Odour Recognition using Electronic Noses in Robotic and Intelligent Systems

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This thesis is about integrating the sense of smell into artificial intelligent systems. In order to endow such systems with olfaction, we use a device called an electronic nose or e-nose. An e-nose consists of a number of gas sensors with partial selectivity and a pattern recognition component trained to recognize both complex and simple types of odours. Discussed in this thesis are a number of challenges which makes the integration of electronic noses into an intelligent system non-trivial. Challenges unique to the current technological state of odour identification include the characteristics of the gas sensing technologies such as sensitivity and drift, and the limitations of the pattern recognition algorithms to cope with these characteristics. Another challenge general to olfaction is the inherent difficulty in conveying or communicating a perception of an odour to a human user.

If we are to consider e-noses into today's and tomorrow's intelligent systems, it is important to examine the ingredients currently present in such systems. Sensing modalities such as vision, sonar and infrared are often used to collect a number of different properties about the external world. Planning and reasoning components are used to determine the appropriate responses to execute. The system can also perform actions which can then change the state of the environment. Using an electronic nose in a system containing these properties requires much more than simply mounting a physical sensor. In order for the system to really embody electronic olfaction, each level of the system architecture needs to be considered. We investigate the use of current techniques from AI and robotics that are available to confront these integration problems. Specifically this thesis investigates (1) the abstraction e-nose data from low-level sensor readings to a high-level representation of odour concepts, (2) the combination of perceptual information from the e-nose with other sensing modalities (3) coordination of sensing actions to determine where and when the e-nose should be activated in this context. We view these three constituents as important contributions for the advancement of electronic olfaction toward real application domains ranging from safety and security to the food industry.

The major experimental platforms used for validation consists of a

mobile robot equipped with an electronic nose, vision and tactile modalities that can perform a number of olfactory related tasks. Other experimental platforms include e-noses as part of a distributed sensing network and also as part of a visual interface interacting with humans.