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Interactive Acquisition of Behavior Models

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ABSTRACT: *This paper describes our work in acquiring models of human behavior. We show 1) how existing knowledge acquisition techniques can be applied to building behavior models and 2) how the techniques can be further improved by developing an efficient acquisition dialogue tool. In particular, we present an approach to representing acquisition goals and principles explicitly and declaratively, making the system actively reason about various acquisition tasks and generate its presentations dynamically. The resulting interactions show that the system is aware of its progress towards acquiring new knowledge, moving forward by understanding what acquisition goals and tasks to pursue.*

1. Introduction

In past research, we have developed several useful approaches to enabling direct knowledge entry [Blythe et al 2001] including 1) tools that analyze KBs (knowledge bases) based on *interdependencies* between pieces of knowledge in the KBs and report inconsistencies and gaps 2) guiding users through *typical sequences of steps to be followed* in knowledge entry 3) *reasoning about general task models* that exploit pre-existing knowledge in order to guide users to provide the knowledge that is relevant to the given task 4) enabling users to enter knowledge by *modifying English paraphrases* of the formal representations. These KA (knowledge acquisition) techniques have been used to build knowledge bases in various domains where users with no formal background in computer science were able to build sizeable knowledge bases. We believe that these techniques can be applied in building behavior models and further improved in the context of supporting end users to develop complex models.

In applying these techniques we realize that although existing tools are individually very useful, they are limited in helping users decide when to use these tools, what to do with them and how well to enter knowledge, etc. They are mostly oblivious to the process or strategy that the user is following and unaware of the progresses made.

In this paper, we present our approaches to 1) *applying existing KA techniques to developing human behavior models for simulation* and further improve them by 2) *developing new techniques for KA dialogue* that makes the system actively reason about acquisition tasks and help users organize various KA tasks.

2. Approach

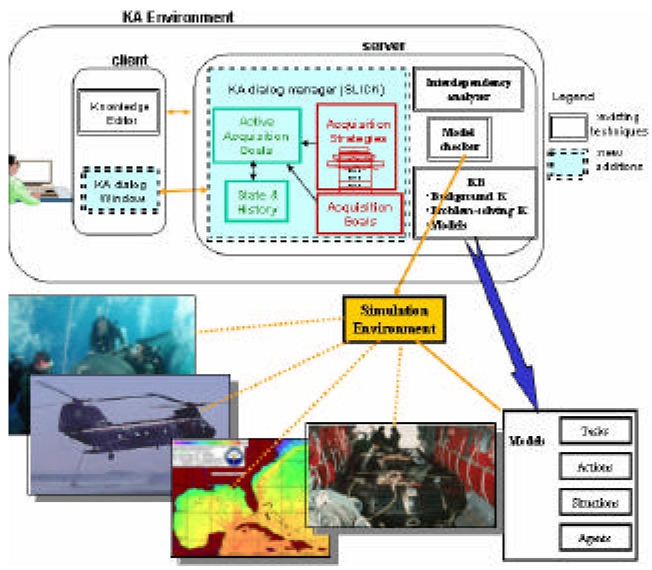

Figure 1: System architecture: capturing human behavior models from users.

In building a general knowledge acquisition framework for modeling behavior, we realize that there is a wide range of approaches to simulate human behavior. Here we make some initial assumptions with respect to the underlying simulation environment. In describing models, we assume that each *task* is composed of a number of *actions* that are performed by some *actors* assigned to the tasks. The tasks are performed in a given *situation* or state. We assume that the models are "declarative" so that the questions about the models can be answered using conventional inference methods. Each individual step has preconditions and effects, where preconditions specify the conditions needed to be satisfied to activate the step and the effects describe changes that result from the execution of the step. Simulation of the models can be supported by some of the readily available tools. Figure 1 shows the architecture that we are building to use in our work. The boxes in double-line represent existing KA techniques that are used in developing behavior models. The dotted boxes show new features that we are developing in order to enhance existing KA capabilities. Users enter behavior models through the Knowledge Editor but they can also interact with the KA Dialog Manager (through the Dialog Window) that actively reason about acquisition tasks and generate presentations based on its goals. The models being built can be given to the simulation environment for tests and the simulation results can be used for verifying and validating the models.

2.1. Applying existing KA techniques to developing human behavior models for simulation

The *English-based editor* enables users enter procedural knowledge using English paraphrase of the internal, more formal representations. This tool can be used for acquiring procedural knowledge that addresses particular capabilities, such as estimating the speed of a vehicle (e.g. SEAL delivery vehicle) while it is moving toward a location (e.g. the surveillance site). The *Interdependency Analyzer* can derive interdependencies between different pieces of knowledge by analyzing how knowledge is used during simulation and problem solving, which can point gaps and errors. For example, the Interdependency Analyzer can point that the user has to enter the type of the given vehicle in order to estimate the time to move it to the given site because computing the moving speed needs that input.

Users can be easily lost in the process of entering a model because even a moderately complex model requires many individual entries. If there are *prototypical sequences of entry tasks* users can follow, they can be exploited in deciding what to do next. For example, when users enter a new step, they typically start with understanding the role of the step, and then identify existing steps and objects relevant to the new step, building connection among them. Once they finish entering the step, they will assess if it was built as they expected. The *Model Checker* makes use of the simulation results in order to verify and validate the models. For example, it can detect missing steps or missing ordering constraints from failed preconditions during the simulation. The model checker can also examine if the process occurs as the user anticipated by testing the post conditions of the composed model given an initial tactical situation. If a suite of test questions is given, they can be used in validating the model, checking if the model is behaving as expected. Specifically, the problems reported by the current system include unachieved preconditions, failed expected effects, unordered steps, inappropriate execution of steps, invalid expressions, loops, disjunctive branches, causal links, etc. In addition, the Model Checker points to potential ways of solving problems based on its analysis results.

2. 2. Develop new techniques for KA dialogue

A second main area of our work is a significant new capability in KA dialogues: a front-end dialogue tool called SLICK (Skills for Learning to Interactively Capture Knowledge). Existing KA approaches fail to provide coherent help in deciding when, what, how and how well to perform many separate KA tasks. If we consider knowledge acquisition tools as students learning new knowledge from the user (teacher), current technology makes users feel like they are teaching a poor student with a lot of potential, one that has a lot of knowledge but appears to have no interest in learning. Our approach is to enable acquisition tools to have acquisition and learning goals represented explicitly and declaratively and be aware of the level of competence and confidence of the knowledge being acquired. This will help acquisition tools become proactive learner, being able to reason about learning activities and with initiative in participating in the process accordingly.

In a recent investigation, we have identified useful principles in the tutoring and learning literature that would be useful in a KA tool in order to turn it into a better student [Kim & Gil 2002]. Based on these analysis results, we have developed several capabilities to structuring KA dialogue where the system can: 1) formulate ***acquisition goals*** to turn acquisition tools into better students where the goals that are achieved at each point during the dialogue represent the progress made towards acquiring the desired body of knowledge. For example, when a KA tool starts an acquisition session, it can start asking about the topics and goals of the lesson. 2) generate ***awareness annotations*** to the KB so that we can make acquisition tools aware of the status of what has been learned, i.e., how much they know about a given topic and how confident they are about that knowledge 3) exploit known ***acquisition strategies*** in order to understand and actively pursue what is involved in learning about a new topic. Acquisition strategies should outline how to achieve acquisition goals.

Figure 2 illustrates what would the interaction be with SLICK while a user is entering an Army Courses of Action (COA). The example uses an actual COA created by an Army General as a part of the DARPA RKF program evaluations. The entry tool supports a simulation environment where the steps are executed one at a time relying on a situation mechanism. SLICK keeps track of: (1) lesson topics and questions that capture the user's intention in order to guide the KA dialogue (2) summary table for showing the objects and tasks involved in the lesson where the objects with potential problems (such as unassigned units) are shown in red and confident subtopics are shown in blue (3) highlights based on remaining tasks and problems found with guesses that provide suggestions on how the user can make progress. (The design of the windows was done based on the Army General's wish list.) For example, a key terrain feature Bridge-1 is not related with any tasks, and the role 'object' of the task has not been assigned yet. Inspecting these problems and the other constraints from existing knowledge, SLICK suggests that the Bridge-1 can play a role of 'object' of the Seize step, which can resolve the two problems. The 'Other Suggestions' section should show other problems and suggestions from SLICK and how they are computed based on acquisition goals and annotations.

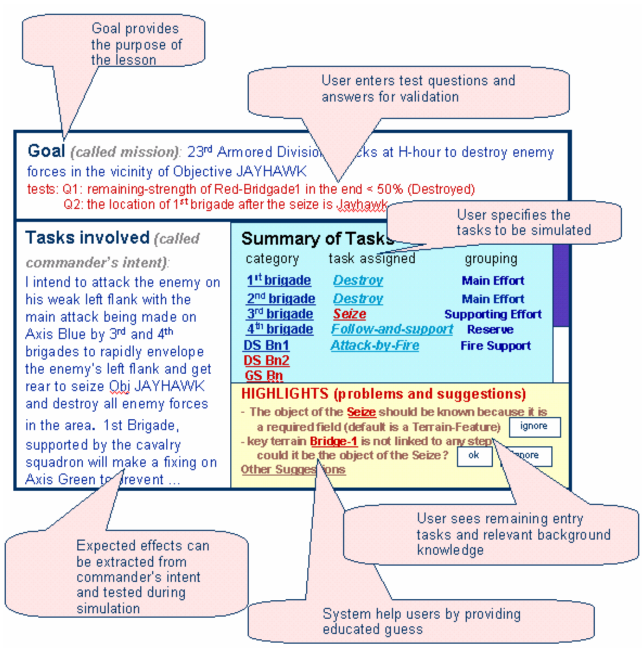

Figure 2. A front-end dialog tool (SLICK) for KA.

We have developed a prototype acquisition environment based on this approach and used it for acquiring two very different types of models: biological process models and military plans (Army courses of action). Although the features of the simulation environment in these problems are different from those in building behavior models, we believe that both share the same kind of issues [Pew and Mavor 1998; Silverman 2002].

In the case of acquiring COAs, SLICK is built as a front end of the basic entry tool. The officers who used our system commented that the SLICK functionalities are very helpful for understanding how they are making progress in building the models. One of the officers said that status report from SLICK is not only useful for the model/plan builder (the commander) but also can be sent out to other people (military units) who participate in the plan. The system has been also applied to acquiring biological process models where learning goals that are active are given the state of the model are shown to the users. From these exercises, we have found that our system may help users more when the acquisition tasks have many steps involving various sub-tasks (searching, editing, testing, fixing, etc.) and the tasks require keeping track of the context of what needs to be achieved. However, if the given acquisition task is very simple, with a small number of steps, then our approach may not provide much help.

We plan to improve the dialogue by incorporating plan recognition module that relates user commands with multi-step plans. We are also investigating other simulation environments that can help us more effectively address the issues arise in building behavior models.

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