Recycling the Cycle of Perception: A Polemic
Extended Talk Abstract

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The Buddhist Middle Way acknowledges, but avoids, the polarities of asceticism and attachment. Analogously, in computational intelligence, we navigate amongst unipolar views on opposing sides of various apparent dichotomies.

Suppose we ask, "What characterizes intelligence?" We might answer with one, or more, of the following nine views. An intelligent agent is:

Proactive An agent achieves goals, implicit or explicit. Its behaviour is teleological, planned and future-oriented.

Reactive An agent perceives and reacts to environmental change. Its behaviour is causal and past-determined.

Model-based It uses models of the world to guide its perception and behaviour.

Learning-oriented It acquires new behaviours and new models.

Rational It reasons, solves problems and uses tools.

Social It collaborates, cooperates, commits and competes with other agents.

Linguistic It communicates and coordinates using language.

Situated It is embedded or situated in a world to which it is coupled. It is particular not universal.

Constraint-based It satisfies and optimizes multiple external and internal constraints.

Each of these aspects represents only a single perspective on intelligence, just as in the Buddhist legend of the elephant encountered by several hunters, each perceiving it idiosyncratically. No single aspect alone is an adequate, or sufficient, characterization of intelligence. Many of the endless controversies in AI, computational vision and robotics come from clashes between single-minded commitments to one of these views. An unexamined theory is not worth believing. Elsewhere, I have characterized the clash between the proactive and the reactive views of agents as the war between GOFAIR and Insect AI. A related clash in vision opposes a top-down, model-based approach with a bottom-up, model-free approach. Both of these clashes exemplify the dangers of extremism in the pursuit of agent theories. In each case we need a theory of the middle way that supports a clean union of both approaches. Otherwise, we'll continue

to see the oscillation from one pole to the other that characterizes much of our scientific history.

The thesis of this informal talk is that a useful way of understanding the evolution of theories of intelligence is an attempt to unify the proactive and reactive views. Consider the schema theories of Kant, Helmholtz, Bartlett, Piaget and Minsky. Piaget's cycle of assimilation and accommodation aims at integration. So do Neisser's Perceptual Cycle and Mackworth's Cycle of Perception, in different ways. The Expectation-Maximization (EM) algorithm involves two complementary phases. The E phase fits evidence to hypotheses and the M phase fits hypotheses to evidence. In logic-based approaches to, say, diagnosis, deduction and abduction play analogous roles for symptoms and diseases. In Bayesian approaches, a Belief Net can determine posteriors on hypotheses, given observations of evidence and *vice versa*, integrating both. The Kalman filter allows for both uncertainty and dynamics: integrating uncertain evidence with an simple, uncertain, predictive model. These approaches all have in common a cyclic interaction, with mutual accommodation and co-arising, between models and evidence or between the agent and its environment.

The obvious dilemma for any synthesis is that a coherent theory must have a single point of view. For example, Mackworth and Zhang's Constraint-Based Agent theory is, surprisingly enough, Constraint-Based. At the same time it is motivated by the claim that Proactive and Reactive views are, together, the necessary and sufficient conditions for intelligent agency. It also, modestly, claims to subsume each of the Model-based, Learning-oriented, Rational, Social, Linguistic and Situated views in a single architecture. Needless to say, some of these claims are more substantiated than others, to date.