A “Society of Mind” Cognitive Architecture Based on the Principles of Artificial Economics

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ABSTRACT

This research investigates the concept of mind as a control system using the “Society of Agents” metaphor, whereby the whole is described as the collective behaviour of simple and intelligent agents. This powerful concept for mind research benefits from the use of metacognition, and eases the development of a self-configurable computational model. A six tiered SMCA (Society of Mind Cognitive Architecture) control model is designed that relies on a society of agents operating using metrics associated with the principles of artificial economics in animal cognition. Qualities such as level of decision making, its cost function and utility behaviour (the microeconomic level), physiological and goal oriented behaviour are investigated. The research builds on current work, and shows the use of affect norms as metacontrol heuristics enables the computational model to adapt and learn in order to optimise its behaviour.

Keywords: Affect, Artificial Economics, Cognitive Architectures, Learning, Metacognition, Norms, Society of Mind

INTRODUCTION

A cognitive architecture can be viewed as an embodiment of a scientific hypothesis of (human and nonhuman, both animal and artificial) cognition. Cognitive architectures are designed to be capable of performing certain behaviours and functions based on our understanding of minds (Newell & Simon, 1972; Franklin, 1995; Davis, 2002). Cognitive science has developed in a number of directions including intelligent systems, reasoning, knowledge representation, and robotics. The evaluation of cognitive architectures has always been challenging. Several common concepts and different methodologies have been applied to developing new architectures.

There are many examples of cognitive architectures developed for different purposes through using different concepts available in different disciplines; for example, SOAR (Newell, 1990), ACT-R (Anderson, 1993), CRIBB
Agent behaviours can be analyzed using many different metrics; for example, affect valencing, (pseudo-)metabolic activity, competition and social interaction with respect to environment and microeconomics. The application of economics to artificial life to analyse adaptive behaviors provides a coherent framework from a cognitive architecture across many levels and types of processing.

ARTIFICIAL MINDS

Minsky (1985) defines mind as the functioning of the brain. Franklin (1995) defines mind as a mechanism of the brain. Minsky says “minds are just what brains do”. Franklin (1995) argues that the foundation for exploring the mechanisms of mind can be done through the possibilities offered by artificial minds. This gives rise to artificial minds defined as man made systems that exhibit behavioral characteristics of natural minds. However, artificial minds need not be limited to being analogues of natural ones. The possibilities offered by computational techniques, and synthetic designs, are equally valid in defining what constitutes an artificial mind.

Reasons for Studying Artificial Minds

Why do we need to study artificial minds? What is the need for studying nonhuman minds such as agents or robots? In “Artificial Minds”, Franklin (1995) gave three important reasons for studying artificial minds.

- Questions related to the nature of intelligence in human and nonhuman natural minds are inherently fascinating. The research on artificial minds may well throw a light on these questions.
- To better understand upcoming man machine mechanisms.
- To build better robots or intelligent machines and to work with them more effectively.

More importantly, such a community of agents requires agents that perform at more abstract levels. In order to provide a truly adaptable framework a “Society of Mind” needs a top layer catalyst like metacognition. Metacognition is a relatively new buzz word in cognitive theory (Adkins, 2004). Metacognition is defined as thinking about thinking and can be viewed in two ways:

- Monitoring a group of agents in an intelligent or cognitive or robotic architecture (i.e. self reflection)
- Making changes by adapting effective strategies in that group of agents (i.e. metacontrol).
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