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Invited Article

Generative Character of Perception: A Neural Architecture for Sensorimotor Anticipation

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Abstract

The basic idea of our anticipatory approach to perception is to avoid the common separation of perception and generation of behavior and to fuse both aspects into a consistent neural process. Our approach tries to explain the phenomenon of perception, in particular, of perception at the level of sensorimotor intelligence, from a behavior-oriented point of view. Perception is assumed to be a generative process of anticipating the course of events resulting from alternative sequences of hypothetically executed actions. By means of this sensorimotor anticipation, it is possible to characterize a visual scenery immediately in categories of behavior, i.e. by a set of actions which describe possible methods of interaction with the objects in the environment. Thus, the competence to perceive a complex situation can be understood as the capability to anticipate the course of events caused by different action sequences. Starting from an abstract description of anticipatory perception and the essential biological evidence for internal simulation, we present two biologically motivated computational models that are able to anticipate and evaluate hypothetically sensorimotor sequences. Both models consider functional aspects of those cortical and subcortical systems that are assumed to be involved in the process of sensory prediction and sensorimotor control. Our first approach, the Model for Anticipation based on Sensory IMagination (MASIM), realizes a sequential search in sensorimotor space using a simple model of lateral cerebellum as sensory predictor. We demonstrate the efficiency of this model approach in the light of visually guided local navigation behaviors of a mobile system. The second approach, the Model for Anticipation based on Cortical Representations (MACOR), is actually still at a conceptual level of realization. We postulate that this model allows a completely parallel search at the neocortical level using assemblies of spiking neurons for grouping, separation, and selection of sensorimotor sequences. Both models are intended as general schemes for anticipation based perception at the level of sensorimotor intelligence.

Keywords: Perception, Sensorimotor intelligence, Anticipation, Mental Movements, Cerebral Cortex, Cerebellum