

Intelligent Robots with a Sense of Smell – Challenges, Current State, and Future Directions

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Abstract:

In this plenary, I will describe how gas sensing, combined with the capabilities of intelligent robots, can be used for impactful real-world applications (e.g., environmental monitoring, industrial safety, infrastructure inspection, and emergency response) and the challenges that must be addressed to realize them.

I will present key results from my research on robots and sensor networks to detect, interpret, and map airborne chemicals, and autonomously localize gas sources using information-driven exploration to reduce search time. From early work that primarily highlights challenges of robotic gas sensing to the most recent approaches that combine chemical sensing, mobile robotics, probabilistic modeling, machine learning, and fluid dynamics. From naively using single gas sensors out-of-the-box to increasingly multimodal approaches combining gas (in situ or remote), wind, 3D, and increasingly visual sensing.

Finally, I'll describe ongoing and expected developments in the community towards more reliable, scalable, and adaptive robotic olfactory capabilities, highlighting dedicated measurement swarms, multimodal approaches combining physical models with data-driven intelligence, 3D modeling, Deep Learning-based gas distribution mapping, the possibility of large-scale self-supervised learning, offering the opportunity to move beyond handcrafted search strategies, and the emergence of olfaction foundation models that promise generalized olfactory reasoning from diverse experience.

Keywords:

Robotics, Artificial Olfaction, Sensor Networks, Gas Distribution Mapping, Gas Source Localization

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