INSECT-INSPIRED NAVIGATION: SMART TRICKS FROM SMALL BRAINS

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Small-brained insects are expert at many tasks that are currently difficult for robots, but especially in the speed and robustness of their learning abilities. In contrast to AI methods which generally take long times to train and large amounts of labelled data, insects are rapid learners of visual and olfactory information and are capable of long distance navigation, exploration and spatial learning. What if we could give robots these abilities, by mimicking the sensors, circuits and behaviours of insects? This is the goal of the Brains on Board project (brainsonboard.co.uk). In this talk, we will discuss the Brains on Board project and our work on insect-inspired visual navigation in particular.

The use of visual information for navigation is a universal strategy for sighted animals, amongst whom ants are particular experts despite have small brains and low-resolution vision [1]. To understand how they achieve this, we combine behavioural experiments with modelling and robotics to show how ants directly acquire and use task-specific information through specialised sensors, brains and behaviours, enabling complex behaviour to emerge without complex processing. In this spirit, we will show that an agent – insect or robot – can robustly navigate without ever knowing where it is, without specifying when or what it should learn, nor requiring it to recognise specific objects, places routes or maps. This leads to an algorithm in which visual information specifies actions not locations in which route navigation is recast as a search for familiar views allowing routes through visually complex worlds to be encoded by a single layer artificial neural network (ANN) after a single training run with only low resolution vision [2]. As well as meaning that the algorithms are plausible in terms of memory load and computation for a small-brained insect, it also makes them very well-suited to a small, power-efficient, robot.

We thus demonstrate that this algorithm, with all computation performed on a small low-power robot, is capable of delivering reliable direction information along outdoor routes, even when scenes contain few local landmarks and have high-levels of noise (from variable lighting and terrain) [3]. Indeed, routes can be precisely recapitulated and we show that the required computation does not increase with the number of training views. Thus the ANN provides a compact representation of the knowledge needed to traverse a route. In fact, rather than the compact representation losing information, there are instances where the use of an ANN ameliorates the problems of sub optimal paths caused by tortuous training routes. Our results suggest the feasibility of familiarity-based navigation for long-range autonomous visual homing.

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