Workshop on Morphologies, Motion and Cognition

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Title:
Functional Circles, Evolvable Morphology, and Improving the Evolvability of Evolutionary Robotics

Abstract

Evolutionary robotics is a methodology by which the controllers, and sometimes a selection of the physical attributes, of a population of robots are varied so that the robots are more likely to exhibit some desired behaviour. It is a method that has allowed the synthesis of models used to investigate dynamical theories in neuroscience and cognitive science. It has the potential to develop as an engineering technology to automatically design robots.

Inspired by the ideas of behaviour-based robotics, researchers that implement evolutionary robot models usually ensure that their robots use little or no symbolic representations of the world. This is usually interpreted to mean that a signal provided by the robot's sensors should be presented largely unaltered to its controller in order that the robot should sense the environment as directly as possible. This means that it generally falls upon the controller to process the signals, distinguish between different input states, and produce the appropriate response in the robot.

However, a different approach can be taken. The ethologist Von Uexküll defined an abstract structure called a functional circle which he used to explain animal behaviour. A functional circle describes the functional relationship between an organism and an object or event in its world. The perceptual sign of an object (its colour, shape, smell, or some more complex set of attributes) give rise to a perceptual cue, the subjective experience of that object in the organism's Umwelt, or perceptual world. This leads to an effector cue which drives the animal to perform some action, changing the organism's relationship to the object. It is an effective theory of behaviour that has previously been applied to evolutionary robotics, and has also been highly influential in the field of behaviour-based robotics.

Empirical evidence is presented here that, inspired by the concept of the functional circle, altering our evolutionary robotic models in specific ways is a simple and efficient method of improving the evolvability of evolved robots. Furthermore, evidence has been collected that making these specific changes produce robots that are more `situated' and `embodied' than robots without these changes. This means that such robots are more closely coupled to their own bodies and environments than would otherwise be the case.

Ideas are put forward as to why this should be the case.

The robots presented have co-evolved morphologies and controllers. It is argued that an effective way of implementing evolvable functional circles, and therefore more easily evolve the (model of the) perceptual worlds of robots, is to allow their morphologies to evolve.