Minimize the Gap between Task Analysis and Cognitive Modeling

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Introduction

Cognitive modeling extends classical usability methods and expands the mainly descriptive and summative repertoire in human factors work by a prospective method that gains insight into detailed cognitive aspects of Human-Machine Interaction (HMI). However, cognitive modeling is seldom employed in usability research of HMI. Today's the most important constraints on practical application is the high cost/low benefit ratio caused by a lack of support tools for modeling and by high requirements on sophisticated knowledge in cognitive psychology and AI programming.

To simplify the development of cognitive models the HTAmap (Hierarchical Task Analysis mapper) approach has been developed. Two key features are essential: firstly, HTAmap minimizes the gap between human factors engineering and cognitive psychology research by using a plain high-level description that provides a stronger connection between task analysis methods and cognitive modeling. Secondly, it supports the reuse of cognitive model components based on cognitive activity patterns.

Theoretical Background

Cognitive architectures are integrative software frameworks of psychological theories to implement cognitive models. They allow the simulation of human behavior in fine-grained steps of cognitive processes. While developing a cognitive model a main bottleneck lies in the preliminary task analysis and is caused by different possible levels of task decomposition and formalization. Task analysis methods describe knowledge about cognitive processes with a greater degree of abstraction and formalization compared to low-level modeling approaches such as ACT-R (Anderson et al., 2004). Hence, the development of high-level languages to model human cognition based on low-level cognitive architecture is a current matter in the cognitive research community.

Research Approach and Practical Application

HTAmap delivers cognitive modeling functionality based on predefined and modifiable "cognitive activity patterns" (CAP). A large part of the complex cognitive model building process is transformed to a simple pattern-oriented modification task. Before building cognitive models composed of CAPs as proposed by HTAmap a structured task analysis is required. For this purpose the "sub-goal template" (SGT) method (Ormerod & Shepherd, 2004) is used. The output of the SGT method is a strategic decomposition of the task to the level of "information handling operations" (IHOs) and its re-description in terms of sub-goal templates, which represent a nomenclature for stereotypical operator tasks. This re-description is the starting point for the HTAmap approach. CAPs are now being used to solve the mapping-problem from high-level to low-level description. A CAP represents a generalized solution for execution of an operator task (e.g. observe, scan, monitor, de-/activate, adjust, evaluate) using cognitive resources to tackle a recurrent problem in a specific context. In general, CAPs describe the specific applications of identified IHOs at a less abstract cognitive level of ACT-R. In detail, a CAP comprises the necessary ACT-R declarative and procedural structures and provides interfaces for parameterization regarding various tasks and environments.

To prove the concept, we analyzed and modeled a selected process control task in ACT-R using the HTAmap approach. The aim of the control task is to stabilize the level of liquid in a container which is moderated by inflow, outflow and evaporation. The resulting HTAmap-model shows that the major parts of the ACT-R model are representable by means of CAPs and the simulated ACT-R model behavior equals to human behavior. For a detailed description see Heinath & Urbas (in-press).

Conclusion and Outlook

An editor for building HTAmap-models is being implemented. The mapping of a more complex process control task into an ACT-R model using the HTAmap approach will be part of future investigations for the third quarter of 2007. We believe that building cognitive models with the help of HTAmap makes the modeling process more accessible for a wider user group in usability research of HMI and simplifies the reuse of model fragments.

References

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