

Interaction Patterns as Support for Cognitive Modeling

Marcus Heinath (mhe@zmms.tu-berlin.de)

Research Training Group prometei, MoDyS, Technische Universität Berlin
Jebensstraße 1, J2-2, 10623 Berlin, Germany

Introduction

Cognitive models represent the knowledge and information processes that are assumed to be required for task performance. Cognitive architectures are used as an integrative framework of psychological theories; they further allow the simulation of human behavior in fine-grained steps. The promising potential of cognitive modeling as a method for evaluating dynamic human-machine systems, especially in early stages of the design process, is well-known. Nevertheless, the use of this method in industrial and research departments is sporadic as a result of both high costs and a huge amount of time to build and verify models. Following from this, the development of high-level languages to model human cognition based on low-level cognitive architecture is a contemporary matter in the cognitive research community (see Ritter et al., 2006, for an overview of current high-level approaches). Simplifying the model-building process and improving concepts for sharing and reusing model components are the main objectives of the various high-level approaches.

The building process of cognitive models

The process of building cognitive models consists of four general steps: (1) analysis of task domain, (2) empirical investigation of user behavior, (3) implementation of cognitive model and (4) its validation. One of the most challenging questions is how to transform analyzed task and domain specifications into an executable notation – the cognitive model. The presented approach concentrates on the cognitive architecture ACT-R (Anderson et al., 2004); consequently the specifications have to be mapped on procedural as well as declarative model primitives. This step is a less restricted interpretation procedure and requires extensive programming knowledge concerning the structures and mechanisms of the cognitive architecture.

Cognitive interaction patterns

To solve this mapping-problem between analysis and implementation, the idea of design patterns, established in software engineering, is transferred to the cognitive model construction process. Design patterns represent general solutions to recurrent problems (Gamma, Helm, Johnson, & Vlissides, 1995). They offer the opportunity to speed up the development process by providing tested development paradigms. Transferring the design pattern methodology to cognitive modeling, cognitive task patterns (CTP) were created. In general, a CTP describes a set of associated production rules illustrating the solution for a recurring task of interaction. For modeling perception, cognition and action processes, different primitive CTPs are specified

(e.g., “observe” a value of an interface element). The CTPs already contain the ACT-R declarative and procedural structures and possibilities for adaptation in respect of varying task situations or domains. Based on primitive CTPs, compound CTPs can be created by setting relations between several primitives (e.g., the compound CTP “scan” is composed of several primitive “observe” CTPs). Two types of relations exist: a predefined order (i.e., sequence) and a non-defined order (i.e., blob). Both single use as well as combination of state-based control structures and reactive situated control structures offers flexibility for reflecting interaction sequences. To transfer CTPs into cognitive design patterns as generic solutions for recurring tasks, a validation based on simulation traces compared to behavior data is required.

First implementation and outlook

Further development focuses on implementing an editor as part of a workbench to assist analysing, implementing, and verifying models. Currently, only a couple of CTPs are specified in a modified XML structure based on jACT-R (Harrison, 2006). Future work will be the development of further CTPs. To visualize the interaction process and to support cognitive modeling on a graphical level, an extended UML activity diagram notation is needed. This work is in progress and will be part of future investigations.

We expect that building high-level cognitive models with the help of cognitive task patterns will accelerate the modeling process, simplify the reuse of model fragments and improve the model communication.

Acknowledgments

This PhD project is funded by Deutsche Forschungsgemeinschaft (research training group GRK 1013 prometei).

References

- Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036-1060.
- Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995) *Design patterns: Elements of reusable object oriented software*. Boston, MA: Addison Wesley.
- Harrison, A. (2006). *jACT-R*. Retrieved March 20, 2006, from <http://jactr.org>
- Ritter, F. R., Haynes, S. R., Cohen, M., Howes, A., John, B., Best, B. et al. (2006). High-level Behavior Representation Languages Revisited. In *Proceedings of ICCM - 2006-Seventh International Conference on Cognitive Modeling*, 404-407. Trieste, Italy: Edizioni Goliardiche.