Ontogenetic Development of Skills, Strategies and Goals for Autonomously Behaving Systems

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Biological organisms display an amazing ability during their ontogenetic development to adaptively develop solutions to the various problems of survival that their environments present to them. Dynamical and embodied models of cognition [1, 2, 3, 4, 5, 6] are beginning to offer new insights into how the numerous, heterogeneous elements of neural structures may self-organize during the development of the organism in order to effectively form adaptive categories and increasingly sophisticated skills, strategies and goals. The ontogenetic development of behavior in biological organisms represents a significant level of improvement over current methods to develop action selection mechanisms for autonomous systems.

We consider biological organisms to be behaving intelligently when they act in ways that will enhance their current and future survival. The behavior exhibited by biological organisms is often very creative and flexible. Yet such behavior is always directed towards the satisfaction of the basic needs of the organism. Freeman [2] describes such behavior as intentional behavior. Intentionality provides a key concept that links the neurodynamics of brains to goal-directed behavior.

One of the primary acts of intentional behavior is in directing sensory observation in expectation of information to guide future actions. Both the formation of expectations, and the real-time dynamic interaction of the organism with the environment, are important principles of intentional behavior. Freeman's view of the mechanisms of intentionality is one of nonlinear dynamic interaction of heterogeneous neural elements on many time scales. The neurodynamic architecture of the brain forms many recurrent loops between brain and brain, brain and body, and organism and environment. But the basic architecture of intentional behavior can be found in the phylogenetically oldest parts of biological brains: the limbic system.

We present an architecture for autonomous behaving systems that we are developing. Our agents are designed to develop skills in a real-time demanding task environment by a process of artificial ontogenetic development. In effect we are developing a simplified model of the biological limbic system for use as a control architecture in autonomous agents. Such a model is capable of supporting limited forms of intentional behavior and ontogenetic like development. The agent self-organizes embodied categories by observing and interacting with its environment. These embodied categories form the basis for action-oriented representations that afford opportunities for appropriate behaviors for the agent. From these basic categories, increasingly complex behaviors and skills are learned while interacting with the task domain.

References

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