Models of the insect brain for odor discrimination and decision making

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In the course of evolution animals, bacteria and plants have developed sophisticated methods and algorithms for solving difficult problems in chemical sensing very efficiently. Complex signaling pathways inside single cells can trigger movement toward the source of a nutrient. Complex networks of neurons are able to compute odor types and the distance to a source in turbulent flows. These networks of neurons use a combination of temporal coding, layered structures, simple Hebbian learning rules, reinforcement learning and inhibition to quickly learn about chemical stimuli that are critical for their survival.

In this talk we revisit the critical elements of the insect brain involved in odor discrimination and determine the impact that each of the areas have in learning an odor discrimination task. We apply these lessons to the problem of gas identification with artificial sensor arrays. The insect brain must cope with those conditions by preprocessing the data using the excitatory-inhibitory network in the first relay station of the insect olfactory system. It manages to extract and dynamically inhibit common odor representation and enhances the sensitivity to novel ones. Thus, we use the insect olfactory system as a base and inspiration to build odor recognition devices that take advantage of the spatial-temporal characteristics of the turbulent gas plume. We demonstrate how they can be merged and compared to state-of-the-art machine learning algorithms.