Communication and Control Co-Design for Risk-Aware Safety of Mobile Robots with Offloaded Localization

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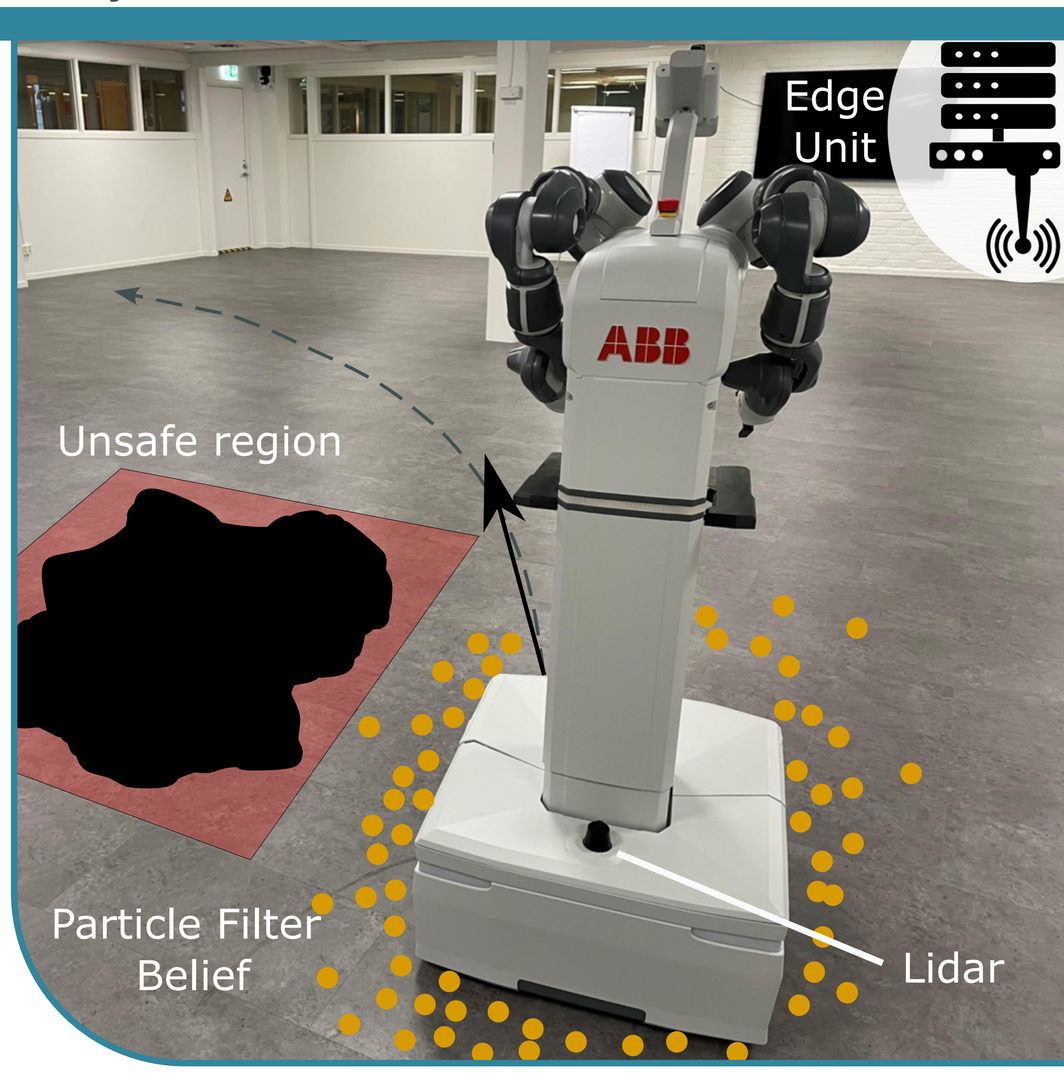
Research Problem

For navigation with offloaded sensor-based localization, both navigation speed v and communication frequency f has an impact on **localization uncertainty**, and thus also **safety**. In [1] we propose a co-design approach to achieving risk-aware safety in three steps:

1. Define **uncertainty requirement** U_{req} based on risk-aware safety in [2].
2. Use data to generate a **model** Δ of how uncertainty depends on f and v.
3. Adjust uncertainty to satisfy requirement using optimization:

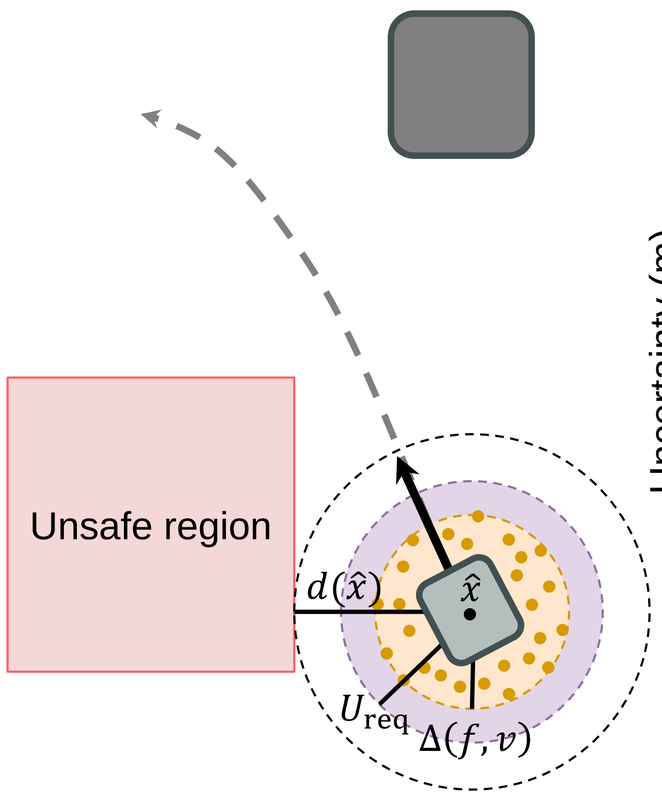
$$\min_{f,v} \text{Cost}(f,v)\,,$$
$$\text{s.t.}\,\Delta(f,v) < U_{\text{req}}.$$

+ We evaluate the method in WARA Robotics and introduce predictions $\widehat{U}_{\text{req}}$ to avoid violating the safety requirement when U_{req} decreases rapidly.



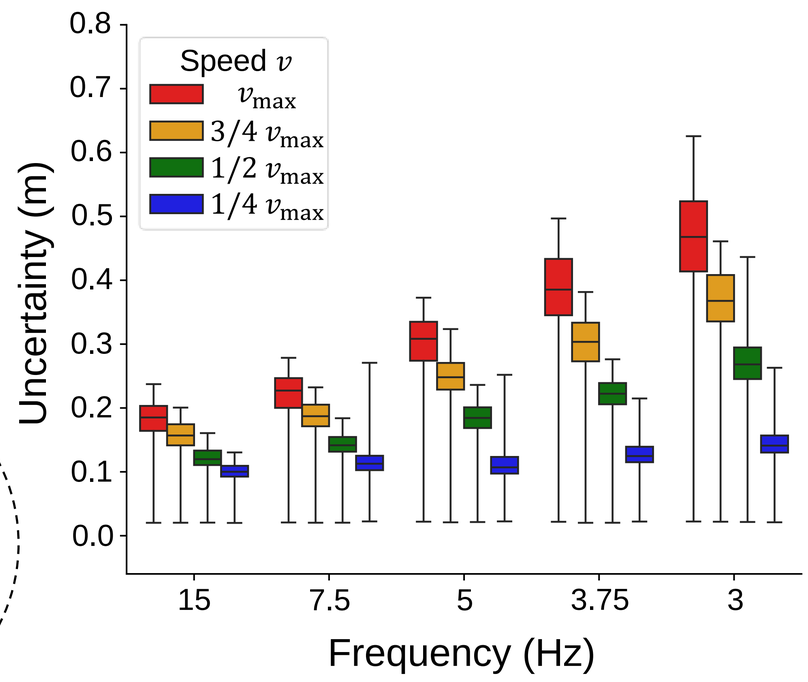
1 Risk-aware safety from uncertainty requirement

Define U_{req} using distance to closest obstacle $\text{d}(\hat{x})$ and the particle belief.

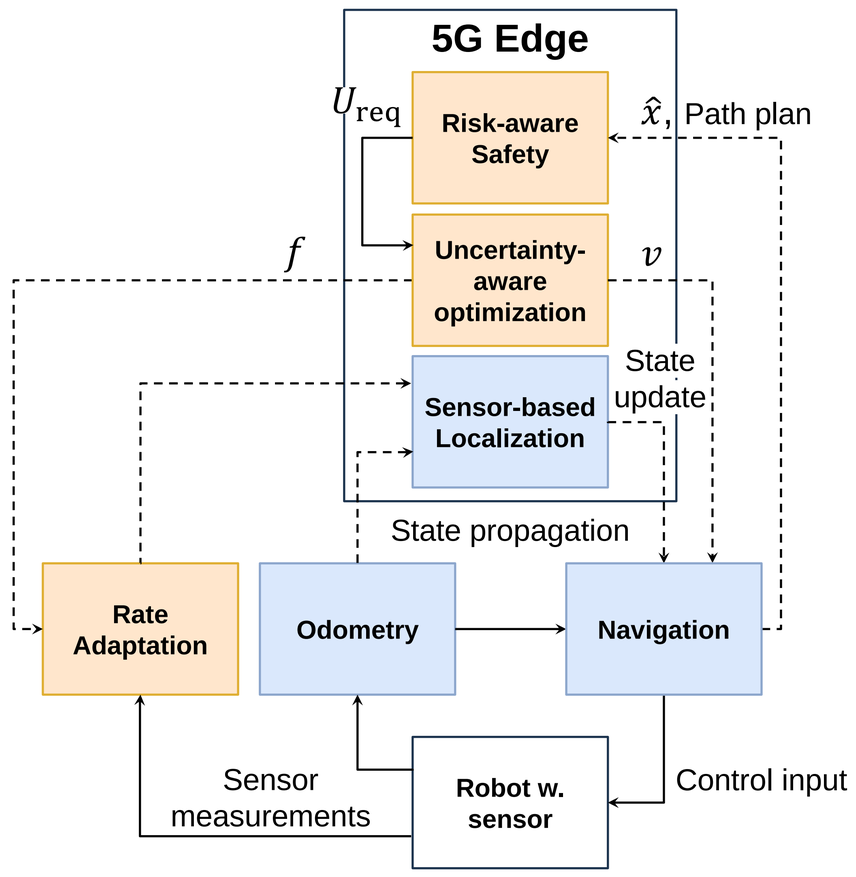


2 Simulation experiments for uncertainty model data

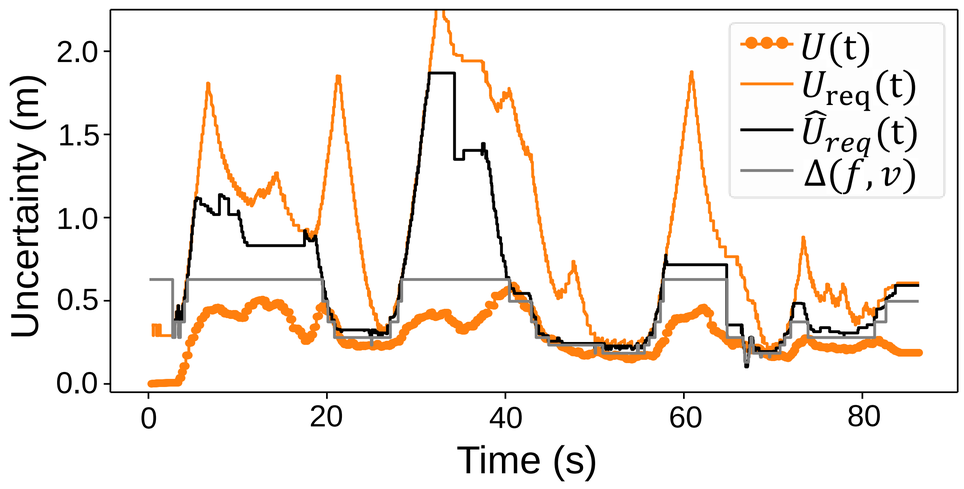
Model from data for all $(f,v) \in \mathcal{F} \times \mathcal{V}$ ($\mathcal{F}$ & $\mathcal{V}$ are sets of available options).



3 Optimization problem integration



+ Experimental evaluation in WARA Robotics



References

[1] A. Miksits et al, ”Communication and Control Co-Design for Risk-Aware Safety of Mobile Robots with Offloaded Localization”, Submitted to: *European Control Conference* (**ECC**). IEEE, 2025.

[2] M. Vahs and J. Tumova, "Risk-aware Control for Robots with Non-Gaussian Belief Spaces,“ In: *International Conference on Robotics and Automation* (**ICRA**). IEEE, 2024.

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