Analysing Head-Thorax Choreography During Free-Flights in Bumblebees

Luise Odenthal[1], Charlotte Doussot[1], Stefan Meyer[2] and Olivier J. N. Bertrand[1]*

[1] Neurobiology, University Bielefeld, Bielefeld, Germany, [2] Department of Informatics, University of Sussex, Brighton, United Kingdom

Animals coordinate their various body parts, sometimes in elaborate manners to swim, walk, climb, fly, and navigate their environment. The coordination of body parts is essential to behaviors such as, chasing, escaping, landing, and the extraction of relevant information. For example, by shaping the movement of the head and body in an active and controlled manner, flying insects structure their flights to facilitate the acquisition of distance information. They condense their turns into a short period of time (the saccade) interspaced by a relatively long translation (the intersaccade). However, due to technological limitations, the precise coordination of the head and thorax during insects' free-flight remains unclear. Here, we propose methods to analyse the orientation of the head and thorax of bumblebees *Bombus terrestris*, to segregate the trajectories of flying insects into saccades and intersaccades by using supervised machine learning (ML) techniques, and finally to analyse the coordination between head and thorax by using artificial neural networks (ANN). The segregation of flights into saccades and intersaccades by ML, based on the thorax angular velocities, decreased the misclassification by 12% compared to classically used methods. Our results demonstrate how machine learning techniques can be used to improve the analyses of insect flight structures and to learn about the complexity of head-body coordination. We anticipate our assay to be a starting point for more sophisticated experiments and analysis on freely flying insects. For example, the coordination of head and body movements during collision avoidance, chasing behavior, or negotiation of gaps could be investigated by monitoring the head and thorax orientation of freely flying insects within and across behavioral tasks, and in different species.

Keywords: bees, machine learning, random forest, decision tree, neural network, coordination, control, active vision

1. INTRODUCTION

Animals travel in their habitat to chase prey, escape predators, find mates, or food. The motile body parts, such as legs, wings, or fins, often differ from the sensory ones. For example, the eyes of most sighted animals are placed on the head, away from wings or legs. The non-collocation of motile and sensory body parts allows many animal species to decouple where to look and where to move. Notably, animals frequently stabilize their head while traveling in their environment to compensate for body motion (e.g., roll movements) that is required for steering (e.g., Van Hateren and Schilstra, 1999a; Ravi et al., 2016) or actively move their head to extract relevant information, for example the