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# Visually Guided Local Navigation Based on Visuomotor Representations in a Hyper Fuzzy ART-Architecture

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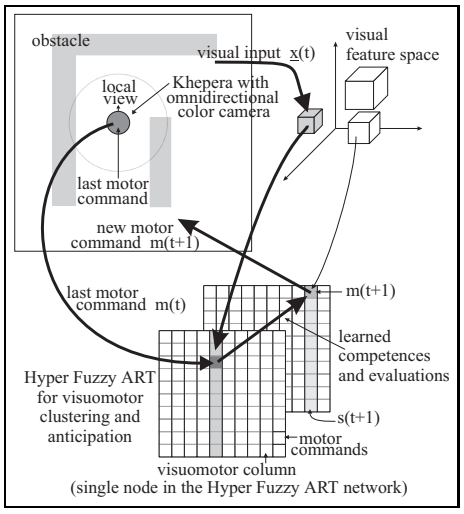
**Central Idea:** Based on novel sensorimotor theories of perception, we developed a new approach that avoids the common separation of perception and generation of behavior and fuses both aspects into a consistent neural process. Perception is regarded to be an active process which anticipates the sensory consequences of alternative hypothetical interactions with the environment. This view emphasizes the generative character of perception considering both sensory and motor aspects of the action-perception-cycle [1].
Of great importance for a successful navigation behavior is the evolution of a general understanding of space and shape, independent of specific visual details of the objects in the scene. In our view, the evolution of such a general understanding must be based on the capability to continuously simulate, evaluate, and select sensorimotor alternatives. This requires a generative process of anticipating the course of events.
**Architecture:** In this context, we developed a biologically motivated computational *Model for Anticipation based on Cortical Representations* able to anticipate and evaluate parallel hypothetical sensorimotor sequences. Prerequisites of this architecture are the development of a suitable sensorimotor representation of the environment and based on this, the generation of behavior appropriate for the actual system's goals.




The visuomotor input for our architecture is formed from the preprocessed image of an omnidirectional color camera and the last motor command executed. Within the architecture, these inputs are represented by a complex Hyper Fuzzy ART-architecture. The nodes of the Hyper Fuzzy ART are trained by the visual input (see figure on the left). Every node of this Hyper ART network contains a separate Fuzzy ART network (visuomotor column), representing the motor commands applied to bring the robot into the actual sensory situation described by the visual input. This results in a description of the visuomotor situation. Then, connections between the present and the preceding visuomotor situation are adapted to reflect both the reinforcement incurred during that particular transition and the aquired competence. Using Fuzzy ART in the context of this visuomotor task allows a fast and non-statistical learning, the handling of the stability-plasticity dilemma and a clustering of task specific, "useful" visuomotor situations.

This architecture thus embeds the functionality required for an entirely *parallel* generation of sequences of sensorimotor hypotheses. In the context of the biological foundations of the architecture, it is assumed that this parallel generation could be realized by a spread of activity through corticocortical connections in the supplementary motor area. These connections allow the direct prediction of subsequent sensorimotor situations as well as a competence and an evaluation for each transition.
**Experimental framework:**

To evaluate the perceptual performance of the systems, observable behaviors are the only indicators. Therefore, we investigate our anticipatory concept within a simple local navigation behavior of the real mobile system Khepera. We can demonstrate that parallel anticipation such as described, actually works in an anticipation based sensorimotor task (see figure on the left as an example), and moreover, yields better results than a purely reactive approach.

[1] Gross, H.-M., Heinze, A., Seiler, T., and Stephan, V. (1999). Generative Character of Perception: A Neural Architecture for Sensorimotor Anticipation. *Neural Networks*, pages 1101-1129.