Retrieving of Remembrances via a Computational Cognitive Model of Knowledge Representation

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Introduction

To understand oneself is one of the greatest challenges for man. Subsequently, a multitude of theories was proposed by the past to model the mind and the behaviour that it dictates. Nowadays, computational technology has progressed to the point that partial implementations of mental models can be rigorously constructed. ACT-R (Anderson et al., 2004) is a computational cognitive theory that allows modellers to develop simulations of human behaviour that cover a wild variety of cognitive phenomena. This implies that the popular ACT-R architecture can offers a fair approximation of human cognitive ability. However, some exceptions do not support this conventional wisdom.

The ACT-R Architecture

The basic architecture of ACT-R consists of a set of modules, each devoted to processing different kind of information. Coordination in the behaviour of these modules is achieved through a central production system. Knowledge of the long-term memory is divided into two distinct categories: declarative knowledge and procedural knowledge. The former is composed of elements having descriptive nature and called chunks. Communication between the various modules is done via buffers. In each buffer, it is permitted to deposit and/or to recuperate only a chunk at a time. The acquisition of new declarative knowledge is made by stimuli interpretation of the environment or by calling procedural knowledge. The later are production rules that manipulate declarative knowledge. Procedural knowledge is acquired in situations of learning by acting. Novel knowledge is initially stored in declarative form and then, with the frequency of activation during the learning process, this knowledge will be compiled, generalised in rules and will be finally treated as procedures.

The Tiramisu Problem

In the research depicted here, we have been interested in the computational and cognitive modelling of the behaviour during food preparation which is suspended by an interruption phenomenon and its impact on the task accomplishment (Cutrell et al., 2001). We show that in a momentarily interrupted realisation of a Tiramisu recipe, the widely acknowledged ACT-R knowledge representation approach cannot offer a model that faithfully reproduces the usual human behaviour. More precisely, we highlight the incapacity of the ACT-R theory to reproduce properly (in a natural fashion) the recall of information in a temporal context. Abstractly, the Tiramisu recipe realisation consists of well-ordered layers of ingredients. A first type of frequent faults due to an interruption is the erroneous layers order. A second kind of errors results in being confused about the number of sets already placed and/or those remaining to place without necessarily being mistaken on the mixtures order. Experimental tests show that our ACT-R model was unable to remember the last chunk used before the interruption. In fact, the chunk which is always reminded was the one having the greatest activation value (see (Najjar et al., 2005) for more details). The activation of a chunk reflects its general usefulness in the past and its relevance to the current context. To resolve the problem, it was indispensable to enrich the defined chunks with additional slots. However, this solution, even if it demonstrates efficiency in memorising ultimate steps done before interruptions, cannot translate a right use of the human cognitive structures. i.e., the model behaves and reasons rather like a machine than like a human being.

An Alternative Theory

We propose an alternative knowledge representation theory which uses additional knowledge structures that are inspired from the human memory. In our approach, the distinction between declarative and procedural knowledge is mainly based on the criteria of the ACT-R theory. However, this new approach takes into account an additional component of the declarative memory – the episodic memory, a structure which is characterised by the capacity to encode information about lived facts and to preserve temporal relations allowing reconstruction of previously experienced events (Tulving, 1993). A model based on our proposed theory has proved its success in remembering events in a much more natural way than the ACT-R model. However, to consider the natural phenomenon of forgetfulness, we think that it is necessary to take into account an equation of remembrance which may be inspired from the activation law (for chunks) of the ACT-R theory. This takes part of our future work.

References

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