Facilitating Human Performance Modeling

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A computational modeling tool was demonstrated that automatically constructed a model of complex behavior from libraries of primitive actions and was able to predict the performance of human operators very accurately. One of the difficulties in developing human interfaces to complex systems is anticipating users' responses to the large space of possible system states and design options. Even extended empirical user testing can fail to uncover serious difficulties. Moreover, current practice fails to make use of the abundance of data and theory that could be applied to evaluate candidate human-system configurations. A promising solution is to develop a computational representation of the user to allow a designer to simulate user responses to a variety of situations and design options. This goal was approached by packaging the abundance of data on human perceptual, cognitive, and motor phenomena into sets of behavioral primitives or templates that can be incorporated directly into predictive, computational models. Templates reduce the amount of psychological and methodological knowledge required to build models, allowing the modeler to focus on task analysis instead of on low-level psychological theories and modeling methodology.

A tool was developed for automatically constructing long sequences of behavior from a small set of templates that describe primitive actions such as moving a mouse to a target, typing a key, or pressing a mouse button. The computational modeling approach, based on a powerful cognitive task analysis method called CPM-GOMS (Critical Path Method-Goals Operators, Methods, Selection rules), has been successful in making accurate, zero-parameter, *a priori* predictions of the routine performance of skilled users in a wide range of procedural tasks. This system, Apex, automatically generates streams of behavioral templates that can be visualized with PERT charts, showing the complex interleaving of cognitive, perceptual, and motor resources deployed by skilled users. Figure 1 shows the close fit between the performance times generated by the model and those generated by human users for a simple human-computer interaction task. The model predicts each mouse click in the task within 100 ms or less. Resource scheduling in Apex automates the difficult task of interleaving the cognitive, perceptual, and motor resources underlying common human-computer interaction task components (e.g. mousing to and clicking on a button). The user interface to Apex displays the PERT chart on command, allowing modelers to visualize a model's complex parallel behavior (Figure 2). Because interleaving and visualization is now automated, it is feasible to construct arbitrarily long sequences of behavior. Apex is being developed into a tool that is robust, fast, and usable in the context of predictive modeling for system design with libraries of behavioral templates for common human-computer interaction activities.

Current modeling environments impose barriers to computational human performance models that limit their use to a few special cases. Modeling has been time consuming, error prone, and requires specialized training in cognitive science. In order for computational cognitive modeling to achieve wider use in software design, it is necessary to make model production easier and more valid than it has been in the past. The implementation of a powerful modeling method by researchers at Ames and their collaborators at Carnegie Mellon University, marks a significant step toward this goal.