Schlieren Imaging of Olfactory Search Strategies in Rats

Venkatesh Gopal¹, Timur Selimkhanov¹, and Mitra JZ Hartmann²

¹Department of Biomedical Engineering, ²Department of Mechanical Engineering, Northwestern University, 2145 Sheridan Road, Evanston IL 60208

Olfactory localization - following an odor to its source - is a vital behavior for many species, allowing them to locate prey, mates, and a variety of other resources. Often, these airborne odorants are transported by turbulent airflows that make the odor plume a ‘patchy’ filamentary structure. Thus, in the absence of smooth concentration gradients, finding the source of the plume is not simple because the organism has to solve the dual problems of (1) searching effectively to encounter the plume, and then (2) maximizing the information that it gains in its momentary contact with the plume.

As part of a broader study of such strategies across different species, we have begun to study how rats accomplish olfactory source localization. To this end, we have constructed two novel high-speed schlieren imaging systems that can visualize with high spatial and temporal resolution, both the stimulus field (the odor plume) and how the rat moves its sensory surfaces (nostrils) through this field. Schlieren imaging is a technique by which changes in the refractive index of a transparent medium may be visualized optically. Thus, airborne odor plumes can be made visible by embedding the odorant in a gas such as CO₂, which has a large refractive index contrast with air. Importantly, this eliminates the need to seed the flow with visible markers such as smoke which can provide the animal with visual cues.

In the first system, called the High Resolution Schlieren System (HRSS), two high-speed cameras are used to obtain orthogonal views of the rat as it explores an odor plume. By combining these two views, the three-dimensional trajectory followed by the nostrils through the odor plume is obtained. The HRSS can image motions within a cubic volume that is 12.5 inches on a side, with a spatial resolution of approximately 300 μm/pixel, and a maximum temporal resolution of 1 frame/ms. A second and much larger system, the Large Area Schlieren System (LASS), has been constructed with a 5ft.×3ft. arena to image odor following behavior in rats in a more neuroethologically accurate setting. The field of view is again covered by two high-speed cameras, giving each camera a spatial resolution of 0.9mm/pixel, and the same maximum time resolution as the HRSS. Data recorded from both these systems will be presented.

Combining these novel features of our experimental technique, we propose to characterize the spatial representation of the olfactory scene that is sampled with each sniff and then quantify how these “snapshots” in time are correlated with movement, and shed light on the neural computations that are required to implement such search behaviors.

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References