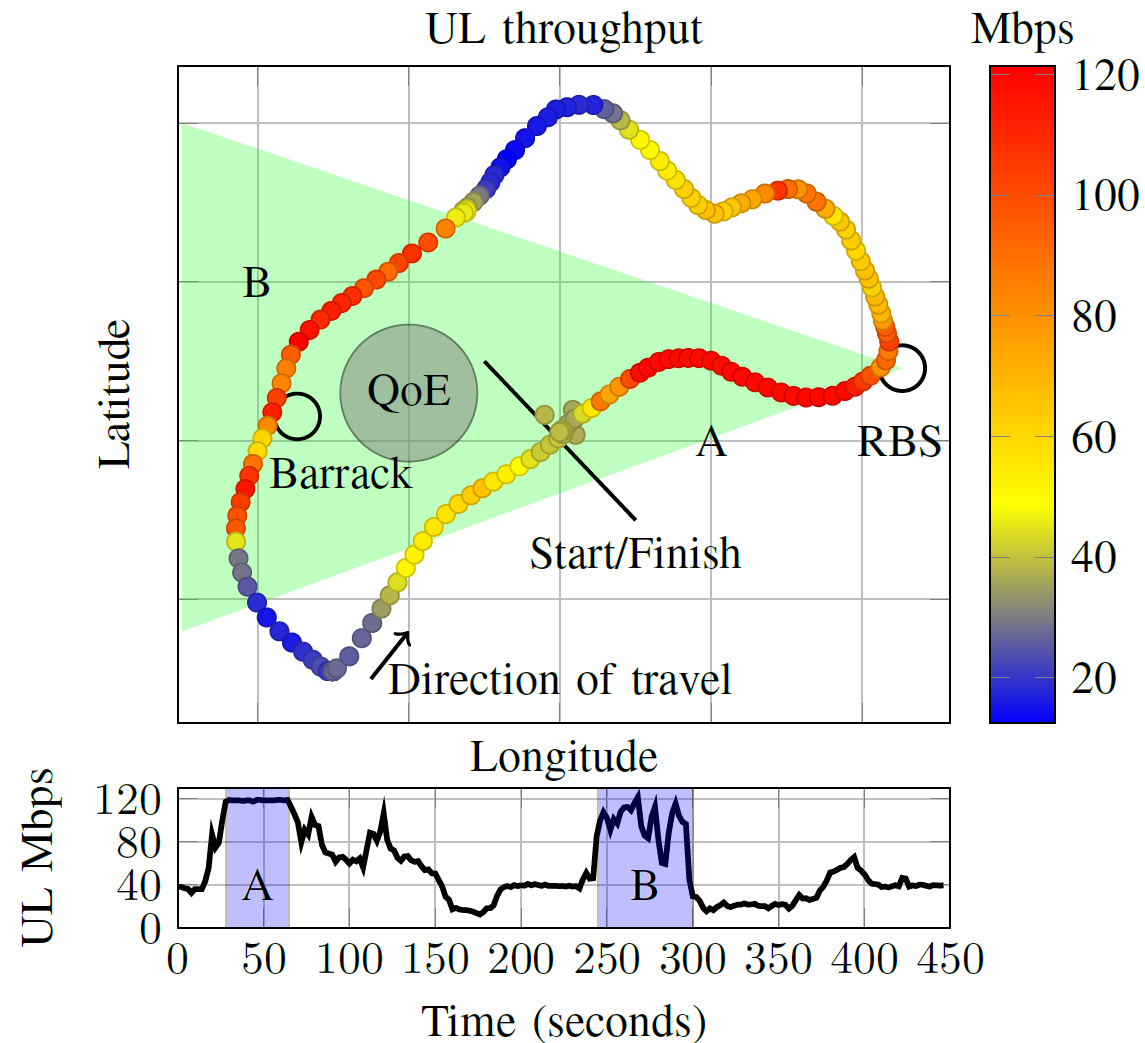


5G and QoE for remote controlled use cases

Kjell Brunnström

Background

- With 5G makes remote controlling of machines realistically possible
- Performance may not be overall good
- QoE issues can be in various dimension e.g. latency, bandwidth, 3D perception
- QoE experiments can be challenging on the real machines



Tärneberg, W., et al. (2020). *Towards Intelligent Industry 4.0 5G Networks: A First Throughput and QoE Measurement Campaign*. in *2020 International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*. 2020.

View Position Impact on QoE in an Immersive Telepresence System for Remote Operation

Subjective experiment

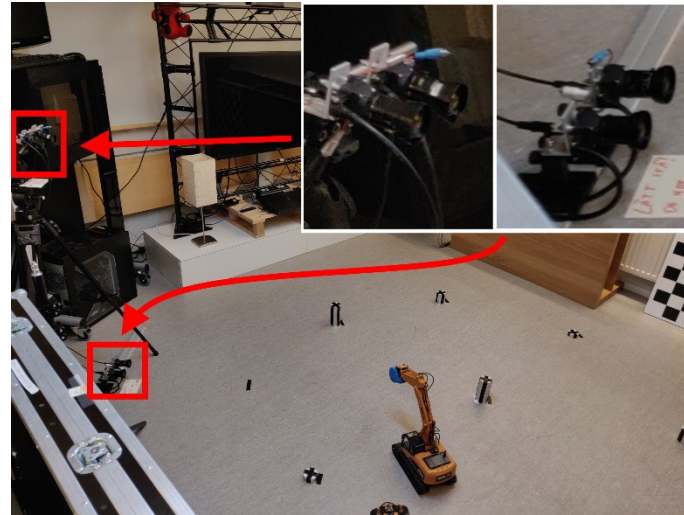
Navigation task

2 viewing positions

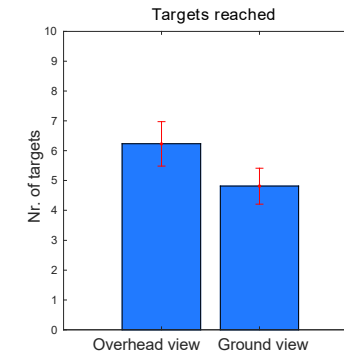
6 random-order targets

Remote control vehicle

VR headset, stereo projection



Task performance (measured)
Task difficulty (opinion)
Task accomplishment (opinion)
Viewpoint helpfulness (opinion)



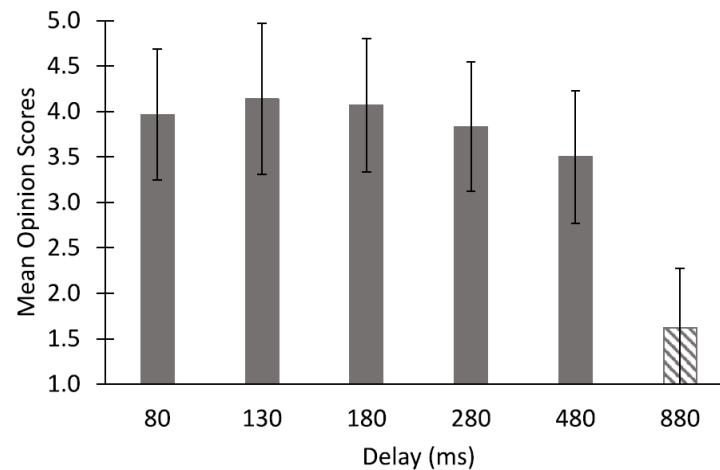
Dima, E., et al., (2020). *Joint effects of depth-aiding augmentations and viewing positions on the quality of experience in augmented telepresence*. Quality and User Experience. 5(1): p. 2, DOI: 10.1007/s41233-020-0031-7.

Latency impact on Quality of Experience in a virtual reality simulator for remote control of machines

Subjective experiment
in VR

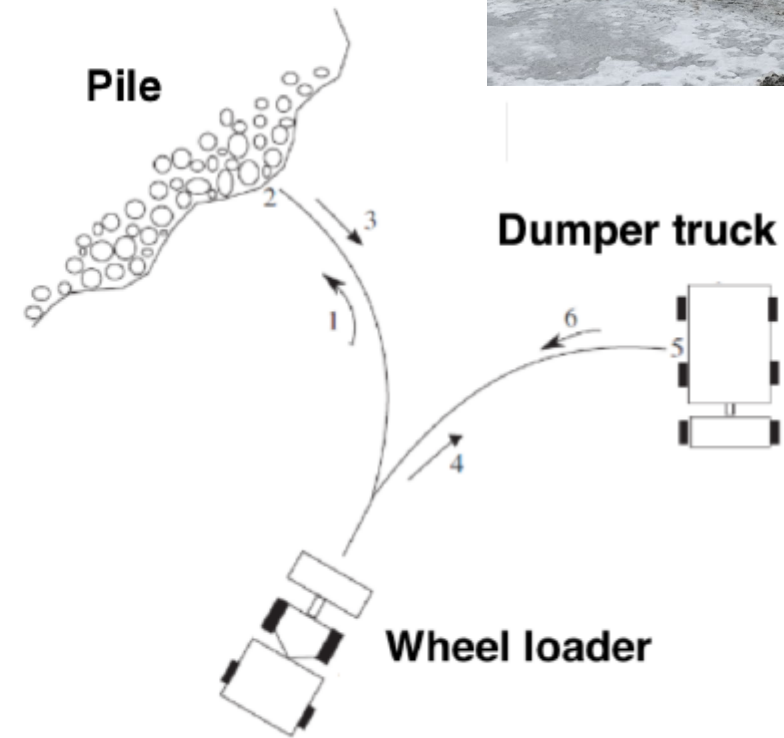
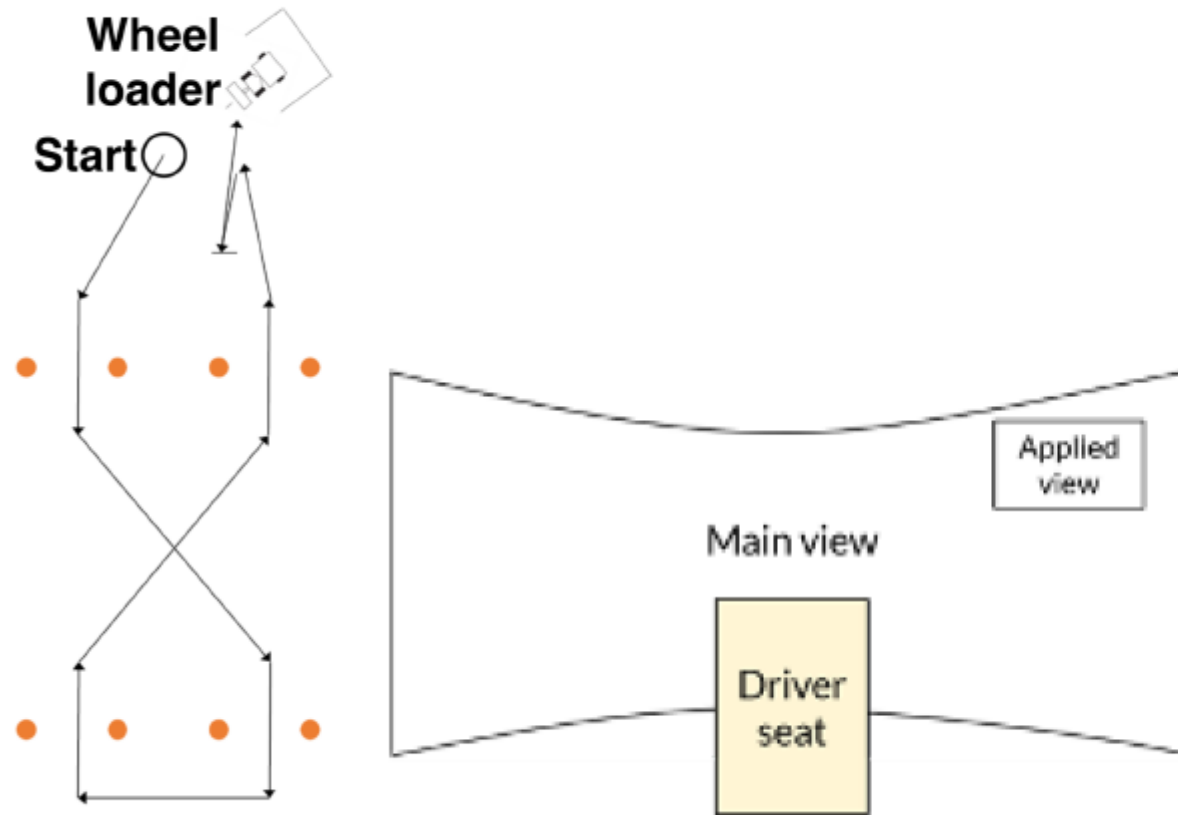
Latency impact on QoE

Not very sensitive >
500 ms to get effect in
the hand controllers



Brunnström, K., et al., (2020). *Latency impact on Quality of Experience in a virtual reality simulator for remote control of machines*. Signal Processing: Image Communication. 89: p. 116005, DOI: <https://doi.org/10.1016/j.image.2020.116005>.

QoE on real machines



QoE on real machines

- Pilot study with 3 drivers
- Many practical problems to perform quantitative QoE studies
- Qualitative method can be used i.e. open questions, interviews etc.
- Also stopped due to Covid-19
- QoE studies are more suited for the lab or simulator
- We think it important to have mixed approach i.e. both qualitative and quantitative methods



Lab platform for QoE studies

- Building a platform for lab studies
- Nvideo Jetson Nano and Basler dart
- First target latency and similar task as for field studies



Thank you