

Shared control methods for powered wheelchairs

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Robotics Master Thesis

Nazarbayev University

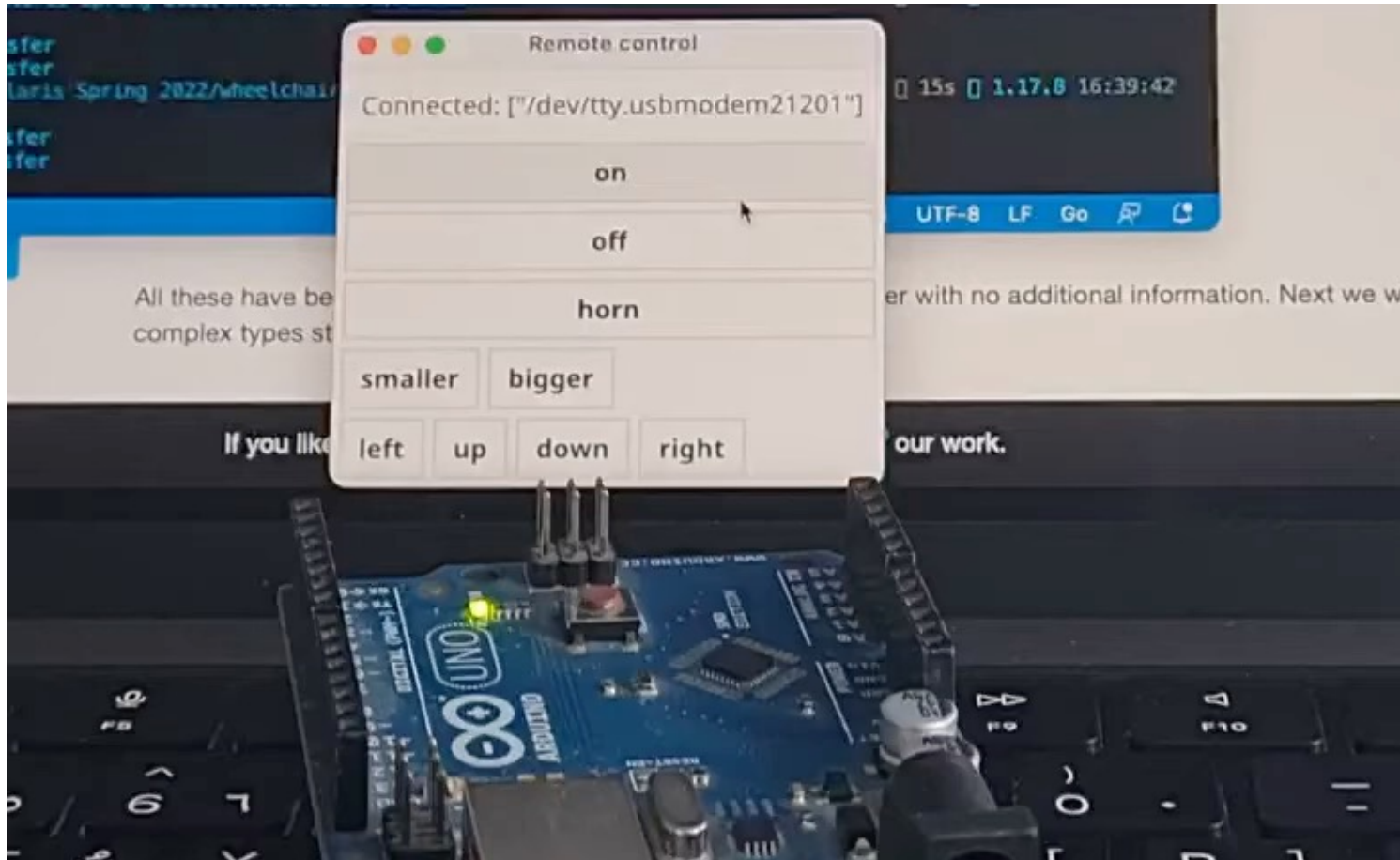
“Make a laptop stand”



Ortonica, Pulse 310



“Hack the remote”



Research Problem

Manual



Joystick



Initial Questions

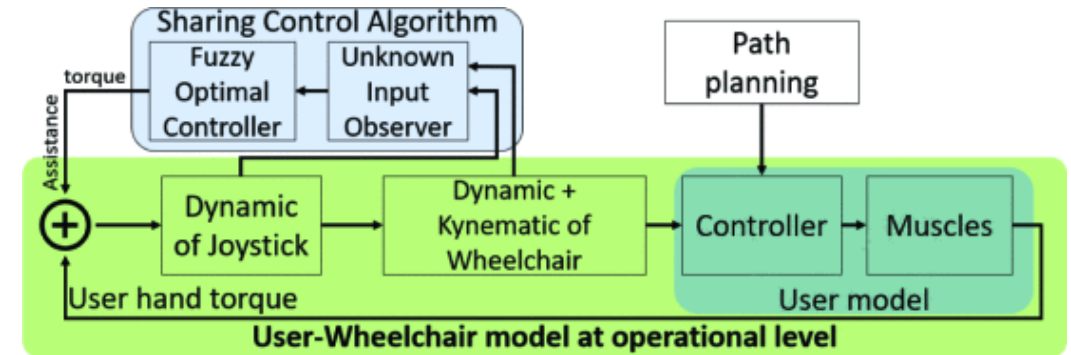
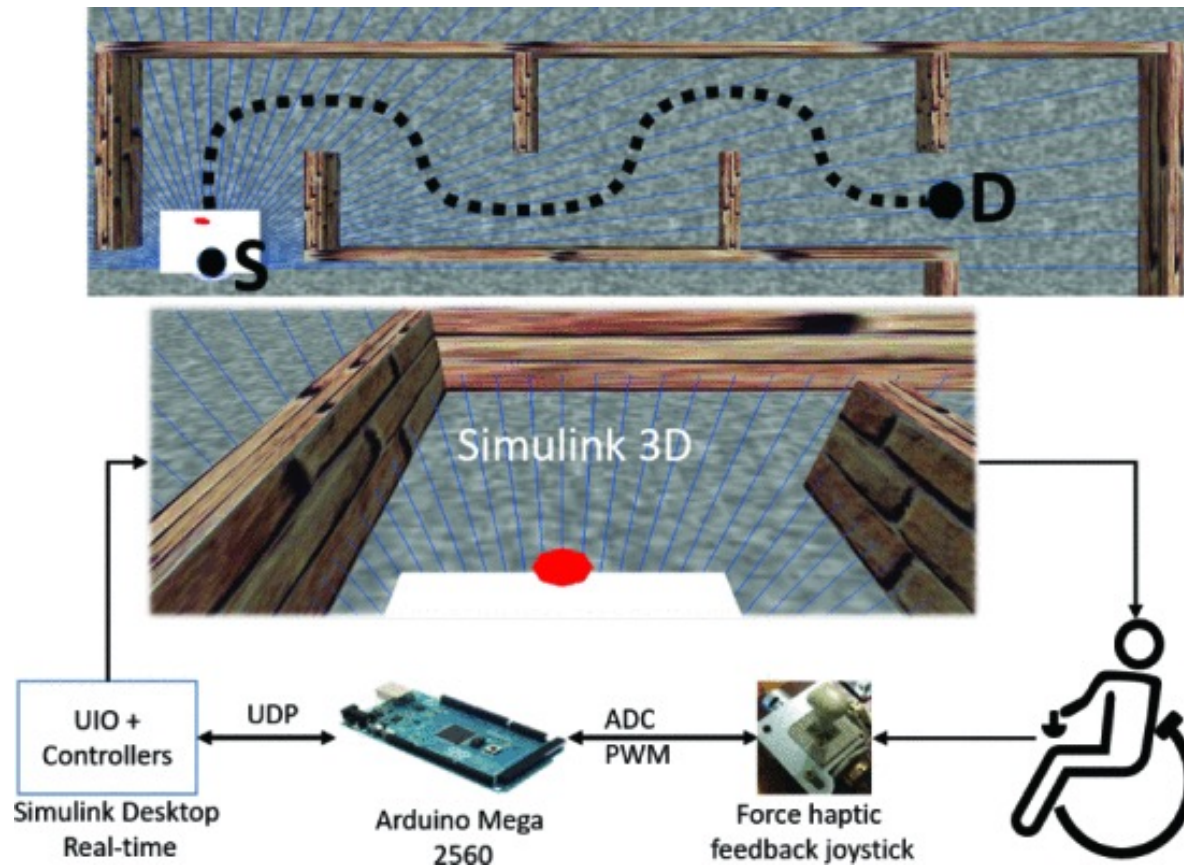
- How to drive wheelchair without external help?
 - What are alternative control methods?
 - What are current solutions?
 - Which can be done?
 - How good are they?

Thesis objective

- Creation of a shared control wheelchair
 - Implement different control methods
 - Compare control methods

Current Solutions (Literature review)

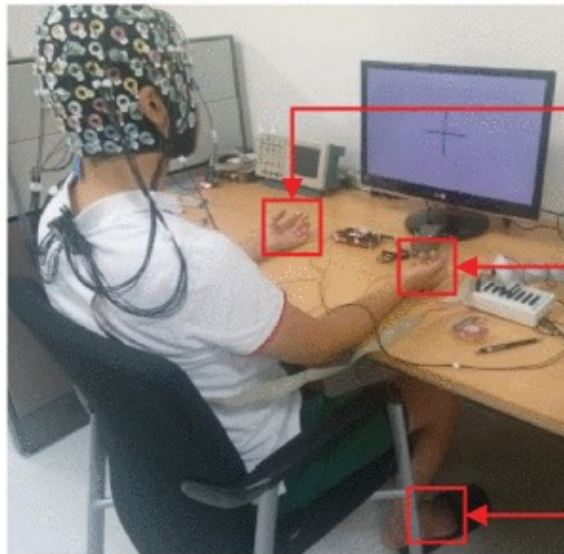
- Joystick Shared Control Approach



[8] Viet Thuan Nguyen, Chouki Sentouh, Philippe Pudlo, and Jean-Christophe Popieul. Path following controller for electric power wheelchair using model predictive control and transverse feedback linearization. In 2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC). IEEE, October 2018.

Current Solutions (Literature review)

- Brain Machine Interface



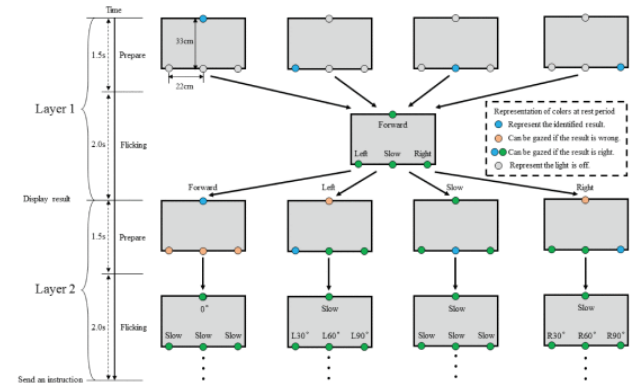
Experimental environments



Transducer



Atmega128



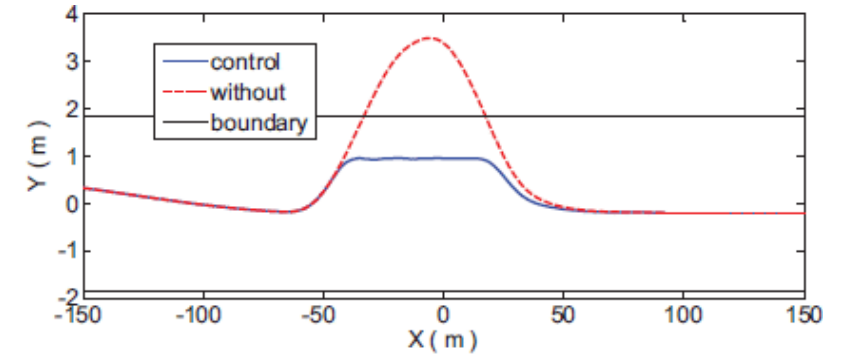
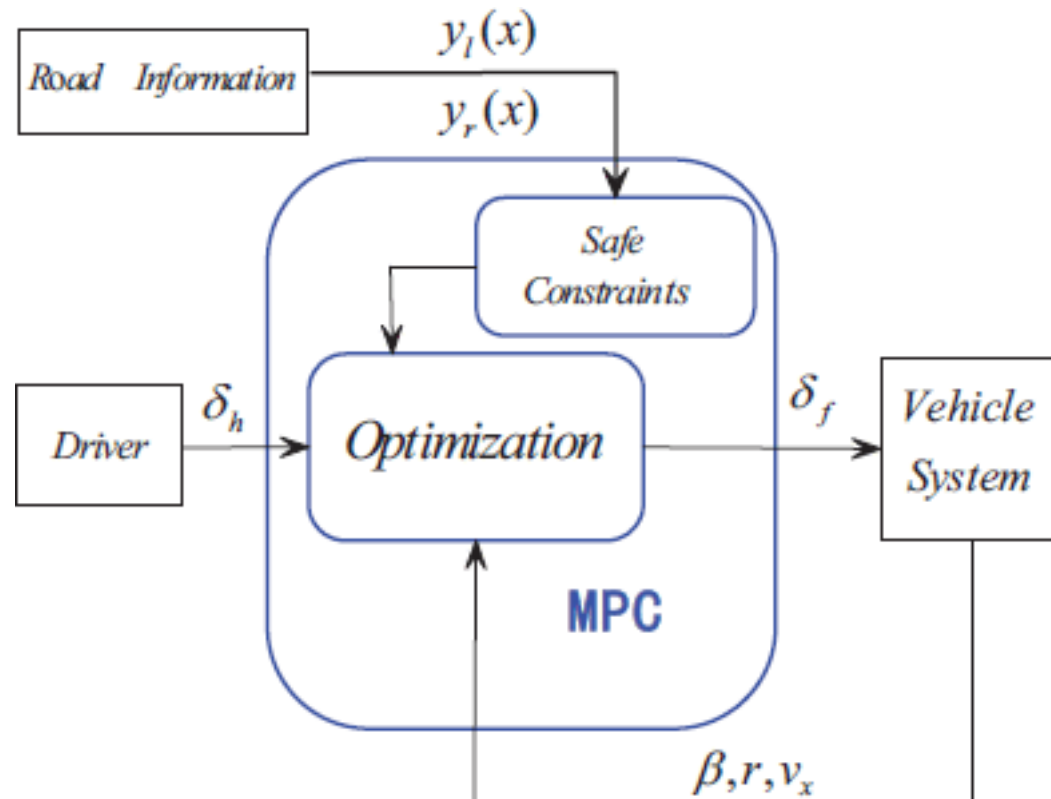
First layer	Second layer	Corresponding command
FD	0°	FD
TL	30°	TL30
	60°	TL60
	90°	TL90
TR	30°	TR30
	60°	TR60
	90°	TR90
The rest of combinations		SD

[3] Keun-Tae Kim, Heung-II Suk, and Seong-Whan Lee. Commanding a brain-controlled wheelchair using steady-state somatosensory evoked potentials. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 26(3):654–665, March 2018

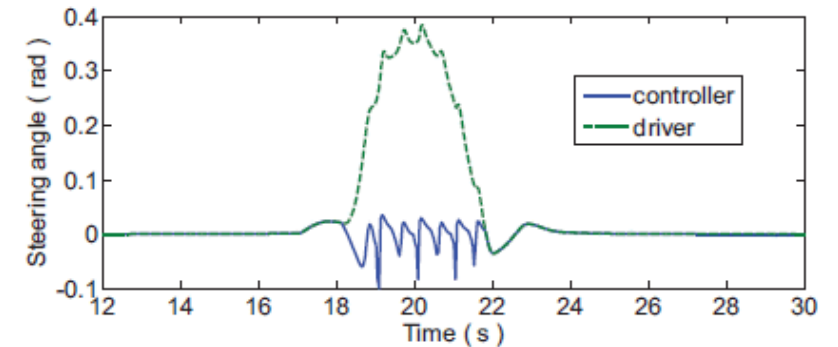
[8] Xiaoyan Deng, Zhu Liang Yu, Canguang Lin, Zhenghui Gu, and Yuanqing Li. A bayesian shared control approach for wheelchair robot with brain machine interface. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 28(1):328–338, January 2020

Current Solutions (Literature review)

- Model Predictive Control



(a) The vehicle's trajectory



(b) The front steering angle

[12] Linhuan Song, Hongyan Guo, Fei Wang, Jun Liu, and Hong Chen. Model pre-dictive control oriented shared steering control for intelligent vehicles. In 2017 29th Chinese Control And Decision Conference (CCDC). IEEE, May 2017

Methodology

- ✓ Literature review
- ✓ Problem formulation
 - Control methods selection
 - System design and development
 - Simulation and testing
 - Performance evaluation
 - Statistical analysis
 - Results and discussion

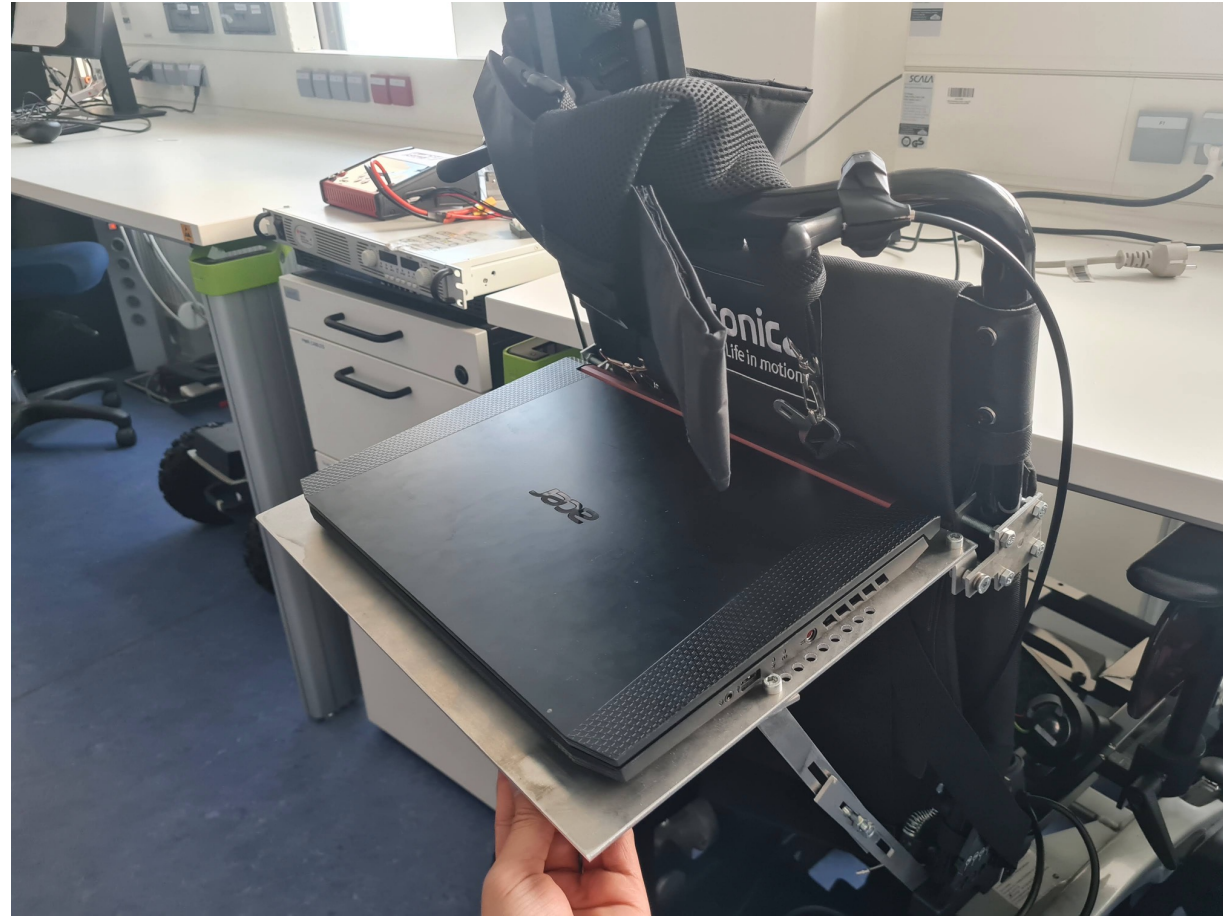
Design steps

- ✓ Host a PC
- ✓ Move wheelchair
 - Read ROS Twist
 - SLAM
 - Motion planning
 - Control methods

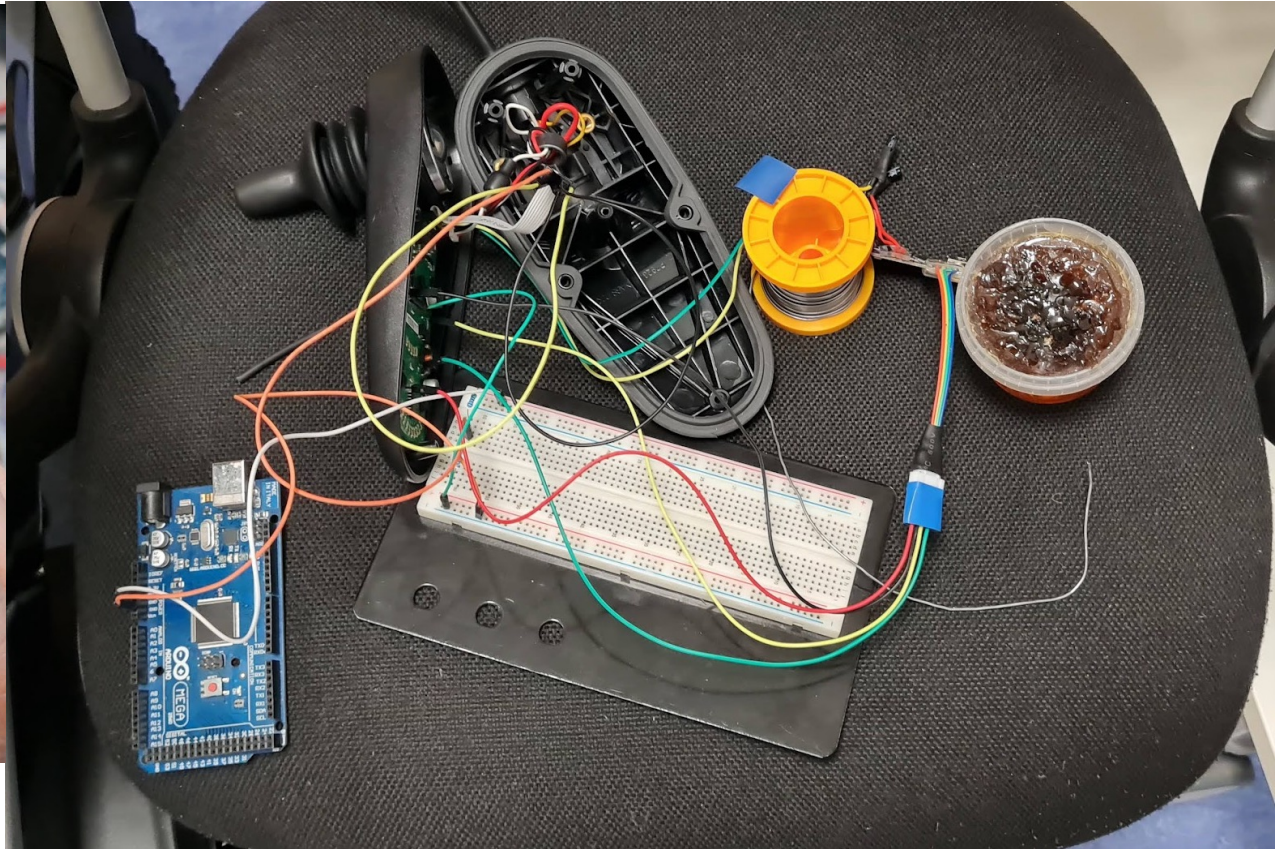
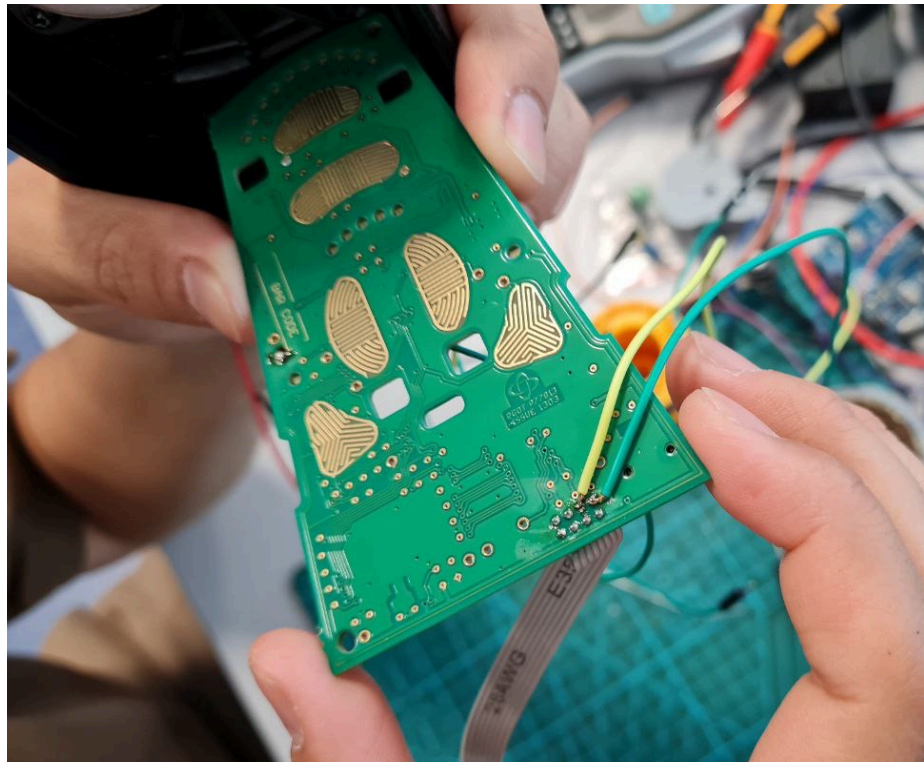
Host a PC



Ortonica, Pulse 310

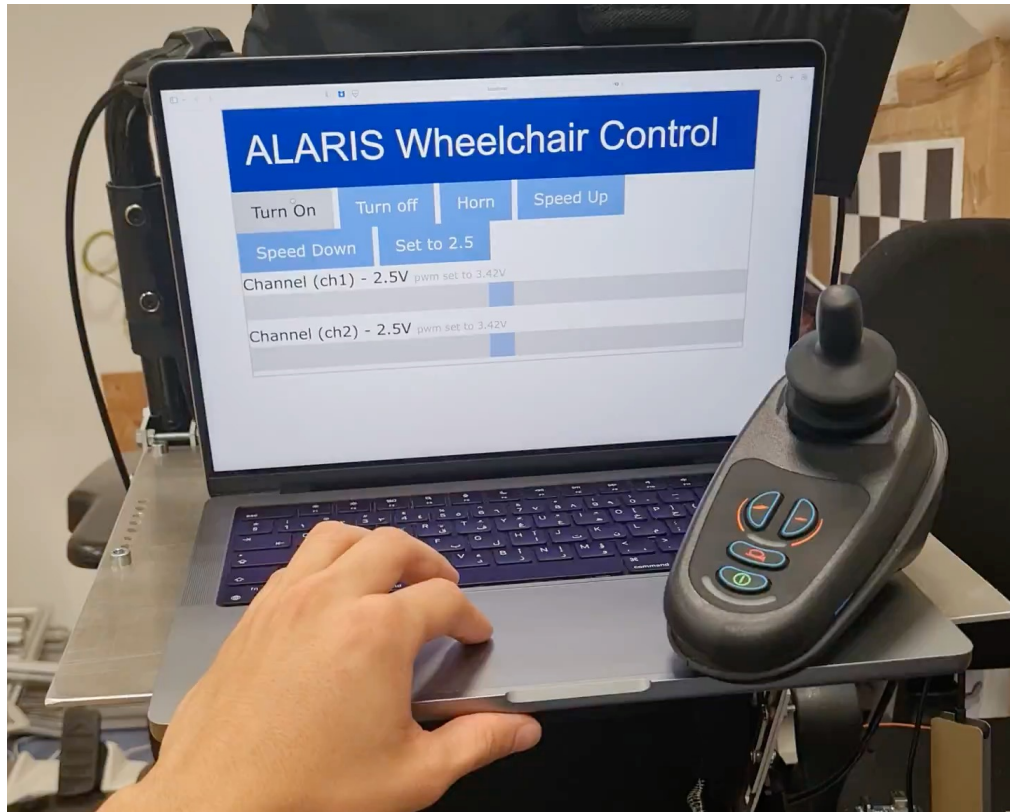


Hacking the wheelchair

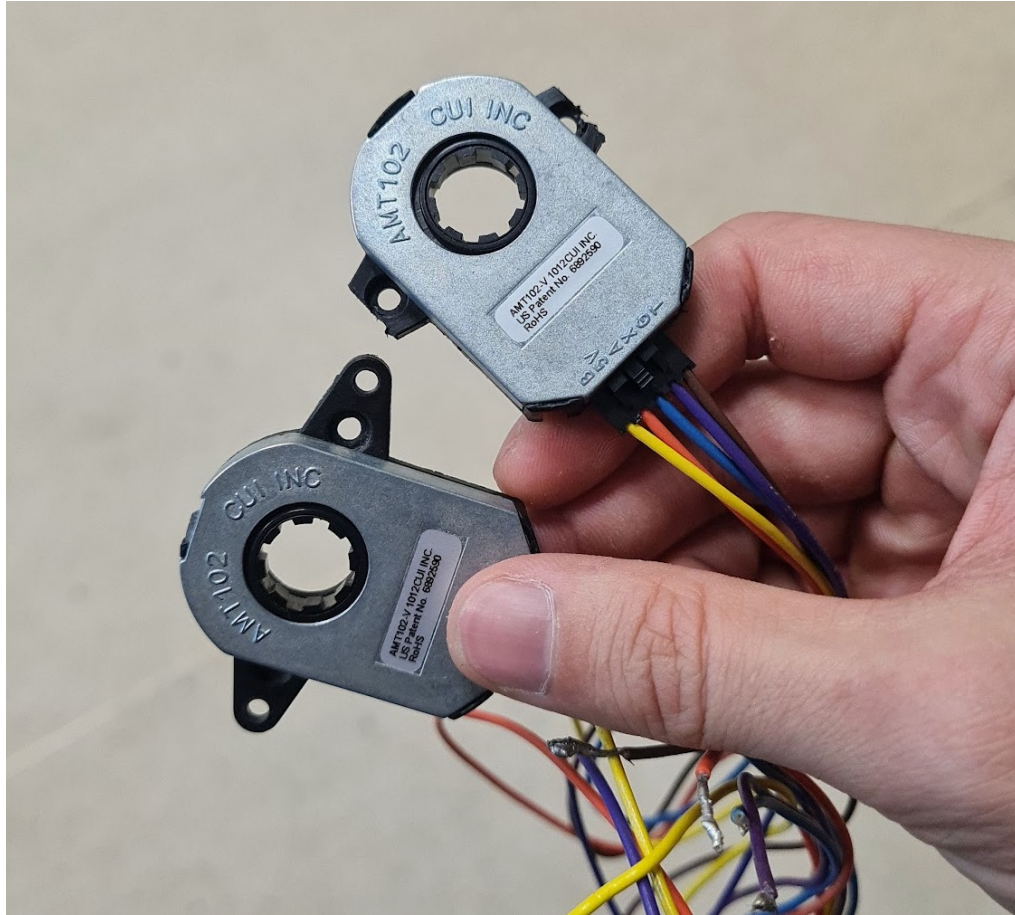


Controller hacking

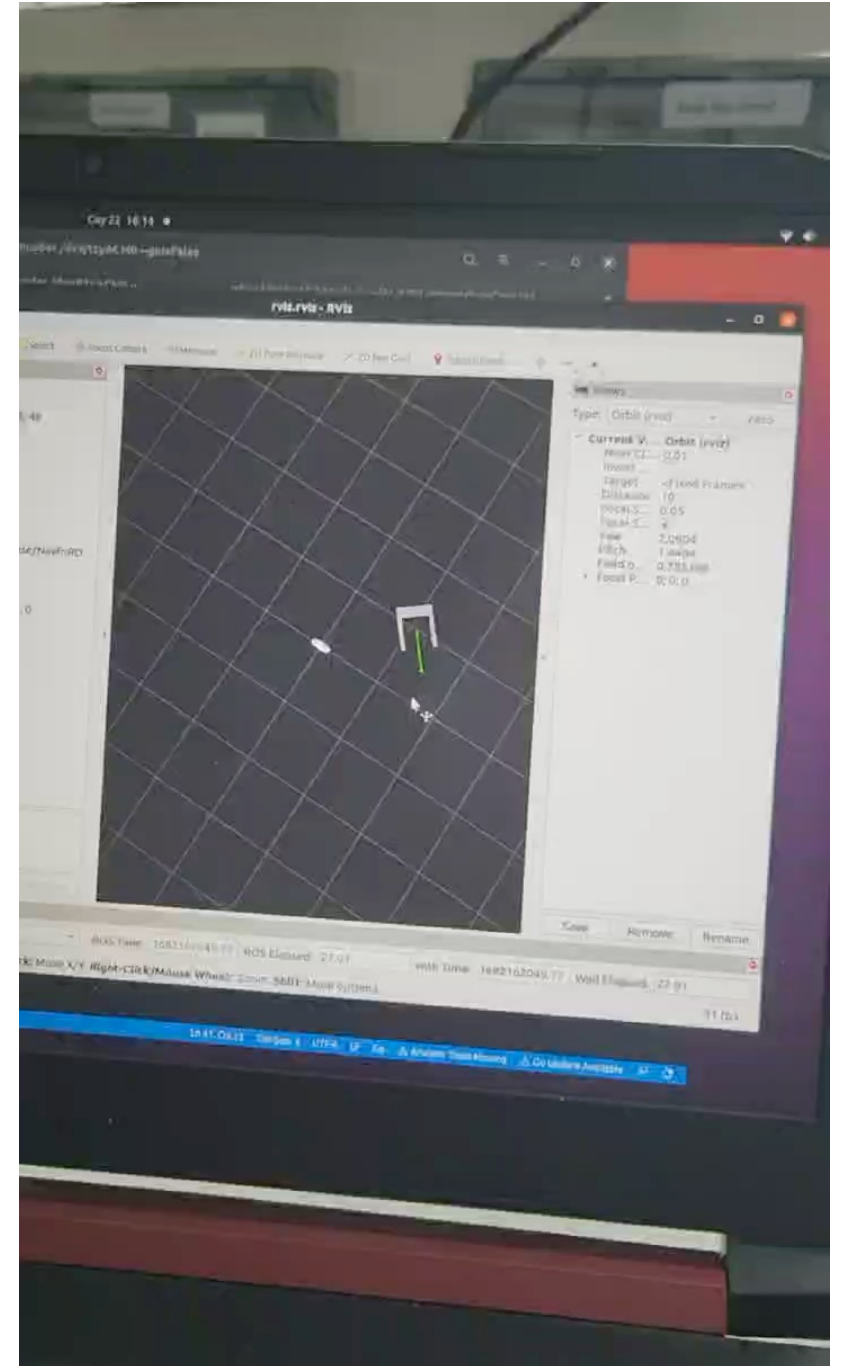
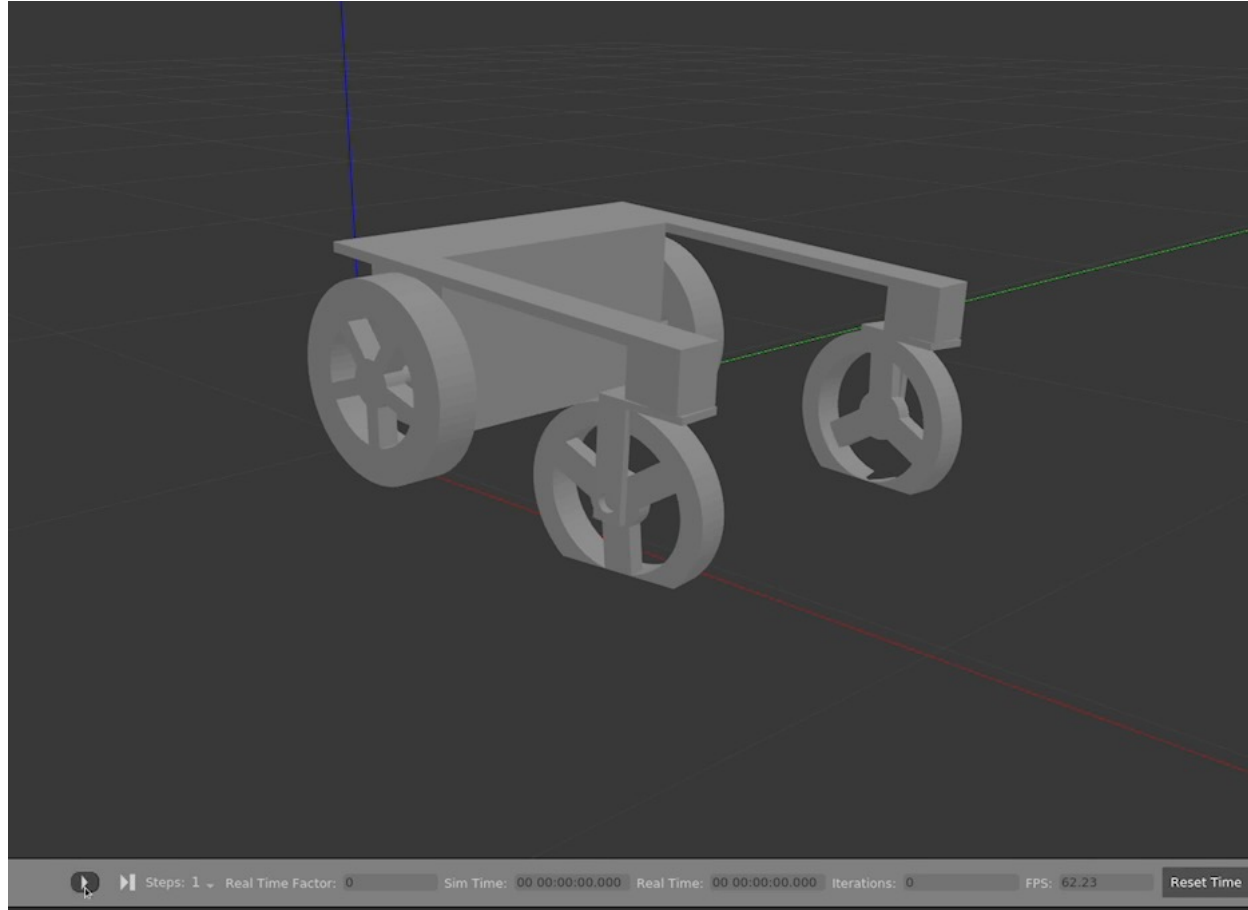
Controlling wheelchair



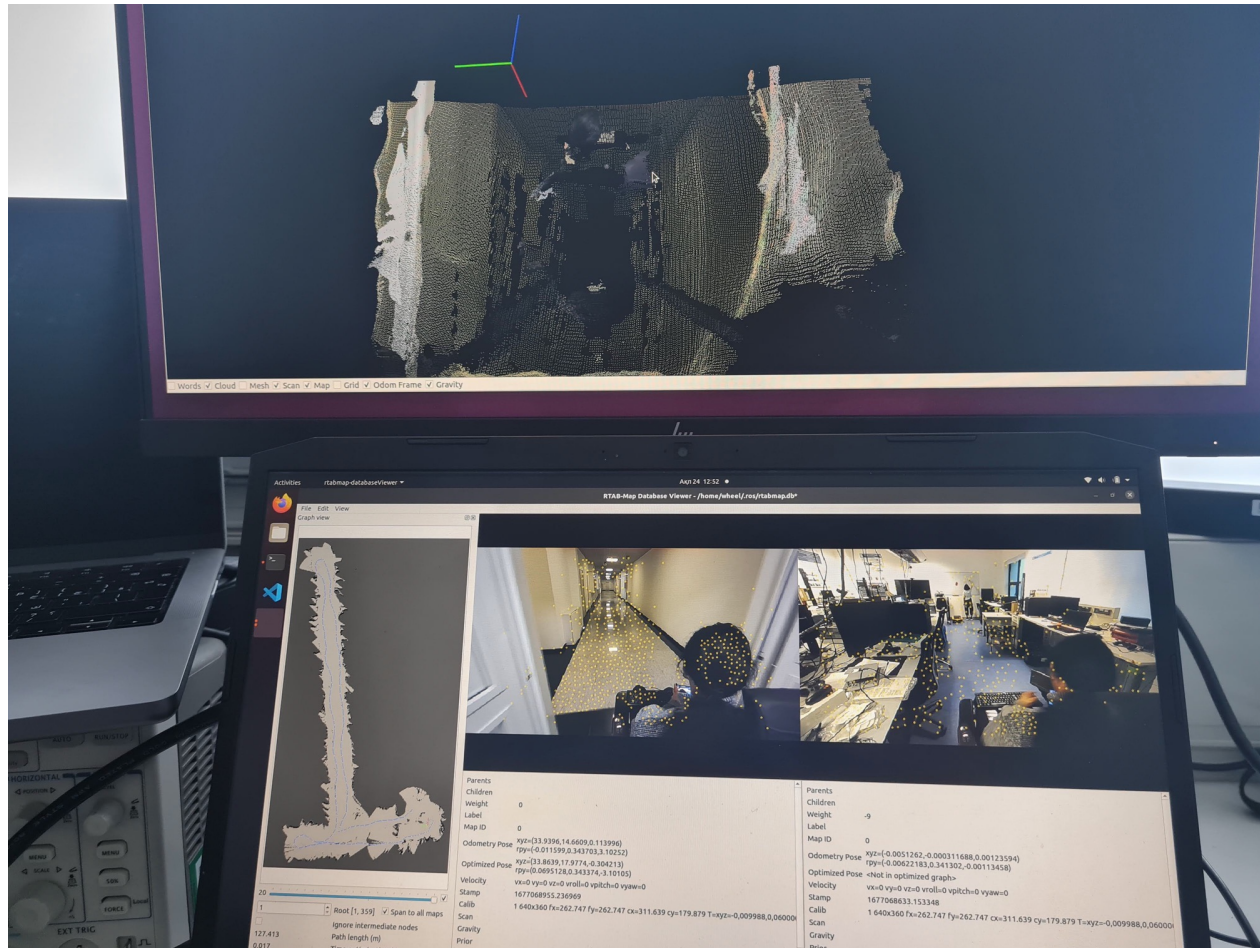
Localization



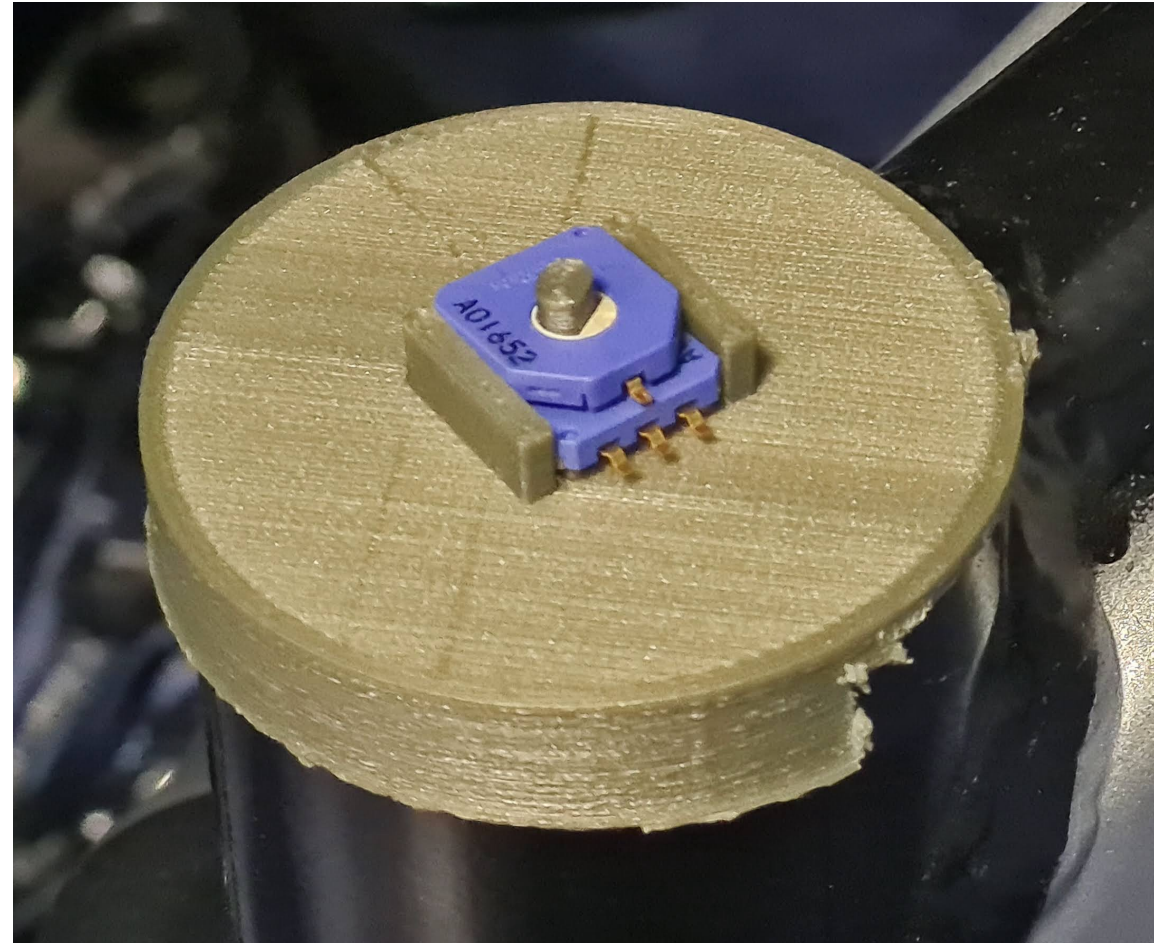
Moving without map



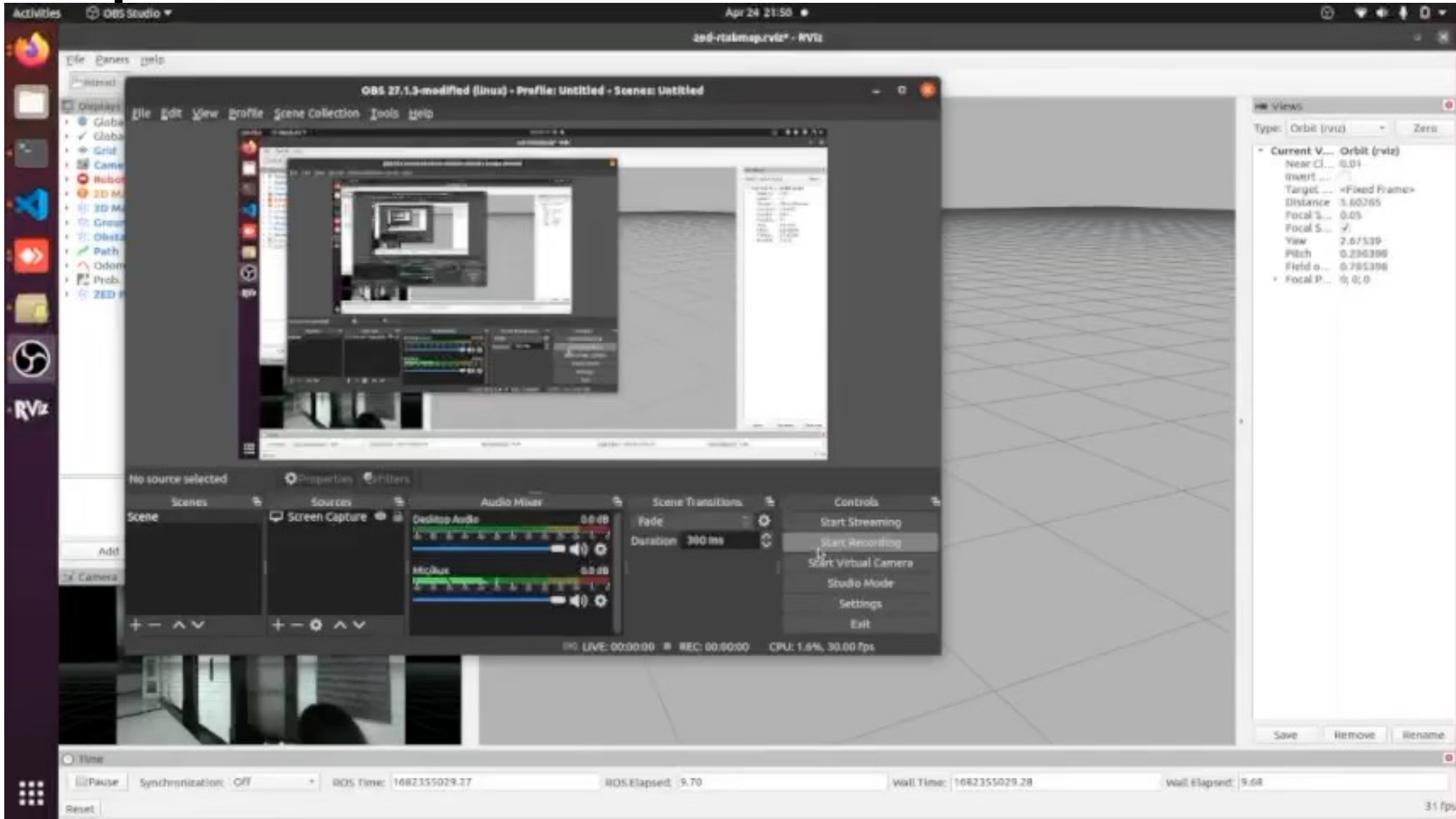
SLAM - Mapping



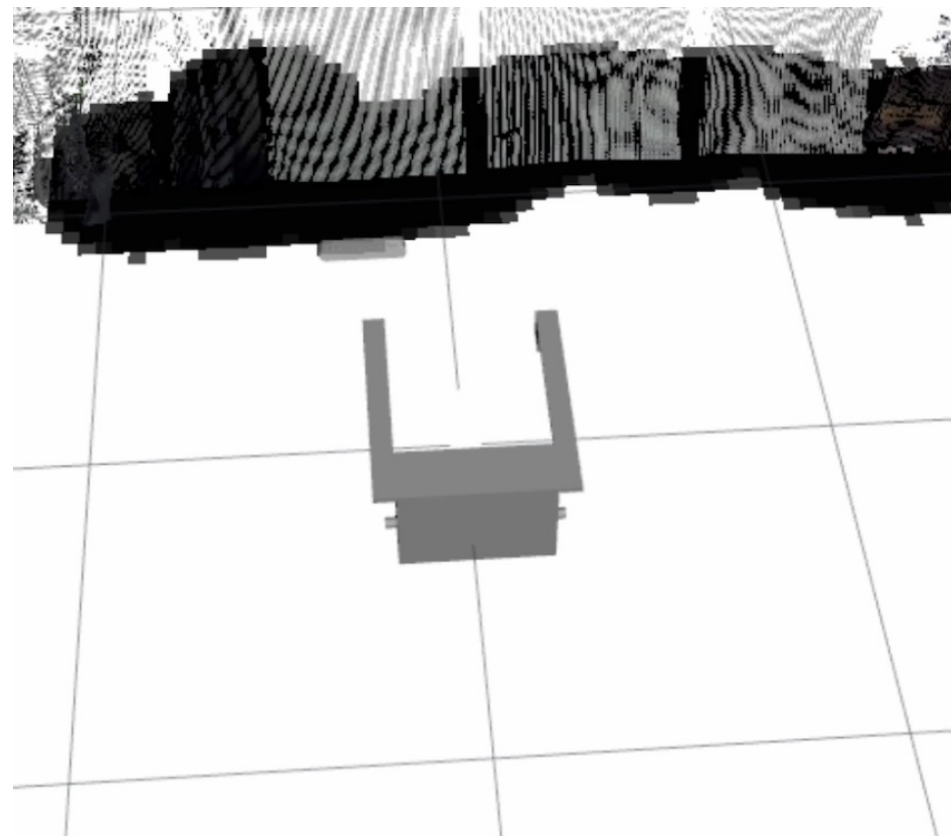
Tracking caster wheels



Implementation



Joystick input as navgoal offset



Setting navgoal with gaze



RDC – test and review

- Touchscreen is easy
- Need rear view
- Hard to pick up object



Timeline (Results)

Hacking

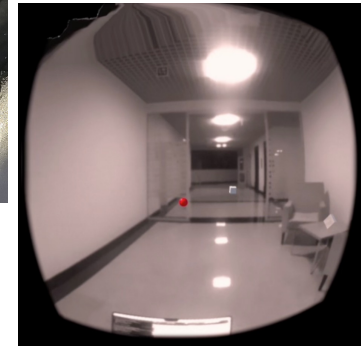
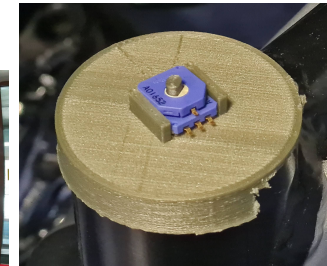
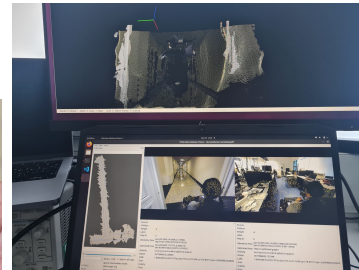
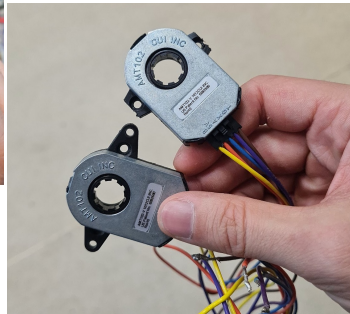
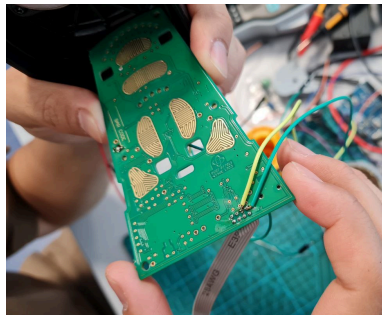
Odom

SLAM

Test

Caster

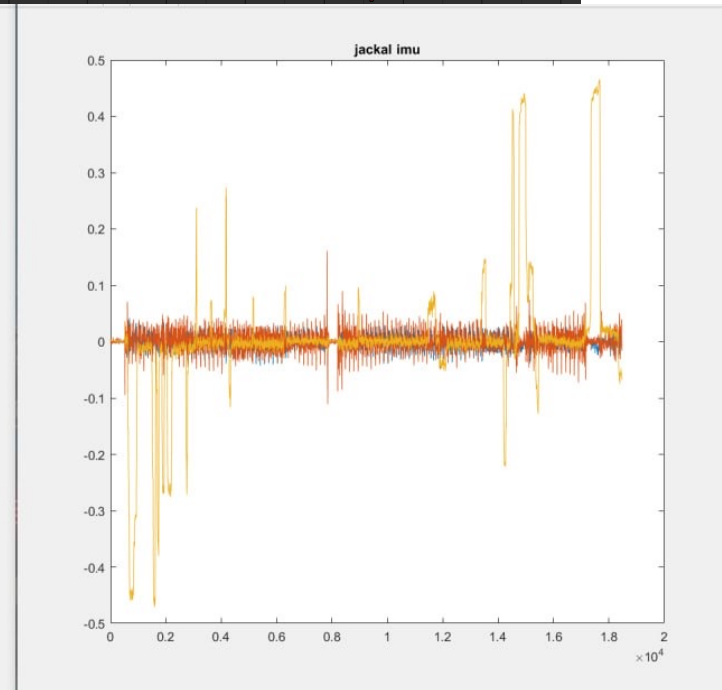
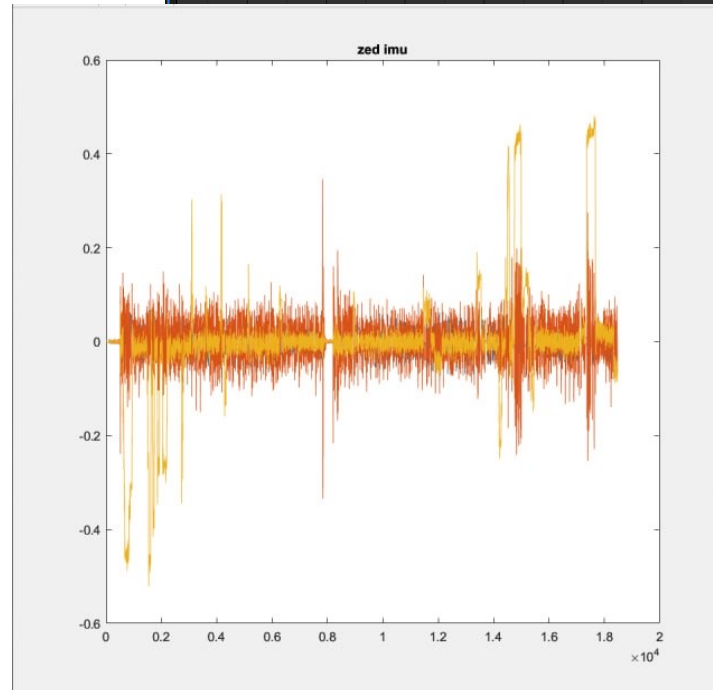
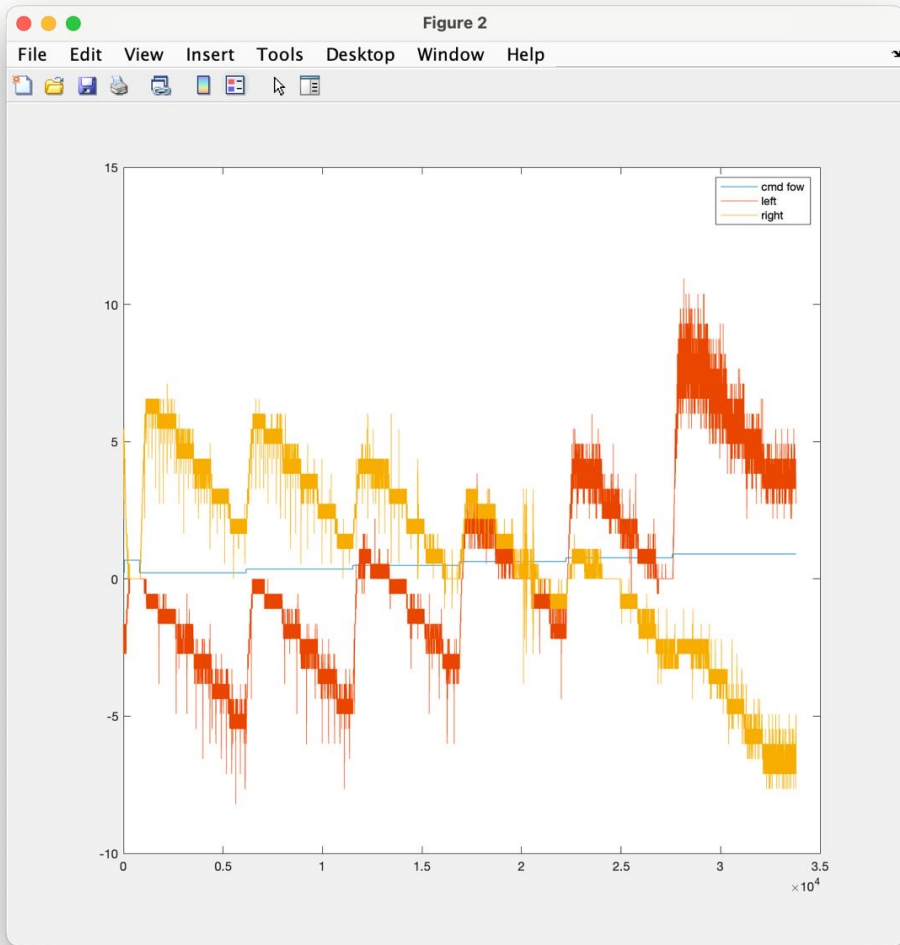
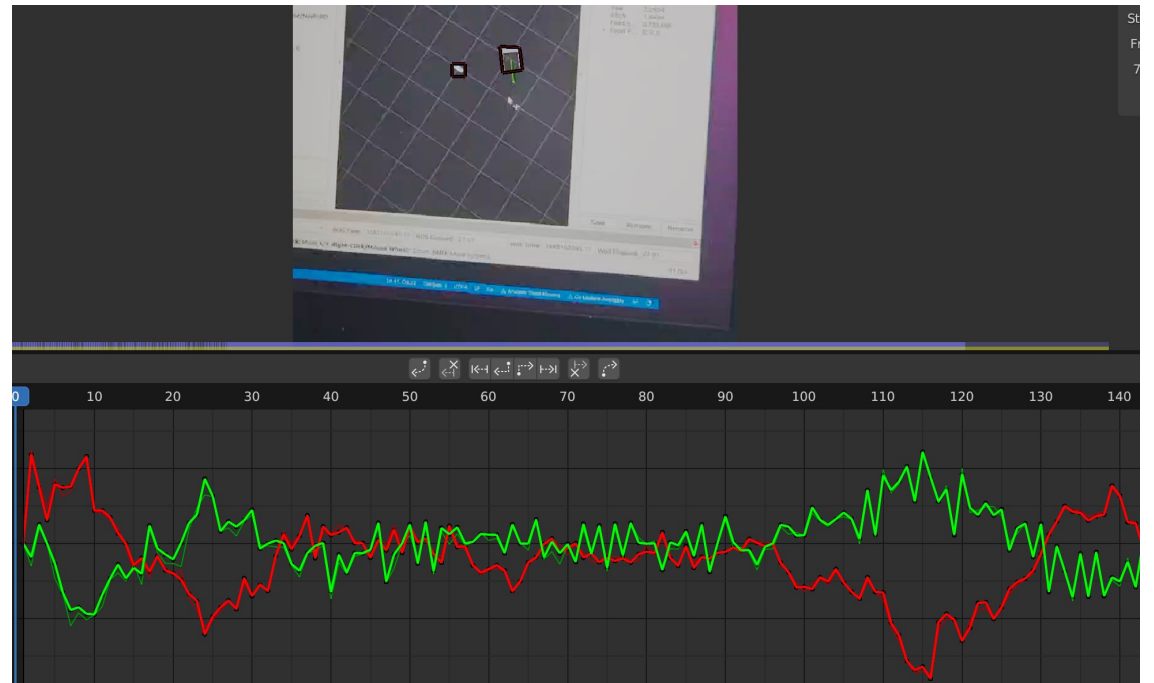
AR



Thesis objective recap

- ✓ Creation of a shared control wheelchair
 - ✓ Implement different control methods
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Analysis



Evaluation

- The twist to wheel mapping is ok
- The localization is bad
- User experience is not so intuitive
- The user feedback was not addressed

Future work

- Include castere wheels into the planner
- Implement MPC
- Test out the BCI
- Test out true gaze input
- Voice activation
- Publication

Conclusion

- I call it a success :D
- Progress in wheelchair hacking
- Implemented control techniques
- Platform for future research