Introduction. The use of artificial neural networks to study perception in animals

Our reasons for applying to the Royal Society to edit this theme issue were not entirely altruistic. Having a young but growing interest in the use of artificial neural networks, we hoped that the publication would be an excuse for us to learn about areas in neural network research that seemed interesting to us and of potential application to our research. The people who will get most from this publication are, therefore, ecologists and evolutionary biologists, perhaps with a notion of using neural network models of perception, but with little experience of their use. That said, the content of this theme issue is extremely broad and we are confident that there is something in it for any scientist with an interest in animal (including human) perception and behaviour.

We organize the issue into four fairly loose categories. The papers by Gurney (2007) and Phelps (2007) are broad reviews and introduce the two main themes of the issue: neural networks as tools to explore the nature of perceptual mechanisms and neural networks as models of perception in ecology and evolutionary biology. Gurney’s (2007) paper is an excellent general introduction to the theory and use of neural networks and tackles the question: what can simple neural network models tell us about real neural circuits and the brain? Phelps’s (2007) paper is a ‘where it’s at and where it’s going’ of artificial neural network models in perceptual allocation and bias, and the models and ideas in it can be applied to many other areas of ecology and evolutionary biology. Like most of the articles in the issue, both these papers can be appreciated with little or no mathematical knowledge on the part of the reader.

The next four papers are research or focused review articles on neural network models and their use in elucidating the nature of perceptual mechanisms in organisms. Borst’s (2007) paper describes and compares the properties of different neural models of motion detection; specifically Reichardt and gradient detectors. We are exited about the potential of applying such models to issues in predator–prey interactions to address how predator targeting accuracy is affected by the speed and number of moving prey items. White & Snyder (2007) use a recurrent neural network model to investigate how accurate internal representations of visual space are formed in primates. Mannella & Baldasarre (2007) use an interesting actor–critic reinforcement model to determine the cues used by domestic chicks to find hidden food items in closed arenas. Finally, Calabretta (2007) introduces the concept of ‘genetic interference’: a phenomenon that can reduce the evolvability of modular and non-modular visual neural networks, but can be alleviated by ‘sexual reproduction’ in neural networks.

The next four papers are by ecologists and evolutionary biologists and apply neural networks to classic questions in these disciplines. Pfennig & Ryan (2007) apply Elman networks to study the evolution of character displacement and mate choice using the calls of tundra frogs as network input. Merilaita (2007) reviews recent work on the anti-predator benefits of prey coloration that uses simple neural network models. Holmgren et al. (2007) review recent work on the use of neural networks to study ecological specialization and sympatric speciation: an interesting approach that offers a potentially powerful alternative to traditional mathematical simulation models in these areas. All of these papers additionally use or discuss genetic algorithms, an optimization framework also applicable to models other than neural networks that produces optimal model parameters through a selective process analogous to natural selection. This powerful ‘organic’ optimization method can be applied to a variety of systems and will be of interest to readers who are not familiar with it. Finally in this section, Ay et al. (2007) use analytical mathematics with simple feed-forward neural networks to show that multimodal signals (animal signals that exploit multiple sensory organs) can increase the robustness of signals through multiple channels (e.g. frequencies in vocalization).

The next three papers are (loosely) on general properties of simple feed-forward networks. The papers of Ghirlanda & Enquist (2007) and Tosh & Ruxton (2007) (the editors) are on the phenomenon coined ‘path dependence’ by the former authors. This is the tendency of certain neural networks with commonly used architectures and training methods to vary in predictive properties, depending on the order of presentation of training inputs or with stochastic variation in the starting properties of networks. This effect could have important biological as well as methodological implications. We also place the paper of Olden (2007) in this section. This paper, as well as being an interesting research paper on the relationship between landscape properties and animal movements, applies methods that allow one to dissect the functioning of neural networks. These methods should hopefully help to dispel the common myth that neural networks are ‘black boxes’ that produce interesting results but whose functioning and action cannot be analysed. Finally, the paper by Williamson & Chrachri (2007) does not fit into any of the aforementioned categories and describes a real neural network: the
cephalopod vestibular system. This paper emphasizes the fact that real neural networks are considerably more complex than most of the simple artificial ones described in the theme issue, and in some (perhaps many) neural systems this complexity must be embraced in order to fully understand the system.

One of our loftier objectives in putting together this issue was to attract readers from a broad and disparate range of disciplines and so foster cross-fertilization of ideas. Papers in the theme issue should interest readers from psychology, neurobiology, mathematics, ethology, ecology and evolutionary biology. It is hoped that readers from each of these disciplines might find something from another discipline that interests them and gives them new ideas for their own research. For example, many psychologists and neurobiologists could undoubtedly benefit from an increased appreciation of the evolutionary context of their study system, while many ecologists and evolutionary biologists could benefit from a greater appreciation of the neural mechanisms underlying phenomena at the level of the whole organism. We also hope that greater use of artificial neural networks might reduce the need for invasive animal experimentation. The study of nervous systems, using artificial models or otherwise, will always be founded on experiments with real nervous system, but models can reduce the need for experimentation at particular stages of a research programme. A reliable model can simulate multiple scenarios and inform researchers on which areas of endeavour are likely to be most rewarding, thereby reducing the need for experimentation in areas that could lead up ‘blind alleys’.

We keep this introduction short and leave the job of covering broad scientific themes in the use of neural network models to study animal perception to the first two papers of the theme issue.

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REFERENCES


