technische universität dortmund

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December 21th, 2023

Master Thesis

Wireless Network Emulation for Reproducible and Realistic Evaluation of Communication-Aware Robotic Navigation Algorithms

Robotic systems often face challenging network conditions during missions and must, therefore, be able to cope with them. This challenge can be addressed by integrating communication-awareness into existing robotic functionality such as navigation for instance. As logic that controls robot navigation based on the quality of the experienced network, communication-aware navigation algorithms are highly susceptible to the environment as it directly affects the quality and performance of the experienced network. Evaluating these algorithms in real-world situations regularly involves a large amount of resources and work to place the robots in the appropriate environments and situations. A solution for realistic and reproducible evaluation of such algorithms in the final stages of their development life cycle is desirable.

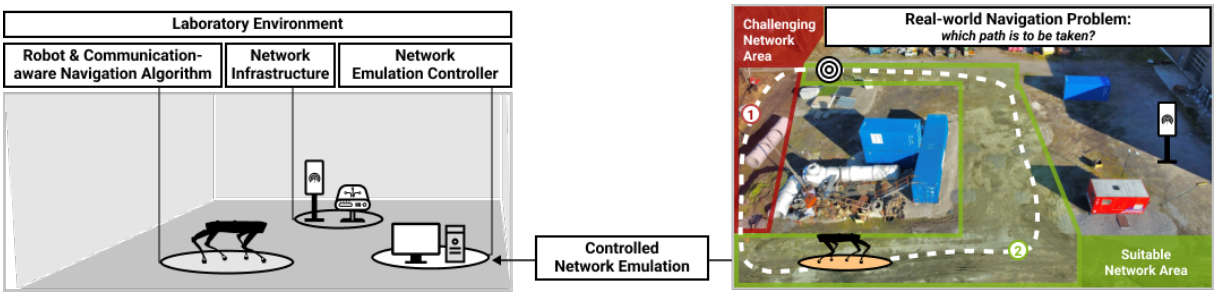

Figure 1: Methodology for the sustainable reproducible evaluation of communication-aware algorithms

Goals

During the thesis, a solution for the evaluation of communication-aware navigation algorithms on real robots based on existing concepts and tools will be designed, implemented, and evaluated.

Possible work steps

- Design a system architecture for evaluating communication-aware algorithms based on the architecture framework in [2] and leveraging the solution in [1].
- Implement the designed solution and ensure it supports multiple robots and communication links per robot and provides a standardized application programming interface (API) to enable automation and third-party integration.
- Evaluate the scalability of the proposed architecture in its ability to reproduce highly dynamic network environments involving multiple robots and multiple network links.
- Formulate a basic communication-aware navigation algorithm.
- Evaluate the formulated communication-aware navigation algorithm on a real system using the developed solution.

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Requirements

- General knowledge and interest in communication networks and robotics
- Advanced Python and basic LaTeX skills.
- Experience with Linux and software development tools (git, etc.)
- Participation in MDK lecture highly desirable & other CNI lectures are a plus.
- Excellent English skills, willingness to write thesis in English highly desirable.

References

[1] M. Patchou, J. Tiemann, C. Arendt, S. Böcker, C. Wietfeld, "Realtime Wireless Network Emulation for Evaluation of Teleoperated Mobile Robots", In 2022 IEEE International Conference on Safety, Security, and Rescue Robotics (SSRR), Sevilla, Spain, November 2022

[2] M. Patchou, C. Arendt, P. Gorczak, J. Güldenring, J. Tiemann, C. Wietfeld, "Hardware in the Simulation Loop Framework for Reproducible Testing of Rescue Robot Communications in Constrained Environments", In IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR), Abu Dhabi, UAE, November 2020

[3] H. Yang, J. Zhang, S. Song, and K. B. Lataief, “Connectivity-aware UAV path planning with aerial coverage maps,” in 2019 IEEE Wireless Communications and Networking Conference (WCNC). IEEE 2019, pp. 1–6

[4] S. De Bast, E. Vinogradov, and S. Pollin, “Cellular coverage-aware path planning for UAVs,” in 2019 IEEE 20th International Workshop on Signal Processing Advances in Wireless Communications (SPA- WC). IEEE, 2019, pp. 1–5

[5] W. Afzal and A. A. Masoud, “Harmonic potential based communication-aware navigation and beam-forming in cluttered spaces with full channel-state information,” in 2017 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2017, pp. 6198–6203.