Special section: smarter periphery, easier central processing

In 2010, at the 11th International Conference on the Simulation of Adaptive Behavior, a workshop was organized on the topic ‘Smarter periphery, easier central processing’ by Dieter Vanderelst and Herbert Peremans, from the University of Antwerp, and myself under the auspices of the ChiRoPing project (FP7-ICT-2007-1 Project number 215370). Its goal was to explore the implications of the embodied artificial intelligence paradigm for the implementation of adaptive behaviour in animals and robots. Specifically, the thesis of the workshop was that smarter peripheral processing, whether implemented as anatomical adaptation, exploitation of physical interactions, or adaptive sensory behaviours that highlight relevant stimuli, could reduce, or indeed occasionally eliminate, the need for central nervous system processing. The workshop attracted some 7 submissions and 20 attendees. The three papers in this special section represent developments of work presented at the workshop.

The first of the three papers, by Kim and Sim, explores the characteristics of the electrosense of fish, by which properties of nearby objects are elicited from the disturbances they induce in a weak electric field generated by the animal. The authors consider both spatial and temporal characteristics of the field disturbances and study the ability of the system to discriminate the locations of multiple near-field objects. The model studied is an active one, in that behaviour of the fish relative to the objects is employed to encode perceptual information in the spatiotemporal electric field which the animal uses to sense them.

In the second paper, Zhang and colleagues consider the auditory system of lizards. Lizards have the most directional broadband hearing system of any vertebrate, largely as a result of their specific peripheral anatomical adaptation which allows their two ears to function as a pressure-difference receiver. Using this physiology, small inter-aural phase differences that encode the relative direction of sound sources are transformed into perceptible inter-aural amplitude differences. Existing work on this type of system assumes that the receiver is bilaterally symmetrical, which is unlikely to be true for real implementations in animals or robots. The paper explores the extent to which the asymmetries of the periphery can be compensated by learning mechanisms putatively located in the central nervous system.

The third paper takes a more central view. Ferreira and colleagues present an emergent, scalable and modular framework within which a collection of perceptual building blocks can be integrated using a Bayesian modelling infrastructure. The approach is inspired by the human dorsal perceptual pathway, and as presented integrates visual, auditory and ego-motion sensory information into a probabilistic egocentric spatial map that supports active behaviours such as visual exploration. Although focused on central processing, where the integration of the various perceptual sources is carried out within the common Bayesian framework, the work offers an interesting perspective on how perceptual modules (that can provide the right kind of outputs) might be integrated in a uniform way into a spatial mapping infrastructure.

The three papers take differing stances with respect to the peripheral-to-central division. Kim and Sim focus on the sensory signals generated in an electrosensory organ by suitable behaviour; Zhang and colleagues show how simple central learning can handle variation in a specific anatomical adaptation; while Ferreira and colleagues advocate a powerful technology for integrating sensory contributions within a central architecture. Other stances are undoubtedly possible; we hope that the three contributions presented here encourage further debate and experimentation.

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