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Institut Thématique Multi-Organismes
Technologies pour la santé

Les apports de la robotique collaborative en santé

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Carnot Interfaces

Typology

"Autonomous" robots

- The programmer gives high level instructions
- The robot translates into simple tasks
- Condition: the task can be described easily for a robot
- Autonomous robots are today limited to close environments and simple / repetitive tasks

Collaborative robots

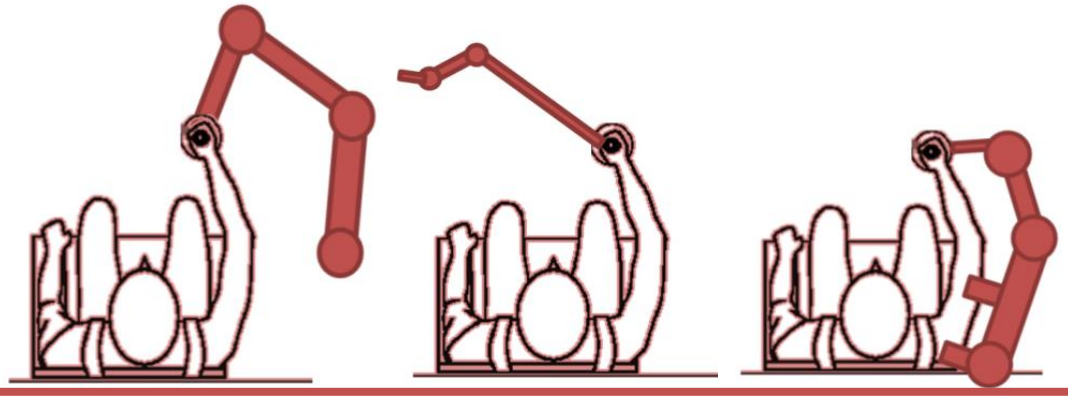
- Robotized tools
- A user is in the loop in real-time and controls the robot movements
- Control sharing
- Telemanipulation (the user is at a distance) vs comanipulation (user + robot co-localized).

Two types of collaborative robots

Telemanipulation

Comanipulation

Parallel comanipulation | Serial comanipulation | Orthotic comanipulation



Comanipulators

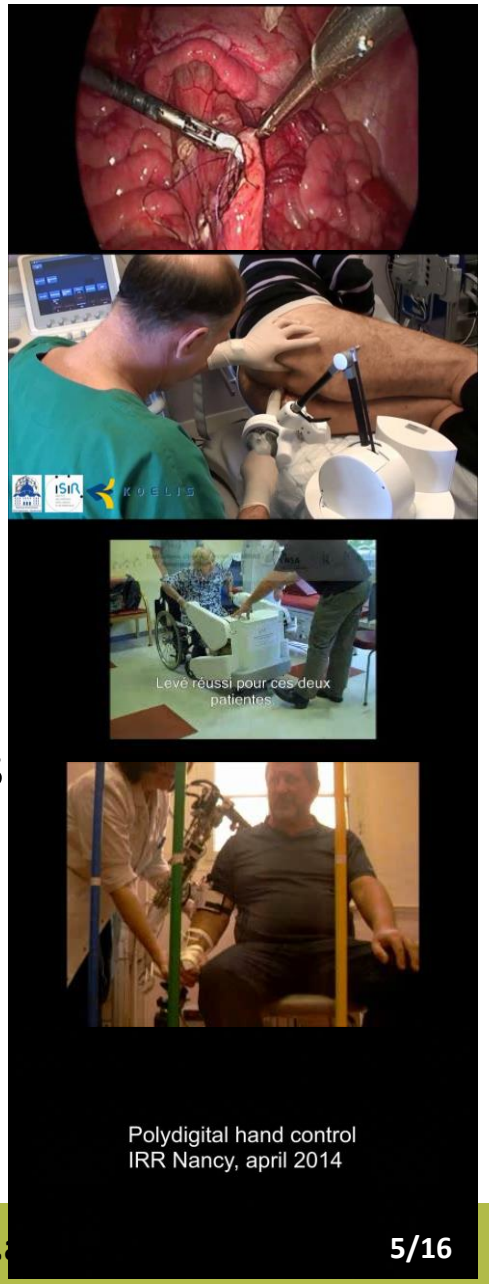
A comanipulator is a smart active tool aimed at:

- Improving the user's performance: higher precision, faster task execution, safer task execution.
- Reducing the user's tiredness (short term) and fatigue (long term, e.g. musculoskeletal disorders).
- Reducing the learning curve for skill acquisition.

Ultimately, it shall allow the realization of a task that is not feasible for the user otherwise (nor manually nor with standard passive instruments)

Applications for health

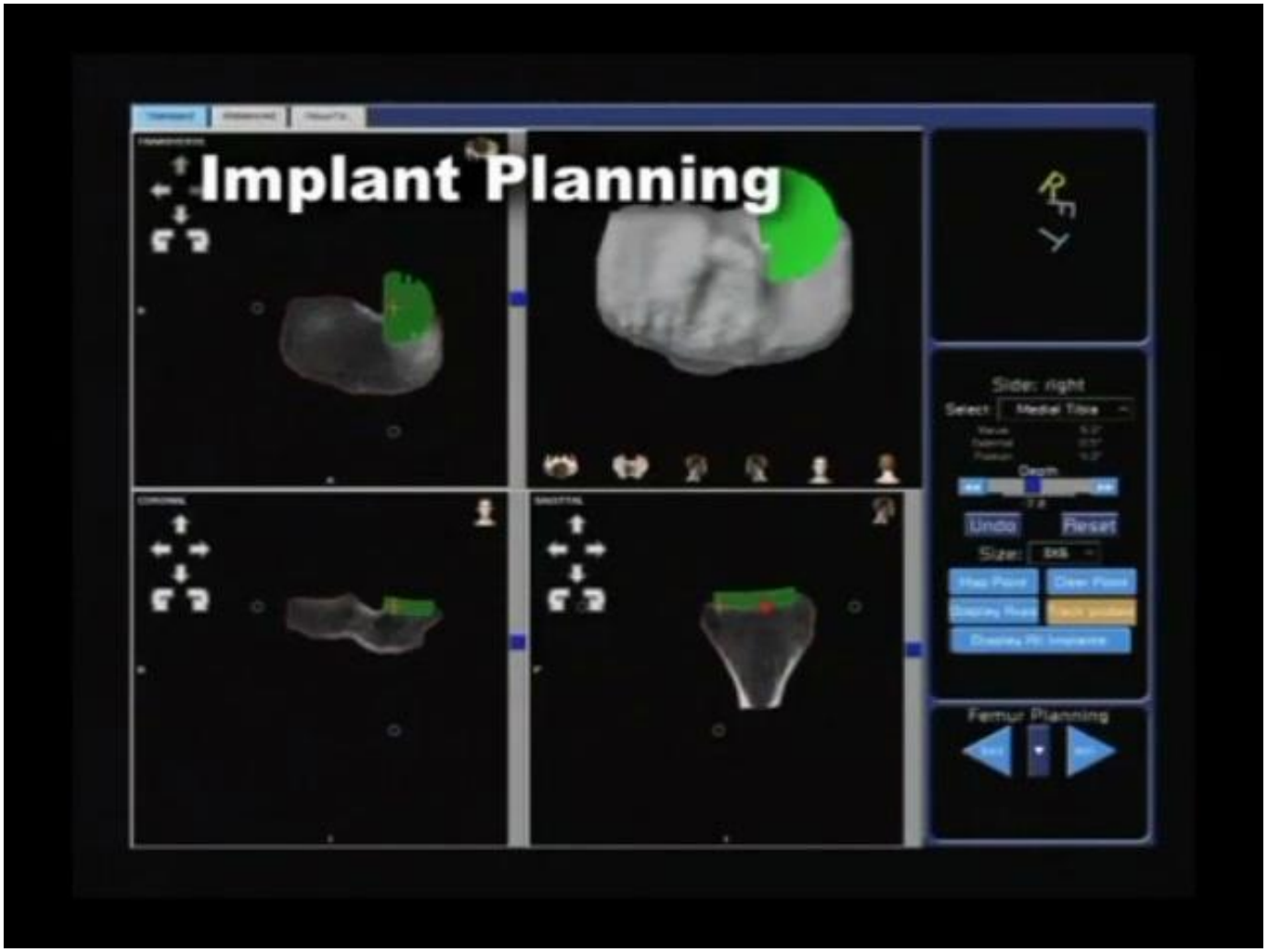
- Assistance to surgery / interventional gestures:
  - Manual instruments integrating a robotized (or even simply motorized) functions
  - Robots guiding a passive instrument held by the surgeon
- Assistance to patients with motor deficiency:
  - Physical Medicine and Rehabilitation (robots that help motor learning)
  - Permanent assistance to movements (e.g. robotized walking aids, exoskeletons, etc.)
  - Robotized limbs (robotic prosthetics).



Challenges

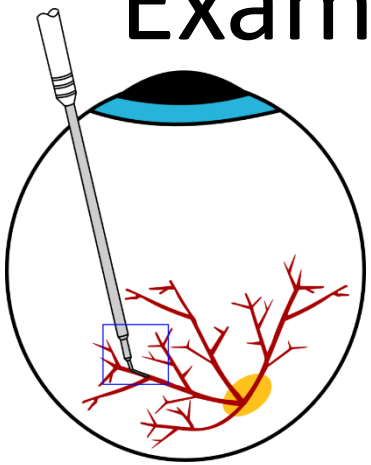
- **Robustness in control sharing** : how to design the sensorimotor coupling so as to ease a gesture ?
  - Constraints : No ambiguous nor wrong behavior
  - Strategies:
    - understanding / anticipating human motor intentions and acting accordingly
    - Applying force fields that change the tool/interaction dynamics so as to ease its manipulation
- **Intuitiveness** : how to ensure that the user does not ultimately, the user shall not notice it is a “smart” tool. It is just a tool that behaves without any
- **Transparency** when not used.

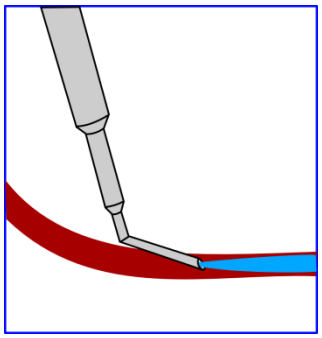
Example 1: guidance from a plan



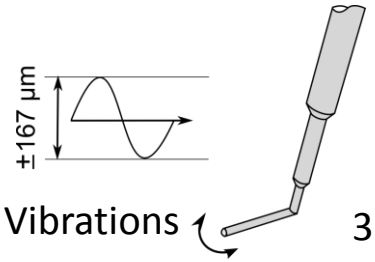
Credits:
MakoSurgical

Example 2: Increasing Precision (1)

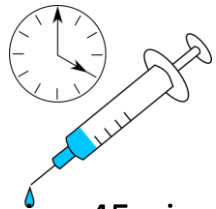




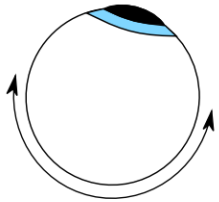
10 µm



Vibrations

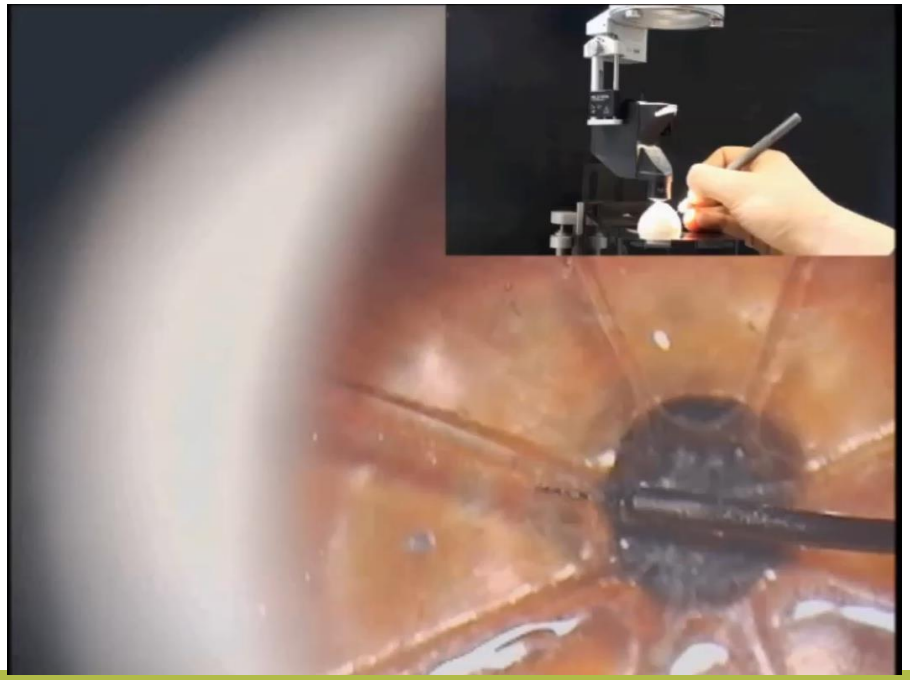


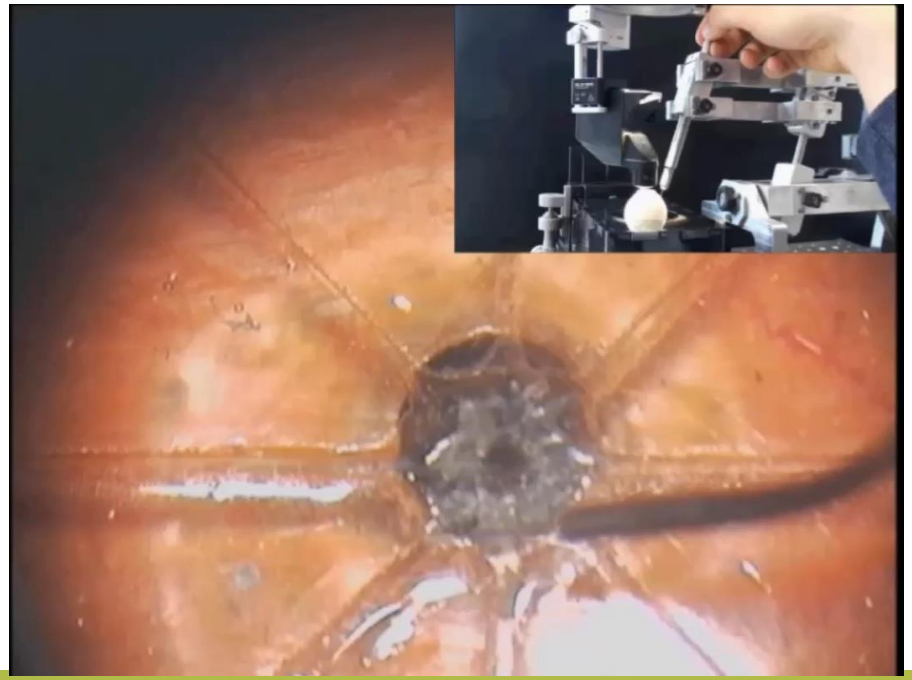
3 min - 45min



Rotation

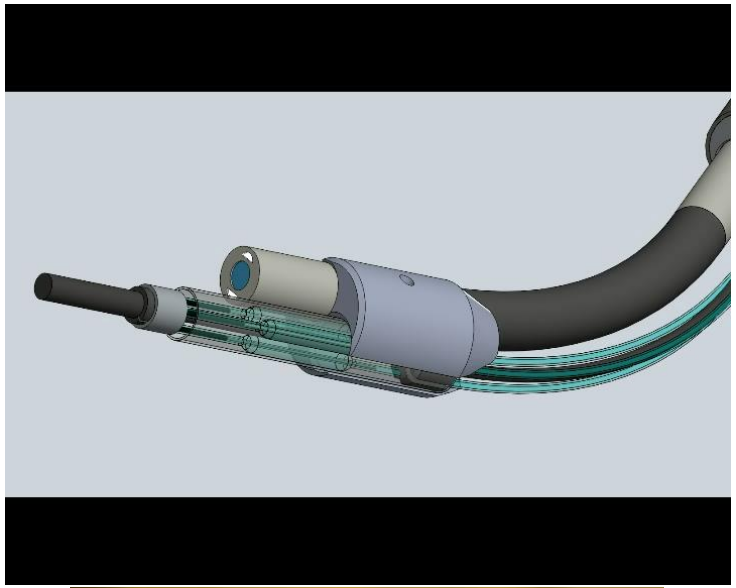
Credits: Emmanuel Van Der Poorten, KU Leuven



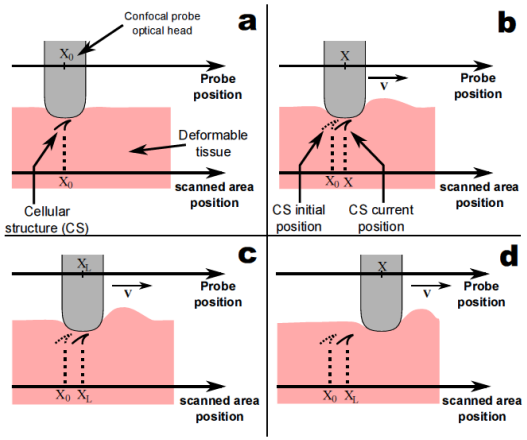


Example 3: Increasing precision (2)

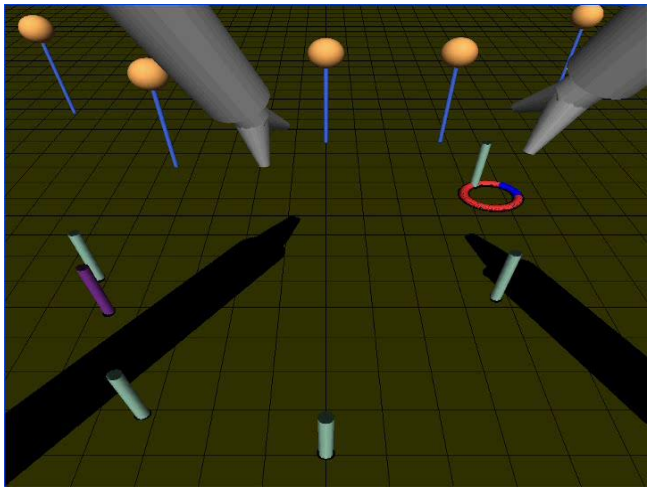
Anchoring and actuation principles



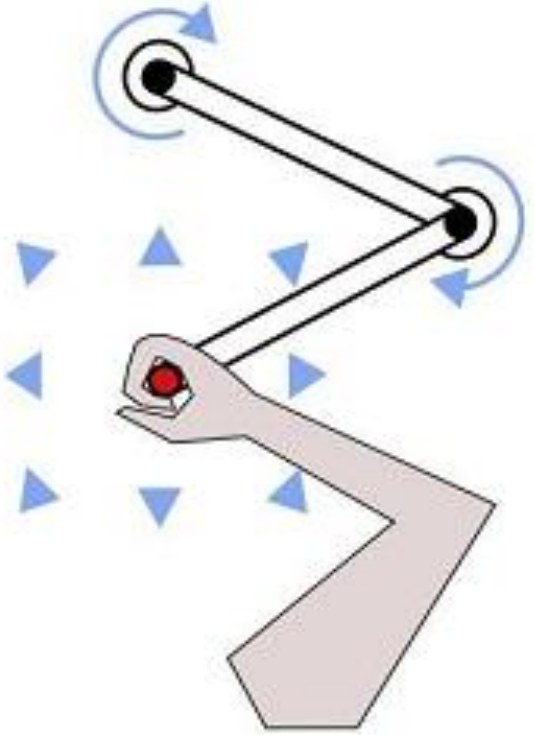
Generating mosaics with visual servoing



Example 4: enhancing dexterity

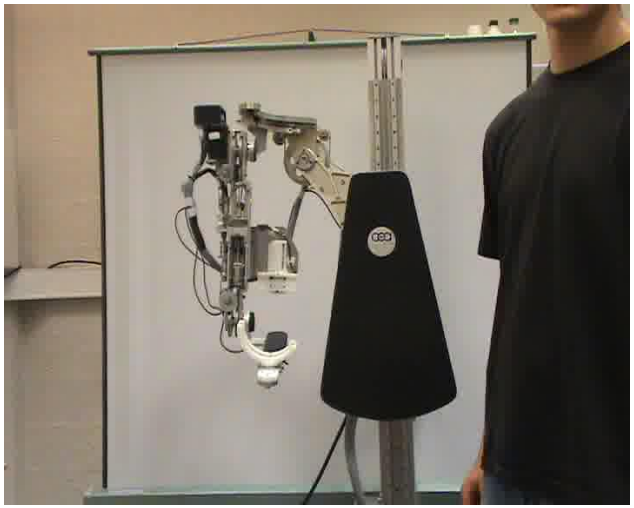


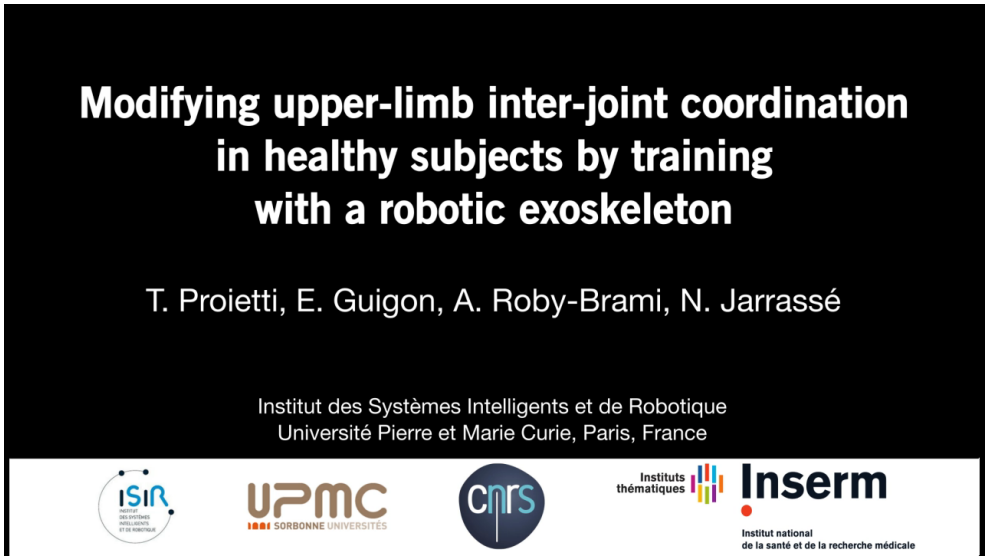
Example 5: rehabilitation robotics



Credits: N. Hogan H. Krebs, MIT

Example 6: exoskeletons for rehab

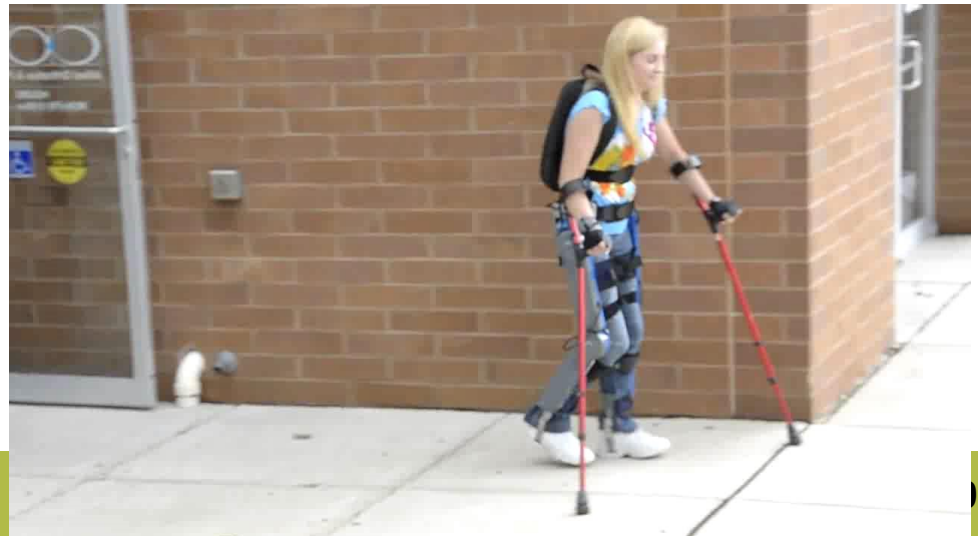




Example 7: Leg exoskeletons for patients without leg motor power

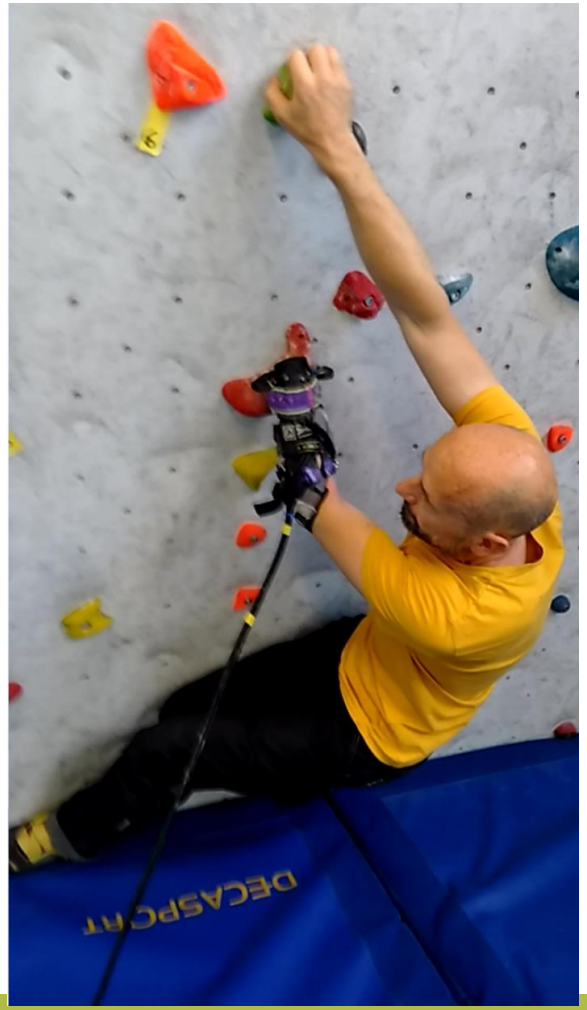
Credits:
🡐 Re-Walk

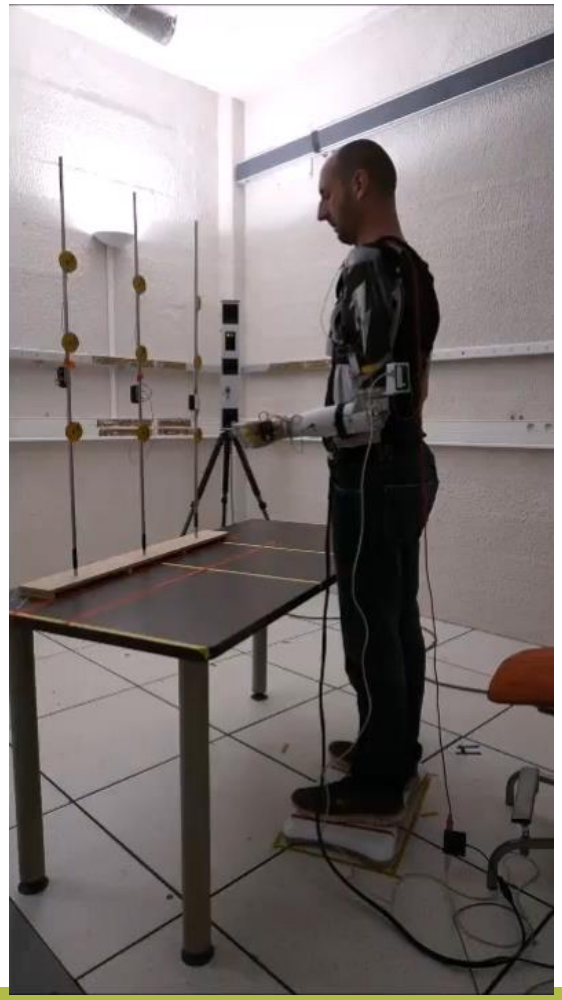
Wandercraft 🡒



Example 8: smart walkers

Example 9: Prostheses with intuitive coupling / control





A short summary & conclusion

- Collaborative robotics is a relatively new approach, offering promises:
  - Useful functions
  - Easy adoption
  - Safety improvement
  - Cost reduction (as compared to e.g. telemanipulation)
- A wide range of technological and scientific questions, most of them pertaining to interactivity and robustness.
- Multidisciplinarity and translational research are a must.