THOMAS WIEDEMANN received his bachelor's and master's degrees from the Faculty of Mechanical Engineering at Technical University of Munich, in 2012 and 2014, respectively. Since 2014 he is working at the Institute of Communications and Navigation at the German Aerospace Center. Since 2017 he is also enrolled as a doctoral student at the Center of Applied Autonomous Sensor Systems at Örebro University.

Deploying mobile robots to explore unknown, hazardous environments provides a convenient way to avoid threats for human operators. After technogenic accidents or in natural disaster scenarios, where toxic or explosive material is leaking, robots are a safe alternative to human reconnaissance. In these situations, it is important to localize the sources of leaking material as fast as possible and to point out their locations to first responders for further intervention. In this thesis an exploration strategy is developed that guides multiple mobile robots automatically to informative locations with the objective to localize emission sources. For this purpose, the robots are equipped with appropriate sensors to measure the concentration of the airborne gas emitted by the sources.

As the main contribution, the thesis proposes to assist exploration and source localization by a-priori available domain knowledge. The thesis shows how to incorporate mathematical models of the gas dispersion process based on a partial differential equation into probabilistic reasoning. Further, the presented source localization strategy tackles the situation where the exact number of sources is unknown. This situation requires a proper regularization which is achieved by just incorporating the weak assumption that the sources are sparsely distributed in the environment.

As it turns out, assisted by domain knowledge and the vague assumption that the sources are sparsely distributed, a powerful and efficient measurement pattern of the robots emerges. Without being explicitly programmed, the robots' behavior observed in numerous simulations and real-world experiments made sense from a fluid dynamics perspective, and compared to insect strategies. Further, the sparsity assumption massively reduces the required time to successfully localize the sources. The proposed approach is flexible and can be extended in the future for other robotic exploration tasks where phenomena of interest can be described by partial differential equations as well.

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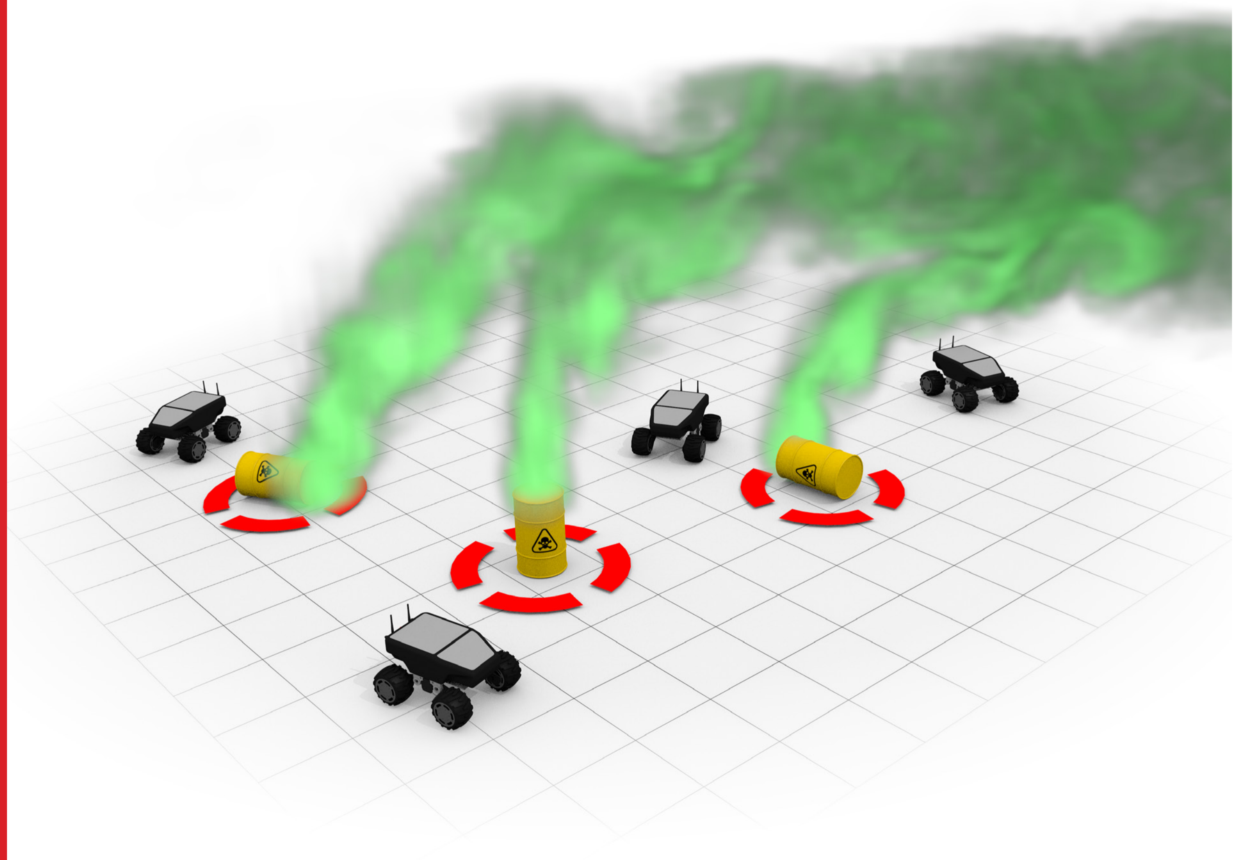

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