OR403

A computational modelling approach to understanding honeybee vision and cognition

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Apis mellifera, the Western honeybee, has a brain consisting of one million neurons, yet is capable of a range of sophisticated social and individual behaviours. These include communication using the 'waggle dance' and choice behaviour based on 'sameness' and 'difference'. This makes the honeybee an important resource for understanding the neural basis of such sophisticated behaviours. Computational modelling is a valuable tool for understanding neural structure and function, and we can use it to provide constraints on neural mechanisms given experimental data, as well as hypotheses about possible anatomy and function where data are sparse. The honeybee presents a challenge to computational modelling, as while some parts of the brain are well characterised (e.g. the olfactory system), others are poorly understood (e.g. the visual system). There are a wealth of behavioural and ecological experimental data, however, for many aspects of honeybee behaviour. To address the sparseness of the anatomical and physiological information it is important that we add other constraints to the model, and these must come from the behavioural and ecological experimental literature. To connect to this literature we are required to model complete sensori-motor loops, where the model takes sensory stimulation, processes it, and generates motor output. For this approach we must model large parts of the honeybee brain, then compare the hypotheses generated against behavioural experiments or ecological observation. In this talk we present recent progress in graphical modelling of neural systems, along with the use of simplified neuron models and parallel graphics processing technology, which allow us to easily develop, visualise, and rapidly simulate large models. These tools allow us to manage large sensori-motor loop models of the honeybee visual system and connect these models to both software and real world visual environments, allowing us to reproduce behavioural and ecological experimental paradigms.