Cognitive Trait Model for Persistent and Fine-Tuned Student Modelling In Adaptive Virtual Learning Environments

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Information Science

Department of Information System
Massey University
Palmerston North,
New Zealand

Taiyu Lin
2003

Abstract

The increasing need for individualised instructional in both academic and corporate training environment encourages the emergence and popularity of adaptivity in virtual learning environments (VLEs). Adaptivity can be applied in VLEs as adaptivity content presentation, which generates the learning content adaptively to suit the particular learner's aptitude, and as adaptive navigational control, which dynamically modifies the structure of the virtual learning environment presented to the learner in order to prevent overloading the learner's cognitive load.

Techniques for both adaptive content presentation and adaptive navigational control need to be integrated in a conceptual framework so their benefits can be synthesised to obtain a synergic result. Exploration space control (ESC) theory attempts to adjust the learning space, called exploration space, to allow the learners to reach an adequate amount of information that their cognitive load is not overloaded. Multiple presentation (MR) approach provides guidelines for the selection of multimedia objects for both the learning content presentation and as navigational links.

ESC is further formalised by including the consideration of individual learner's cognitive traits, which are the cognitive characteristics and abilities the learner relevant in the process of learning. Cognitive traits selected in the formalisation include working memory capacity, inductive reasoning skill, associative learning skill, and information processing speed. The formalisation attempts to formulate a guideline on how the learning content and navigational space should be adjusted in order to support a learner with a particular set of cognitive traits.

However, in order to support the provision of adaptivity, the learners and their activities in the VLEs need to be profiled; the profiling process is called student modelling. Student models nowadays can be categorised into state models, and process models. State models record learners' progress as states (e.g. learned, not learned), whereas a process model represents the learners in term of both the knowledge they learned in the domain, and the inference procedures they used for completing a process (task). State models and process models are both competence-

based, and they do not provide the information of an individual's cognitive abilities required by the formalisation of exploration space control. A new approach of student modelling is required, and this approach is called cognitive trait model (CTM).

The basis of CTM lies in the field of cognitive science. The process for the creation of CTM includes the following subtasks. The cognitive trait under inquiry is studied in order to find its indicative signs (e.g. sign A indicates high working memory capacity). The signs are called the manifests of the cognitive trait. Manifests are always in pairs, i.e. if manifest A indicates high working memory capacity, A's inverse, B, would indicates low working memory capacity. The manifests are then translated into implementation patterns which are observable patterns in the records of learner-system interaction. Implementation patterns are regarded as machine-recognisable manifests. The manifests are used to create nodes in a neural network like structure called individualised temperament network (ITN). Every node in the ITN has its weight that conditions and is conditioned by the overall result of the execution of ITN. The output of the ITN's execution is used to update the CTM.

A formative evaluation was carried out for a prototype created in this work. The positive results of the evaluation show the educational potential of the CTM approach. The current CTM only cater for the working memory capacity, in the future research more cognitive traits will be studied and included into the CTM.

Table of Content