SWARM 2019: The 3rd International Symposium on Swarm Behavior and Bio-Inspired Robotics, Nov. 20-22, 2019

Workshop on "Role of movement-based active perception in navigation and its neurorobotic correlates"

Date and time: 22 November 2019, 13:00-16:30

Location: Room A (Auditorium), Okinawa Institute of Science and Technology

Program:

13:00   Welcome address and introduction

Danish Shaikh

13:15   Eye capping suggests eyes drive independent motor control functions during visual navigation

Andrew Philippides, Cornelia Buehlmann, Cody Freas, Paul Graham

In view based homing, the current view of the world is compared to remembered views to generate a movement direction. We believe the comparison/movement to be an active process whereby ants physically scan the world (either through rotations or oscillatory paths), sampling views facing different directions and moving forwards when the view is familiar. While visual panoramas can be matched as entire views, we showed improved navigation by using wide-field panoramic segments to generate independent heading estimates, suggesting ants could improve visual homing by using input from each eye independently. To address this, zero-vector ants with food were caught on their return at the nest entrance and transported to familiar or unfamiliar locations. Ants were released with left or right eye-capped (covered) and trajectories recorded. Eye-capping led to asymmetric paths with rapid turns away from the eye-capped side. As this asymmetry disappeared in unfamiliar locations, it is likely that it is a due to a perturbation of visual navigation by eye-capping rather than a general change in movement control. Thus, during visual homing input to each eye may be used independently, perhaps controlling the extent of contra-lateral turns. Indeed, alternating control of left/right turns would give an unbiased method for polling independent heading estimates from different panoramic segments.

13:45   Modeling the insect brain: a bio-plausible approach for navigating in complex environments

Florent Le Moël, Antoine Wystrach

Central-place foraging insects must face the task of navigating through their complex environments to search and bring food back to their nest. One key strategy they developed to do so is based on learning the visual appearance of the surroundings: the solitary foraging Cataglyphis velox ants can visually learn and follow idiosyncratic routes through their semidesertic habitat. Such learning involves the transfer of visual information to a higher brain centre, the Mushroom Bodies (MB), of which circuitry has spawned several modelling studies geared towards vision. However, a common problem to these simulations lays in how the perception/action loop is closed: in many cases, they require the navigating agent to perform an exhaustive sampling of its surroundings at each step forward – a behaviour that is not observed in navigating ants. With the aim of building a fully biologically-plausible sensory-motor loop allowing successful navigation, we embedded a bio-plausible computational model of the MB in an oscillating agent, moving through a virtual 3D world mapped on real-life Cataglyphis ants habitat. We show how the classic limitations of previous MB models can be overcame by rather simple motor and learning processes, which, interestingly, fit adequately with the choreography of the learning walks that naive ants perform when first leaving their nest.

14:15   Break

14:30   Active perception - the role of motion in insect olfaction

Einat Couzin-Fuchs

Renowned for their speed, agility and evolutionary success, cockroaches serve as a leading model organism to study neural mechanism of both sensing and behavior. In my talk I will describe our work to study the relation between sensory perception and motion—the role of proprioception in regulating locomotion, and the role of motion in assisting olfaction. Focusing here on the later, I will show that there is an intimate feedback between motion and sensing and that, in the context of olfaction (which has traditionally been considered a static sense), movement— sniffing, antennal movements, flight manoeuvres etc.—can dramatically enhance odor perception. Using an integrative approach in which behavioral experiments are combined with electrophysiology we study the neural

mechanisms underlying odor-guided movement decisions. Specifically, we characterize antennal scanning patterns in different olfactory environments and test to what degree movement decisions are linked to time-varying fluctuations in odor cues. We provide evidence that distinct patterns of wide antennal sweeping and high-frequency flicking play different roles in odor localization and neural signal enhancement respectively.

15:00   Towards neurorobotic models of active perception and its role in navigation

Danish Shaikh, Alejandro Pequeno Zurro, Ignacio Rano

Perception is an active operation in which the detection, representation, and processing of sensory information is heavily modulated via motor behaviour. Active perception may allow an animal to selectively sample information in space and in time, vary stimulus intensity and dynamics to optimise sensory processing and extract relevant features. Viewing sensory systems in the context of active sensing could provide a better understanding of the principles underlying biological perception. In this talk I present on-going work on modelling active olfactory perception in the American cockroach via the neurorobotic approach. I will first describe relevant anatomical correlates and neural coding in olfactory receptor neurons in the cockroach antennae and link these to olfactory navigation strategies. I will then present a neurorobotic model for olfactory navigation that allows for incorporating temporal dynamics of stimulus as additional spatial olfactory cues. The model linearly fuses instantaneous stimulus values with its temporal dynamics and implements Braitenberg vehicle-like sensorimotor connections that generate edge-following behaviour in simulated odour plumes, similar to those observed in freely moving cockroaches.

15:30   Source Taxis Simulator (STS): a software tool for exploring sensorimotor connections, embodiment and emergence behaviour of artificial agents in the context of odour localization.

Alejandro Pequeno Zurro

Insects can locate food resources in different scenarios using multiple sensory information in the environment. The implementation of these strategies into robotics may lead to more robust navigation algorithms but also give insights about perception and neural information processing in nature. Considering the synthetic approach of understanding animal behaviours by building agents, we created a simulation tool that explores embodiment and sensory perception of a software agent in the context of odour source localization. The software simulates navigation trajectories given sensorimotor connections and embodiment of an insect-like agent in a chemical environment. STS allows easy customisation and scalability to other sensory modalities and animal embodiments. Analysis of the trajectories provides insights about insect navigation strategies as well as the role of active perception and the neurophysiological mechanisms of animal behaviour. Applying this software in a case study, we explored the neural processing in the ON/OFF olfactory receptor neurons in the American cockroach via Braitenberg vehicles and its performance in olfactory navigation.

15:45   Hands-on STS tutorial

16:15   General discussion, participant feedback and closing remarks

16:30   End of workshop