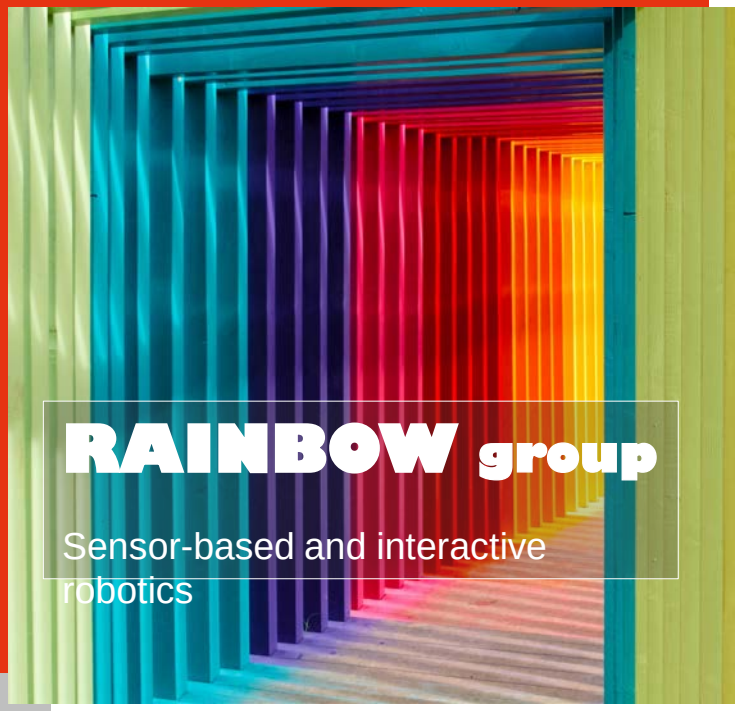


Assistive robotics and mobility aids: Compensation, rehabilitation and interaction

Marie Babel

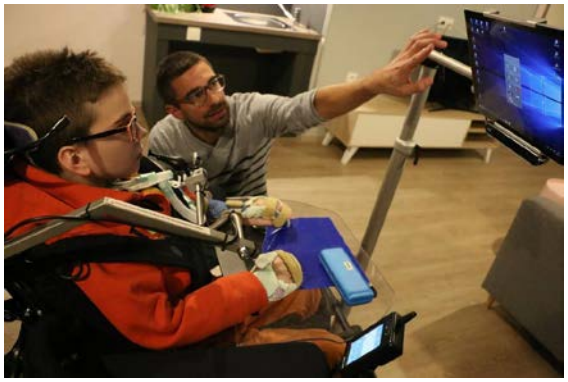
Innovation, Handicap, Autonomy and Accessibility Chair / INSA Rennes
IRISA/Inria – Rainbow team

2020/12/15 – Rob&IA seminar

Mobility assistance: needs and trends

Mobility deficiency: a worldwide challenge

- 110 to 190 millions of adults with mobility difficulties
- Mobility aids as an answer
- Limitation of use due to visual/cognitive deficiencies



Designing assistive technologies should…

- Enhance mobility capacities
- Compensate impairments
- Match individual needs

… but should not

- Increase cognitive workload
- Lower capacities or overcompensate
- Do tasks in place of the user

Creation and innovation

User-centered conception for people with disabilities

- Enhancing mobility performances
- Increasing motivation for rehabilitation
- Improving and securing rehabilitation processes

Rennes : multidisciplinary teams and projects

- Computer science, Robotics, Electroniques, Mechanics, Virtual reality
- Biomechanics, psychology
- Physical medicine and rehabilitation

A truly useful and used device: methodology

Co-design with medical staffs

- to guarantee the acceptance of the solution
- to prevent from a mismatch between user expectations and final design

Iterative and pragmatic process

- regular clinical trials
- continous integration of hardware and software components

Enhancing the mobility: contributions

Achieving effective navigation

- Robotics and shared control
- Navigation assistance: smart power wheelchair, smart walker…
- Social navigation and interaction: respect of social conventions for an inclusive mobility

For an augmented navigation experience

- Creation and fabrication of the next generation of physical human-robot-environment interfaces
  - > provide multiple sensations
  - > improve the performance of navigation tasks

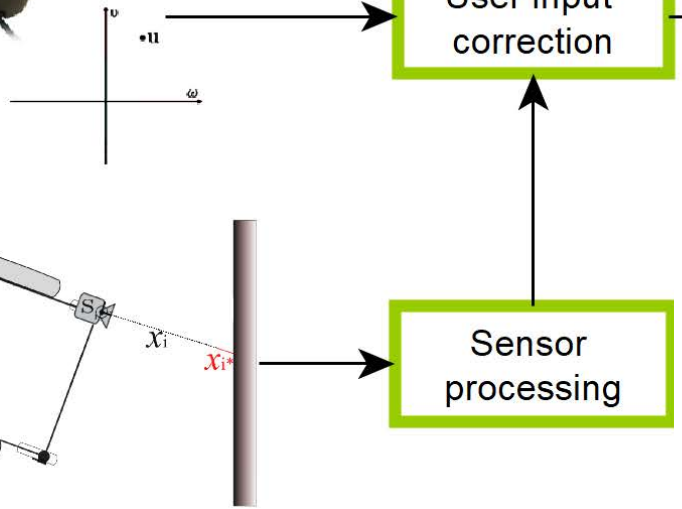
Simulation and Virtual Reality

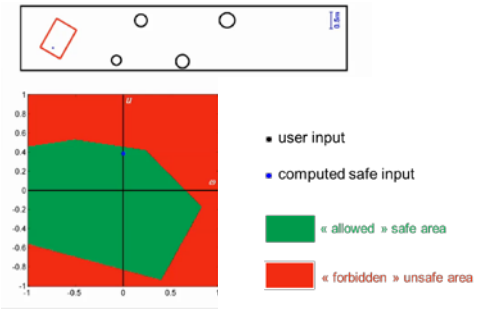
- Design of an immersive simulator for assisted power wheelchair driving: towards training and rehabilitation applications

Trajectory correction and obstacle avoidance

Shared control: principles [ICORR2017][IROS 2016]

- Sensor-based servoing and user intention detection





Trajectory correction and obstacle avoidance

Case study – Indoor navigation

- Patient from Pôle Saint Hélier – cognitive and visual deficiencies
  - > First time driving with a power wheelchair

Navigation in corridor

Navigation in cluttered environment

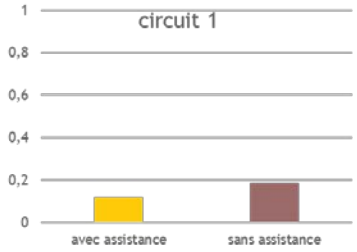
Elevator entrance

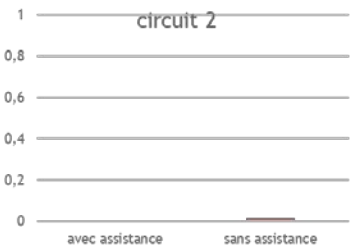
- > Navigation without collision
- > Enhance motivation for rehabilitation
- > Positive feedback from clinicians

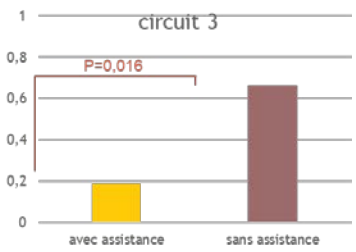
SWADAPT 1

Clinical trials on standardized courses

- Tests in Rehab center Pôle Saint Hélier (Rennes) in June 2019
- 30 patients with neurological disorders, regular power wheelchair drivers
- Increase of driving performances (less collisions, smoothness…)







SWADAPT 2

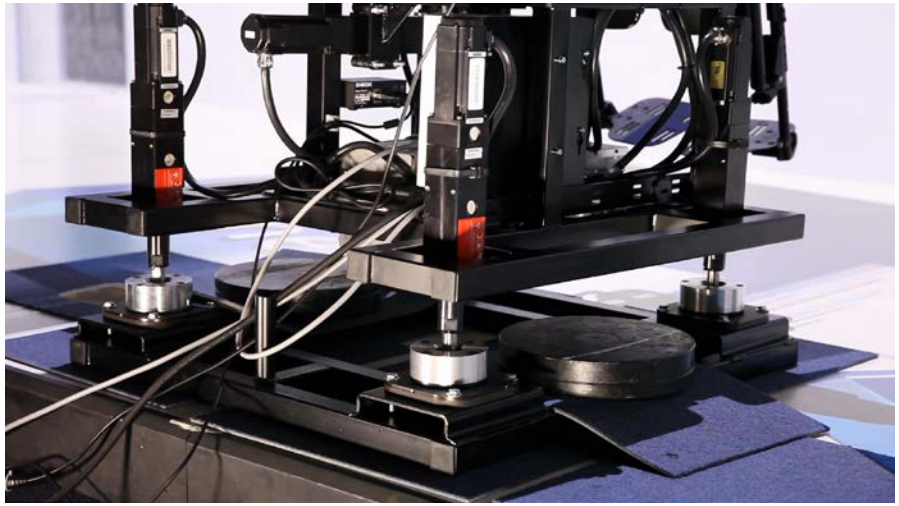
Clinical trials on standardized courses

- Tests in INSA (Rennes) in July 2020
- 8 patients experiencing driving difficulties and/or not allowed to have a power wheelchair
- Illustrative trial : patient with cerebellar syndrome and visual impairment

Immersive driving simulator [ICORR2019]

Objectives

- Training (first-time users, people experiencing driving difficulties…)
- Rehabilitation
- Evaluation of shared control solutions for research purposes



Driving virtual and immersive experience challenges

- Virtual Reality
  - > Multisensory simulator
  - > Motion platform: reproducing wheelchair motion cues and physical interaction with Virtual Environment
  - > Visual, haptic, auditory feedbacks

Various scenarios and display modalities

Indoor navigation – Immersia (large immersive room)

SIMADAPT1

[ICORR2019][SOFMER2019][HRI2020]

Real PWC vs simulator

- Evaluation of the quality and impression of driving with the INSA simulator

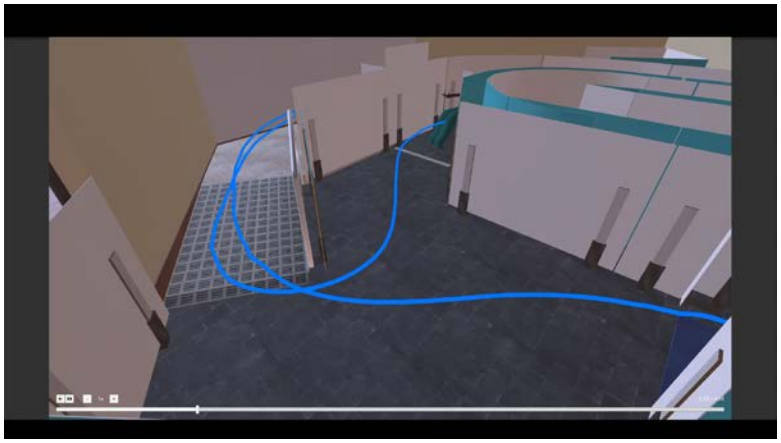
SIMADAPT1

High Sense of presence

- Personal presence: sense of being in the virtual environment
  - > Driving on a ramp: realistic “emptiness”
  - > Approaching an obstacle
- Environmental presence: feel motion reaction of the platform

Limited cybersickness

- Big difference between with and without motion plaform!



Social interaction for efficient virtual/real navigation

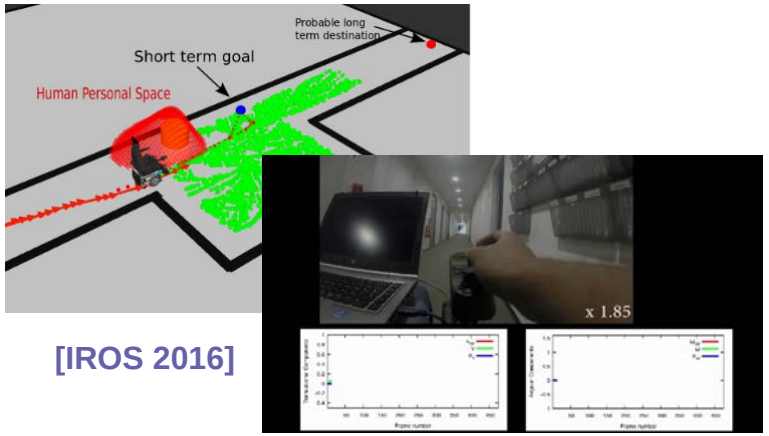
Objectives

- Defining smart assistance and efficient path-planning strategy
- Defining realistic behavior of virtual humans in case of interaction with wheelchair driver

Understanding social convention and interactions

- Walker / power wheelchair driver interaction: asymmetrical physical risk inducing differences in the walker's behavior in comparison to walker-walker situations.
- Adaptation of the personal space model

[SOFPEL 2019]



[IROS 2016]

Enhancing navigation comfort

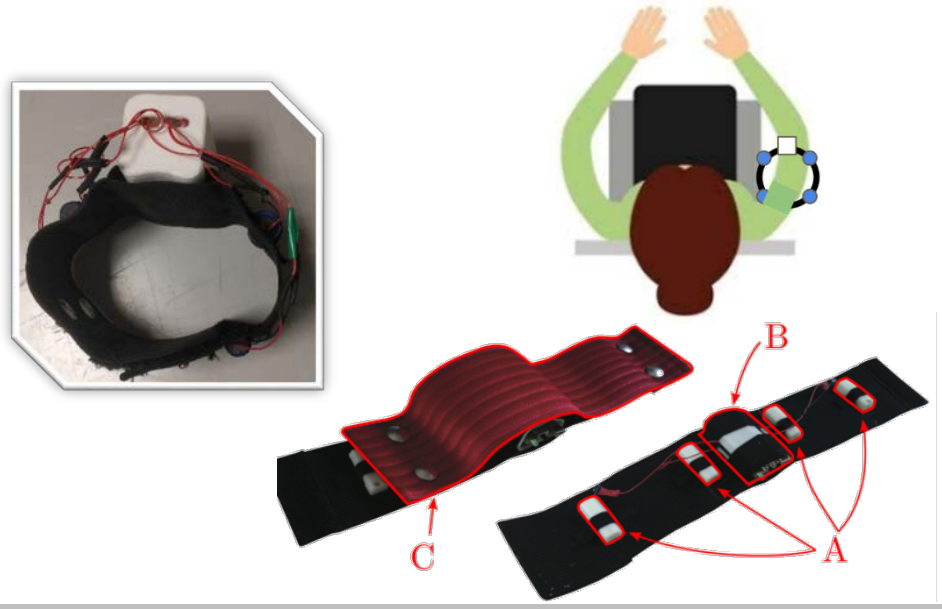
Path planning and trajectory curvature [ongoing…]

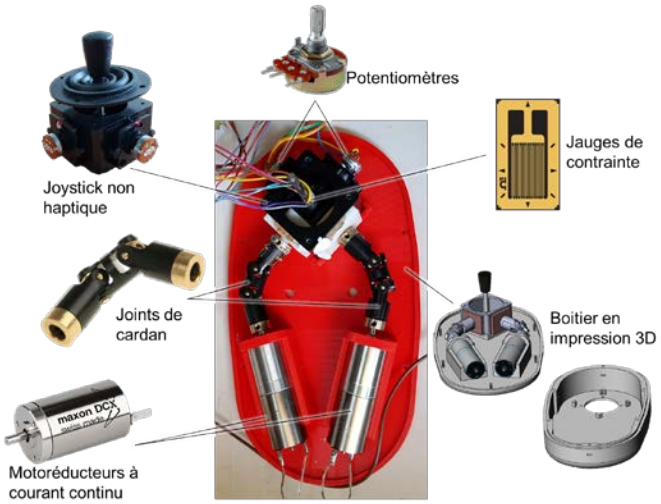
- Trajectory curvature directly linked to feasibility and comfort
- Cubic Bézier based RRT* version

Enriching perception

Haptic tools [SMC 2018, IEEE TH 2020] – Inria Associated team ISI4NaVE

- Analysis of physical Human-Robot Interaction
- Innovative multisensory physical interfaces
  - > Compensate both sensorimotor disabilities and cognitive impairments
  - > Definition of control strategies for warning and for rehabilitation
  - > Haptic joystick, haptic bracelet, tactile metaphors…

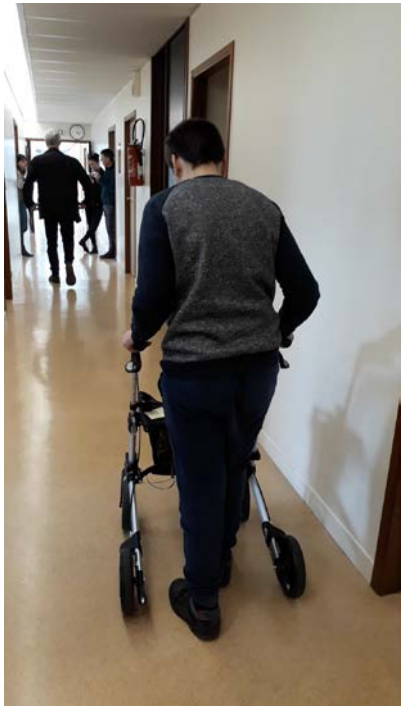




Interaction and assistance

Smart walker - Co-creation with the pediatric center Rey-Leroux

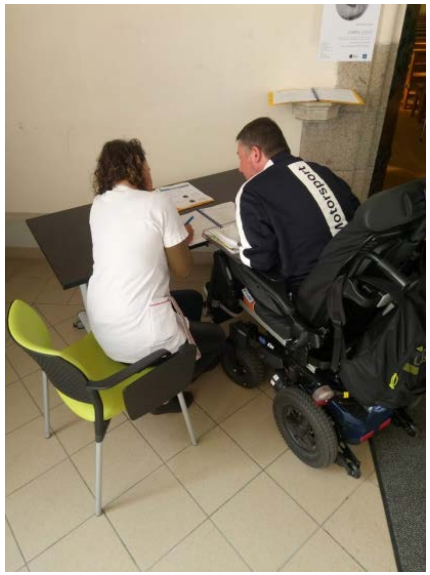
- Haptic feedback to help a blind boy (with severe cerebellar syndrome) to navigate safely
  - > not able to walk alone
  - > same sensors mounted onto the walker
  - > vibrating motors in the handles



Conclusion

Enhancing the mobility: a multidisciplinary question

- Assisting to increase accessibility and independance
- Co-creation as a key of success



Need of people at the interface of clinical and scientific worlds

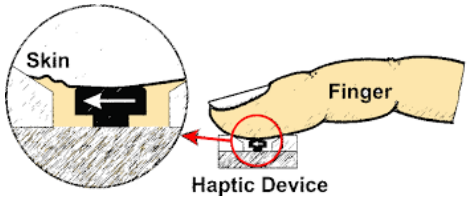
> 1 PhD in robotics (Louise Devigne) co-supervised by Marie Babel (INSA) and Philippe Gallien (medical doctor PSH) – 2015/2018

> 1 medical doctor (Emilie Leblong) will realize a PhD work with Marie Babel and Anne-Hélène Olivier (M2S) – 2020/2024

Next steps, new ideas, future projects…

Multimodal haptics, shared control, social interaction…

- Inria Challenge Dornell: A multimodal, shapeable haptic handle for mobility assistance of people with disabilities
- Collaboration with CEA-List / Clinatec: human-robot shared control through motor neuroprostheses (BCI) and multisensory feedback for severe motor disabilities
  - > wheelchair driving assistance
  - > upper-limb reach-to-grasp assistance
- Collaboration M2S/Pôle Saint Hélier/ University of Laval (Quebec): Integrating social Interaction in a Virtual Reality powered wheelchair simulator: Improving learning for inclusive mobility



Thanks!

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