Morphodynamics and perceptual worlds: conceptual approach and an experiment in evolutionary robotics

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From New A.I. came the deep conceptual insight that cognition is a consequence of the opportunistic exploitation of all morphodynamical properties of an agent's body and environment, which acts to minimize control at the algorithmic level. These properties structure the agent's perceptual world. Here, we aim at those morphological properties that structure the environment "as perceived" by the agent. Jakob von Uexküll's functional circle hypothesis, provides a general framework to understand active perception as morphologically-based. This framework must be seen within a broader *morphological turn*; this occurred in the second half of the 20th century across various fields of research, and is morphologically-based, as opposed to information-theoretic based (Almeida e Costa, 2008, Alife XI, these proceedings). For some authors, developments in dynamical systems theory opened the possibility of a nonreductionist physics of perception and meaning (e.g,. Petitot 2000, Physique du Sens, CNRS Éditions). A dynamicist approach regards organisms as being perturbed by and responding to cues they have been evolutionarily selected to respond to, rather than mirroring or extracting information from the outside world. The morphological structuring of the perceived environment is highly constrained by the particular morphologies of its body, and by the dynamics of those morphologies. To exploit this aspect for engineering and conceptual purposes, a particular method in evolutionary robotics is proposed, based on the functional circle hypothesis by Jakob von Uexküll (Macinnes et al., 2005 Adaptive Behaviour, Vol:14.2. p. 147). A functional circle is an abstract structure that describes the functional relationship between an organism, its "perceived world", and its environment. According to the functional circle hypothesis, a perceptual sign of an object (say, the smell of a mammal's butyric acid, captured by a tick) give rise to a perceptual cue, the *subjective experience* of that object in the organism's (the tick's) *Umwelt*: the word Umwelt was used by von Uexküll to describe the biologically evolved world of perceptions, as perceived by a particular organism/species, which results from the morphodynamical interaction with its environment. This leads to an effector cue which drives the animal to perform some action (say, fall down from the tree under which the mammal is passing), changing the organism's relationship to the object. After the action is performed, the perceptual cue is gone and therefore that functional circle is extinguished but may lead to another (say, dealing with the fur, finding warm skin, then biting). The proposed method consists of changing the mutational operators to evolve functional circles instead of directly evolving sensorimotor loops. The agent's morphodynamics and perceptual world are co-evolved; evidence suggests this enables a closer coupling between body, controller, and environment. The evolving functional circle hypothesis predicts that adding multiple perceptual cues produces robots more adapted to their environment than they would be otherwise. A comparative analysis of the evolved robots suggests that this is the case. An explanation is suggested: the specific positions of the sensors using mutable locations together with body morphology define spatial and temporal relationships with the environment. Co-evolving the agent's morphology, locations of its sensors, and controllers, evolve these relationships as well which implies that we are evolving perceptual cues, and therefore evolving perceptual worlds.