Proposal for Summer Internship, 2010, Dr Bernard Scott

Title: A Cognitive Architecture for Learning and Skill Acquisition

Abstract

In the 1970s, the principal investigator implemented a computer program model of the cognitive processes involved in learning and skill acquisition (Scott, 1976). Programming was carried out in Fortran IV. The proposal is to (i) review and update the cognitive model in the light of more recent findings and developments in experimental cognitive psychology and cognitive modelling and implement it using current versions of Fortran and (ii) provide the model with a graphical user interface that permits the setting of model parameters and the display of model behaviour as it evolves over time.

The model is an explanatory model designed to provide understanding of the processes and empirically observed phenomena that are involved in learning and skill acquisition. The model focuses on the processes of learning and skill acquisition that occur in the following phases:

1. The problem-solving involved in building up a conscious representation of the structure of a skill.
2. The acquisition of sub-skills.
3. The integration of sub-skills.
4. Practice of the skill leading to proceduralisation.

Key features of the model are:

1. The learner is modelled as a complex adaptive system that is dynamically self-organising.
2. Achievement of goals set is subject to a free energy economy simulated as available processing time.
3. Learning is conceived of as an evolutionary process in which problem-solving 'operators' are selected from a population of possible responses.
4. Complex operators may be composed from simple operators. The driver for doing so is simulated by the rule that a complex operator consumes less processing time than the equivalent set of simple operators.
5. The model simulates concurrency in the proceduralisation and skill performance phases. This is conceived of as a competition between operators in which the outcomes of the application of one may have implications for the outcomes of the application of others. The possible interaction of operators applied concurrently is simulated by a set of serial executions of the operators that exhausts the set of possible interactions.

The model provides an explanatory account of two empirically observed phenomena:

1. Skilled practitioners lose access to a conscious knowledge of the skill structure.
2. Skilled practitioners are frequently aware, prior to the receipt of feedback about the consequences of their actions, that an error has been made.

As a model of a cognitive architecture, the model can be fruitfully contrasted with ACT-R (Anderson, 1983; Anderson et al, 2009) and with SOAR (Newell, 1991;

Newell et al, 2009), particularly in the way the dynamics of cognition are modelled and in the way concurrency is simulated.

References

Anderson, J. R. (1983). *The Architecture of Cognition*. Cambridge, MA: Harvard University Press.

Anderson J. R. et al (2009). *ACT-R*. http://act-r.psy.cmu.edu/ , accessed October 6th, 2009.

Newell, A. (1991). *Unified Theories of Cognition*. Cambridge, MA: Harvard University Press.

Newell, A. et al (2009). *SOAR*. http://sitemaker.umich.edu/soar/home , accessed October 6th, 2009.

Scott, B. (1976). *Cognitive Representations and Their Transformations in the Acquisition of Keyboard Skills*, PhD thesis, Department of Cybernetics, Brunel University.

Pre-requisites

Familiarity with Fortran and MatLab and the ability to get up to speed with programming skills very quickly.

An interest in artificial intelligence and cognitive modelling.