Visual-based decision making in collective motion

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1 Introduction

Collective motion is ubiquitous in natural systems and serves as inspiration for the development of swarming robotics applications. Animal swarm's coordinated and synchronized movements rely on local interactions among individuals in the group and their swift and appropriate decision-making. A major challenge is deciphering decision-making rules in animals that could be implemented in technological developments.

The formation and sustention of locust swarms predominantly rely on visual interactions, within exceptionally complex and noisy visual surroundings. Utilizing behavioral monitoring and neurophysiological recordings of individual locusts in a specially designed and controlled experimental set-up, we identified and characterized swarming-related visual cues and investigated their effect on the individual's decision-making process.

Figure 1: An individual locust utilizes complex visual stimuli in the repeated decision making needed to maintain the swarm. Adapted from [1].

2 Experimental results

Our results revealed the use of a match filter in the visual system, filtering stimuli with speeds below an appropriate threshold. A clear threshold was also evident in identifying motion coherence levels or common group direction. Further findings revealed a tendency for preferred alignment with larger stimuli and interactions between the position of the stimulus within the field of view and its direction of motion. Our results emphasize the instrumental role of visual perception in collective-motion-related decision-making and offer valuable insights for the generation of swarming robotics algorithms.

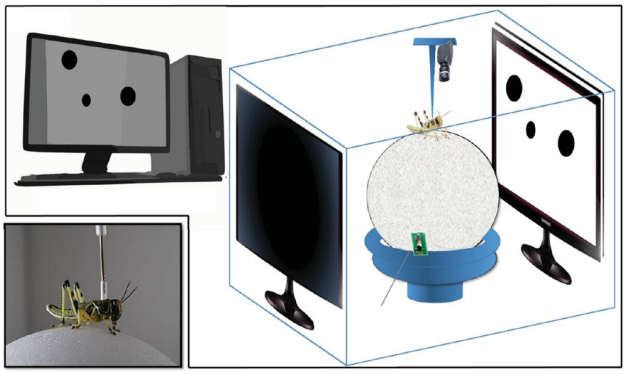

Figure 2: The Experimental set-up: the complete set-up and an individual tethered locust (inset). An individual locust was tethered, with a fixed heading, over an airflow-suspended trackball. Random dot kinematograms were presented on two parallel LCD screens. High-speed video camera and a mouse sensor were used for behavioral tracking (their relative positions are only for illustration purposes). Adapted from [2].

3 Conclusions

We explored swarming-related decision-making at the behavioral level in desert locust nymphs, by analyzing different aspects of the individual locust's walking behavior. These served in our investigation of the role of visual feature recognition and discrimination as possible underlying mechanisms in decision-making. A complementary preliminary electrophysiological study of the processing of visual motion inputs, relevant to the dynamic interactions between the individuals in a marching swarm, has lent further support to our hypotheses. Our findings support locusts as a model for investigating sensory-motor integration and motion-related decision-making in the intricate swarm environment, and as inspiration for the development of swarming robotics applications.

4 Acknowledgements

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5 References

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[2] Bleichman, I., Yadav, P., & Ayali, A. (2023). Visual processing and collective motion-related decision-making in desert locusts. Proceedings of the Royal Society B, 290(1991), 20221862.