

Service robots and Exoskeletons: Part II

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Agenda: Training part II - 10. 3. 2021

Padlet assignment and questions

Mobile robot live coding with Santeri Saari

Lecture: Exoskeletons (by Anja Poberznik)

Presentation: Industrial exoskeletons (by Meditas Oy)

Wrap up

Padlet Assignment and Questions

How could be a mobile robot combined with / connected to other devices/technologies in the future?

<https://padlet.com/anjapoberznik/assignment>

Santeri Saari

Mobile robot live coding

Service robots and Exoskeletons: Part II

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Lecture contents

Introduction to exoskeletons: definition & history

Classification of exoskeletons

Military exoskeletons

Sports exoskeletons

Industrial exoskeletons



Service robots and exoskeletons



Service robots and exoskeletons

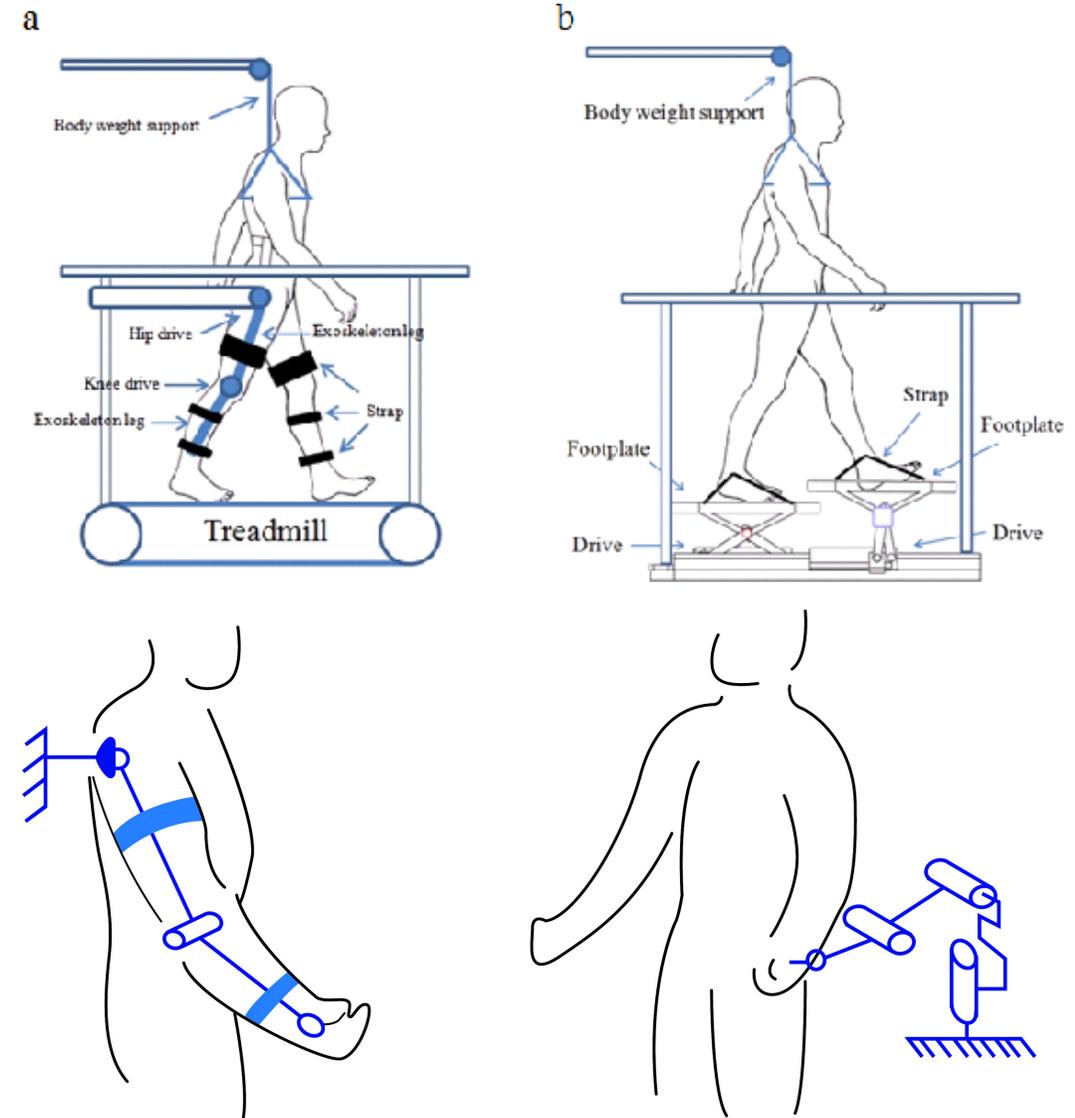
Introduction

Exoskeleton is an external, anatomical and mechanical support frame which the user wears (=wearable robot).

Exoskeleton vs end-effector

End-effector = only the distal part is connected to the user, the robot joints don't match with the human joints. Force generated at the distal interface changes the positions of other joints simultaneously, making isolated movement of a single joint difficult.

Exoskeleton = mechanic joints resemble the human joints and force is generated at these joints.



History of exoskeletons: where did it all start?

- 1960s scientific and technological work on exoskeletons
- Industrial exoskeleton Hardiman project 1965-1971, unsuccessful
- From military applications to medical rehabilitation and mobility aids
- End of 1960s and early 1970s exoskeletons for gait assistance at Mihajlo Pupin Institute (Serbia) and University of Wisconsin-Madison (USA)
- Today applied in military, industry, sports and healthcare (therapeutic exoskeletons, assistive devices)



Hardiman
Image: cyberneticzoo.com

Classification and types

Body part actuation:

- full body
- upper extremities: arms and torso
- lower extremities: legs

How is it built?

- **rigid**: rigid materials such as metals or carbon fiber
- **soft**: flexible materials in the entire construction (soft exoskeleton or exosuit)



LiftSuit by Auxivo

Classification: power supply

- **active = powered** (batteries or electric cable connections to run sensors and actuators)
- **passive = unpowered** (increase strength and provide stability through a combination of human guided flexion/extension, weight re-distribution, locking mechanisms, energy capture)
- **pseudo-passive** (use batteries, sensors, and other electronics, but they are not used to provide actuation)
- **hybrid** (utilize FES)

Classification: user-machine interface

- **joystick:** reserved for exoskeletons that provide 100% of the energy for motion needed by the wearer (e.g. Rex)
- **buttons or control panels:** the exoskeleton is placed in different pre-programmed modes.
- **mind-controlled:** using an electrode skull cap
- **sensors:** integrated sensors that monitor rotation, torque, tilt, pressure and can capture nerve signals in the arms and legs
- **no control:** some passive exoskeletons have no control buttons or switches

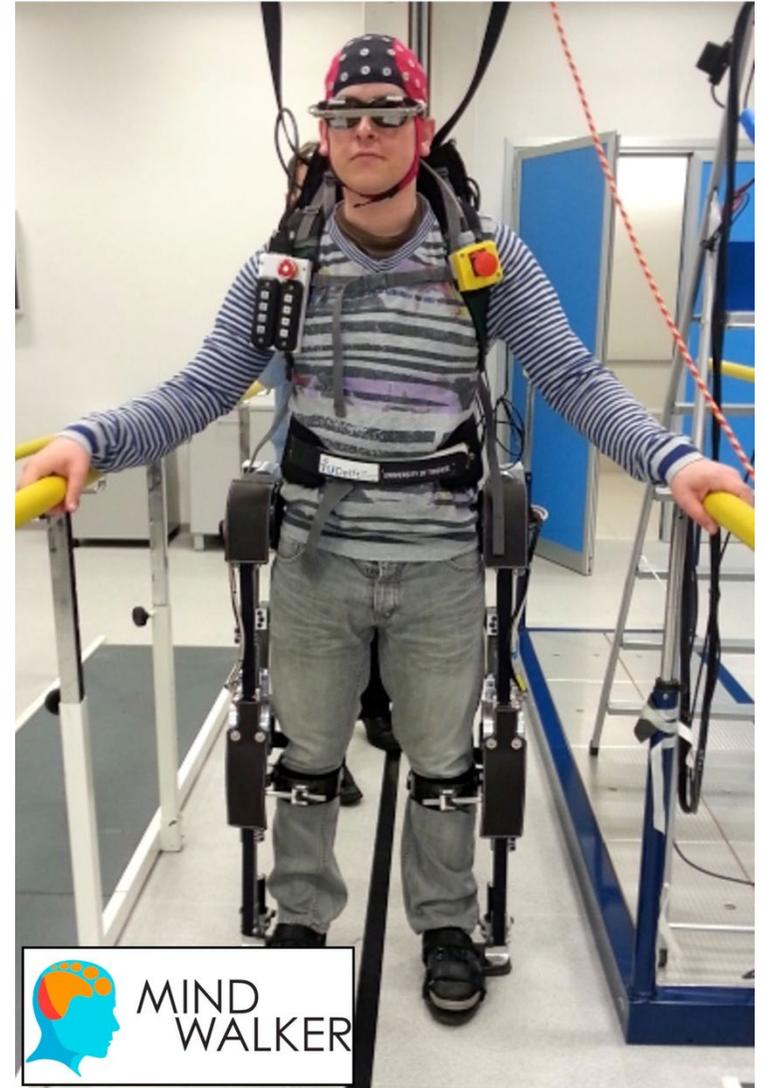


Image: researchgate.net

Classification: mobility

- **fixed:** the exoskeleton is tethered, attached to a wall or suspended from the air by a fixed hook and harness.
- **supported:** the exoskeleton is attached to an overhead rail, supported by a moving frame or supported by an adjacent wheeled robot.
- **mobile:** the user and exoskeleton can move over ground freely.



Military exoskeletons

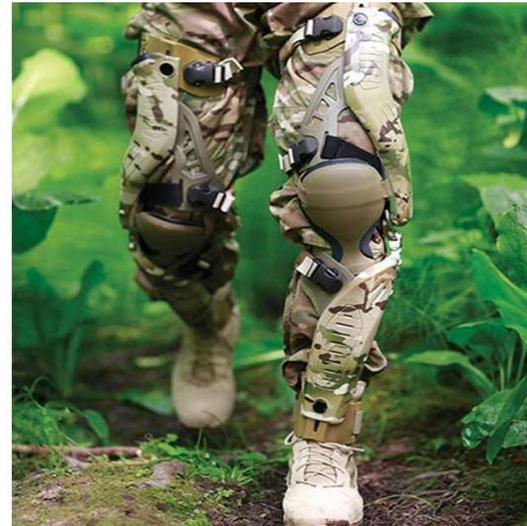
- redirect the load carried by the soldier to the ground
- help to evenly distribute weight and avoid skeletal overstress and pressure injuries
- increase ability to traverse stairs, inclines, and rough terrain, especially with load
- reduce fatigue



UPRISE by MAWASHI



ONYX by Lockheed Martin



PowerWalk by Bionic Power



Marine Mojo

Sports (consumer) exoskeletons

- reduce the physical impact from bumps and shocks on the body
- delay muscle fatigue and reduce pain in the legs
- don't take over the skiing experience from the user but instead allow them to ski longer and safer



Elevate by Roam Robotics



Ski~Mojo by Kinetic



Xnovers by Levier

Industrial exoskeletons

The role of industrial exoskeletons

- Exoskeleton technology can be seen as a bridging solution between the extremes of fully manual work and those tasks that demand typical industrial robots.
The intelligence of human operators combined with the strength and endurance of industrial robots.

Advantages of industrial exoskeletons

- repetitive tasks that are physically demanding
- utilized as a capabilities amplifier or as a fatigue and strain reducer
- body weight support
- lift assistance
- load maintenance
- positioning correction (ergonomics)
- body stabilization
- decrease the number of worker related injuries
- reducing healthcare and disability costs
- eliminating the need for expensive, “full on” automation solutions

Types of industrial exoskeletons



ARM SUPPORT



BACK SUPPORT



LEG SUPPORT



POWER GLOVE



TOOL HOLDING EXO



Skelex by Skelex



AIRFRAME by Levitate Tech.



legX by SuitX



Ironhand by BioServo



Fortis by Lockheed Martin Corp.

Some considerations

by Exoskeleton Advisory Committee, Washington State Department of Labor & Industries (2019) regarding "[Return to work and use of exoskeletons](#)".

- Appropriateness for returning to work?
- Exoskeleton benefits for injured workers?
- Prescribing an exoskeleton for injured worker e.g. assigning type of exoskeleton to type of injury?
- Assessing efficacy of exoskeletons for injured workers?
- Unintended consequences, e.g. adverse effects of using exoskeletons post-injury?
- Acceptance of exoskeletons in workplace?
- Psychological factors, e.g. overcoming fear of re-injury, social acceptability of exoskeletons, cognitive workload?
- Determining training/acclimatization?



Situation in Finland

Meditas Oy: <https://www.meditas.fi/exoskeletonit>

Skelex 360-XFR

Ironhand®

Auxivo lift suit

Exofinland Oy: <https://www.exofinland.fi/>

Laevo exoskeleton

Comau MATE exoskeleton

Part III: 11. 3. 2021

1pm – 3pm (CET) / 2pm – 4 pm (EET)

Sneak peek...

Lecture: Medical exoskeletons

Guest interview with Taina Jyräkoski
(physiotherapist) about using a medical
exoskeleton

Live demoing of a medical exoskeleton



Thank you!

See you tomorrow!