A Viewpoint on Embodied Synthetic Agency

Ovi Chris Rouly

Maelzel, Inc.
Mc Lean, Virginia
Contact: ocr@maelzel.com or http://www.maelzel.com

Abstract

An artificial (synthetic) intelligence can enjoy no more complex domain of sensory input than that provided by instantiation within an autonomous vehicular device. In order to embody an artificial intelligence (a synthetic agency) within a vehicular device (a host), the system designer must be prepared to integrate an array of mechanical components together with computational hardware, mission-specific behavioral heuristics, and autonomous control algorithms. Systems whose requirements specify adaptive, stimulus generalized, and purposive sensorimotor behavior may be a lesser challenge to design, if a degree of non-deterministic system behavior is allowed. However, the opposite is true for military systems that will require demonstration of not only deterministic concrete and even formal reasoning behavior but also retain positive control over an array of lethal and survival-motivated sensorimotor behaviors. Such "cognate" systems will have an implicit need for mechanisms that map raw sensation onto dissimilar cognitive sub-processing elements. Common to these systems will be the problem that the mechanism(s) they employ to map raw sensation onto cognitive sub-processes will be plagued by inherent representational, scope limited, and frame of reference offset errors. Further, all of these problems will be exacerbated in systems where specifications require evidence of agent learning as a deliverable. Obviously, these are not trivial problems and their solution will require methods derived from a variety of sources. In this essay, the author describes a focused array of principles taken from cybernetics and biogenic-psychology, a controversial view of intelligence, and a Turing algorithm history misplaced. Taken together, the author has found the principles useful in creating models of synthetic agency and host interface technology.

Position

The challenge of developing an intelligent, general purpose, artificial agent technology is itself the act of creating a computational system whose inputs are the spark of sensations yet uncaptured and whose outputs rest along the boundary between mathematical determinism and the chaos of an evolved sentient consciousness. Thus, if we are to embody artificial agencies, we should draw our inspiration from those natural agencies whose neurological engines (central nervous systems) are the basis of the behaviors, mechanisms, and adaptive teleology that we seek to model.

The Cornerstones

Norbert Wiener said of the central nervous system, "its most characteristic activities are explicable only as circular processes, emerging from the nervous system into the muscles, and re-entering the nervous system through the sense organs, whether they be proprioceptors or organs of the special senses" (Wiener, 1957, p. 15). Wiener coined the expression "cybernetic" from a Greek word meaning "steersman," or one who steers, to reflect on just the type of circular processes we are now considering. The first cornerstone of our model is a cybernetic paradigm.

The second cornerstone is a biogenic view of psychology and Piagetian equilibration theory. A working definition of equilibration is: a process by which the central nervous system acts to assimilate sufficient phenocopy behaviors (while still accommodating current stimulus events) as may ultimately prove to be adaptively successful. Admittedly, this is a simplification of a complex theory and an abstraction of a biological process. However, a meta-view of the purpose of the biological process and the scope of equilibratory theory recommends the mechanism of equilibration as an algebra of logicomathematic operations intimately related to a cybernetic paradigm.

Others have offered related views. For example, "for Piaget, cybernetics provides the dialectical area of a general theory of equilibration" (Boden, 1979, p. 134). And, in approximating the Piagetian logicomathematic process (" a quantifier … whose domain of variation is the set of propositions" (Piaget, 1985, p13)) we have derived a convolution integral that produces a satisfying mathematical result for sensorimotor structures (Rouly, 2000). However, the question of using ontogenetic or epigenetic mechanisms to map sensation onto synthetic cognitive elements remains unresolved.

The third cornerstone of our model holds that intelligence is not a computable function. Here, intelligence is seen only as a property of an adaptive system. Acting alone, intelligence is not capable of steering an agent (in a cybernetic sense) toward adaptive success. Rather, it is an enabler. In particular, the property of intelligence represents a quantifiable aspect of the equilibratory engine serving as both an abstract and species-specific indicator of the potential rate of equilibria acquisition and the adaptive quality of the equilibria equilibrated (consider the ideas basic to Herrnstein, 1994).

The fourth and final cornerstone of our model is an algorithm created by Alan Turing (Turing, 1948). In an experiment, the algorithm was instantiated as an agent and embodied within a host (Rouly, 2000). The algorithm induced a formal grammar within an unorganized finite state transducer. The resulting machine converted sensory input (sequences) into motor behavior output (sequences). The agent-host demonstrated Darwinian fit (adaptive) and purposive behavior over generalized stimuli. It reduced specific drives (compare Hull, 1943). The agent derived its behavioral ecology from a host-specific library of taxes and kinesis. Using basically stimulus / response learning, the agent assimilated sensorimotor schema when either self- or teacher-taught.

Conclusion

Systems that require deterministic sensorimotor, concrete, and formal reasoning behaviors will require complicated mechanisms that map raw sensation onto cognitive sub-processing elements. Systems that must demonstrate learning and general-purpose intelligence will be more complicated still. Paradigms relying on principles from evolutionary cognitive psychology (as found in Cummins, 1998) may prove useful in the instantiation of an embodied, synthetic, and cognate agency through their foundations in explicit ontogenetic versus epigenetic mapping. Our position is to recommend that we draw inspiration for our models from the prototypes of intelligence and not to rely solely upon abstract logical relations apparent in the behavioral artifacts of natural intelligence.

References

Boden, M.1979. *Jean Piaget.* New York: The Viking Press.

Cummins, D. D., and Allen, C. 1998. *The Evolution of Mind.* New York: Oxford University Press.

Herrnstein, R. J., and Murray, C. 1994. *The Bell Curve: Intelligence and Class Structure in American Life.* New York: The Free Press.

Hull, C.L. 1943. *Principles of Behavior.* New York: Appleton-Century-Crofts.

Piaget, J. 1985. *The Equilibration of Cognitive Structures: The Central Problem of Intellectual Development.* (Brown, T. & Thampy, K. J., Trans.). Chicago: University of Chicago Press.

Rouly, O. C. 2000. *Cybernetic Intelligence: A Return to Qualitative Feedback Theory*. Graduate Thesis, Dept. of Electrical and Computer Engineering, New Mexico State University.

Turing, A. M. 1948. *Intelligent Machinery. N. P. L. Report of the Controller.* (H.M.S.O. 1-20).

Wiener, N. 1957. *Cybernetics: Or control and communication in the animal and the machine.* New York: Wiley.