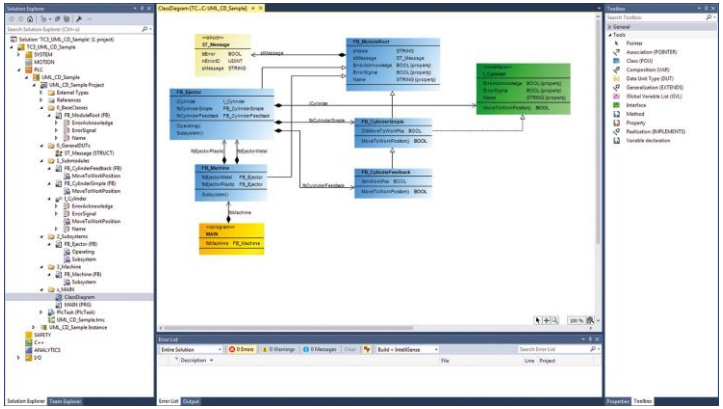
Control System

Multi-axis controller, MiniMACS



Cable-driven units

Industrial PC, Beckhoff



Software: TwinCAT 3

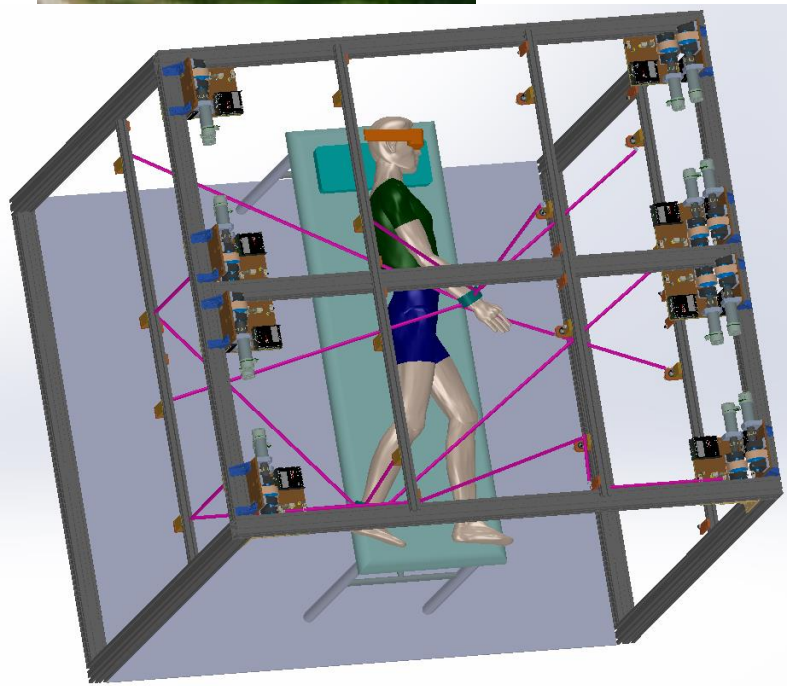
Conclusions and Future Work

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

Reha Rheinfelden



Thank you for your attention.