SOLO: A Cognitive Orthosis

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Abstract

Solo is a cognitive assistive device which provides support in remembering when to perform tasks, executing the steps in a task, and recovering from unexpected events. The system includes an interface for clients to receive reminders, an interface for caregivers to enter information about the client's scheduled tasks, and a Cognition Manager which provides reminders and task guidance at appropriate times.

Introduction

We are developing a cognitive orthosis, called Solo, to aid cognitively impaired clients and their caregivers in managing their daily activities. Solo will allow a caregiver to organize a client's activities into a daily schedule and will instruct the client in how to perform activities in the schedule. Solo has four components:

- An Activity Assistant that guides a client through instructions to perform daily tasks as they arise on his or her schedule.
- A Design Assistant that aids a caregiver in defining the steps within a task and in creating a schedule of multiple tasks.
- A Cognition Manager that (1) builds a client schedule using information supplied by the caregiver and (2) generates and monitors the client instructions using knowledge from task analyses encoded by the caregiver and client feedback during activity execution.
- An Information Server that hosts the Cognition Manager.

The Cognition Manager consists of a Schedule Supervisor that builds and tracks activities in the client's schedule, and an Instruction Sequencer that dynamically constructs the sequence of steps to accomplish a task. The Schedule Supervisor is based on a deliberative planner developed for the military, called the Adversarial Planner [1] and the Instruction Sequencer is based on a reactive planner developed for use with mobile robots, the Reactive Action Package System (RAPS) [2]. The Schedule Supervisor activates individual tasks at the appropriate time by initiating the instruction guidance for the task and rearranges the schedule if it becomes apparent that more time is required for a particular task. The Instruction Sequencer guides the client in performing the currently active task, providing subsequent steps as the user progresses through the task. It can automatically alter the sequence of steps in response to problems or based on client responses.

The Activity Assistant receives information about the current step of the active task from the Cognition Manager. Based on this information, it dynamically generates a web page which presents this information to the client. The Activity Assistant makes this dynamically generated web page available over the internet. The client can direct a standard web browser on his or her PDA or other device to the page generated for him or her by the Activity Assistant. As the client progresses through the task, his or her web browser remains directed to the same web address. The Activity Assistant dynamically changes the web page at this address to reflect the current step in the task as further information is provided by the Cognition Manager. The Activity Assistant also collects information based on the client's response and/or the passage of time, and returns this information to the Cognition Manager for use in selecting the next step.

The Design Assistant allows caregivers to define the steps necessary to complete an activity. The user interface is designed to support caregivers both with and without skills in task analysis. A caregiver who is familiar with a client's typical difficulties will be able to incorporate contingency steps in the task so that clients can recover from common errors. The Design Assistant will also allow the caregiver to compose the client's daily schedule.

During nominal interaction, Solo will support the client by providing a portable view of his or her daily schedule. When it is time to perform a scheduled activity, the Cognition Manager will alert the client using a signal customized for the client (e.g., audio file of client speaking) and will display the appropriate instructions for performing the activity. Once the client begins to perform the task, he will be prompted for each step of the task and asked to give feedback when he completes the step. He also can ask for help if an instruction is unclear.

If a step takes significantly longer than expected, the user is prompted again with an alternative step (i.e., the

same step presented differently or an alternative way of performing the same step). If the user still does not indicate the step is complete, the caregiver can be notified to provide further assistance or the task can be abandoned. All such interaction will be logged for use by the caregiver and clinician in adjusting instructions.

If tasks are abandoned before completion or if a task takes significantly longer than expected, the Schedule Supervisor will adjust the client's schedule. When a task is abandoned, it frees up time to do other tasks on the schedule early if constraints permit. When a task runs late, it requires making choices about what planned tasks to delay to another day based on priority information provided by the caregiver or clinician when the schedule is built. When the caregiver or clinician builds the client's next schedule, tasks that were abandoned during the day will be reconsidered for scheduling the next day.

To support contingencies, Solo integrates deliberative planning with plan repair for activity scheduling and reactive planning for situated instructional assistance with alternative steps. It models tasks as goal states to be achieved. Task failure occurs when a goal state is not achieved by executing the associated instruction. Schedule repair is needed when tasks fail or are delayed.

The architecture of Solo's Cognition Manager resembles the integration between deliberative and reactive planning in 3T [3], a control architecture for mobile robots and crew space systems [4, 5]. In both cases, the deliberative planner passes a goal to the reactive planner. The reactive planner adds a task to its agenda that should accomplish that goal. When the task is removed from the agenda, the reactive planner passes back status information to the deliberative planner indicating whether the task was successful or not. This corresponds to whether the RAP associated with the goal from the planner completed successfully or not. While the 3T approach has been used to track humans performing tasks, specifically astronauts performing procedures [6], the Cognition Manager represents the first use of this approach to provide instructional assistance integrated with task tracking.

Current Status

Our current efforts are focused on developing and evaluating the Design Assistant. A major challenge in developing the Design Assistant is providing a simple approach for caregivers to follow when defining the steps of an activity. Essentially, breaking an activity into steps for a client is an exercise in task analysis, where the caregiver must identify each individual step of the activity and develop unambiguous instructions that can guide the client through each step. Rather than provide a programming-style interface, we are using a graphical approach that allows caregivers to specify each step and the relationship between steps from a display of options.

Concurrent with development of the Design Assistant, we have developed the Cognition Manager's Instruction Sequencer in conjunction with the Activity Assistant. Together, these components can present a series of prompts to a user, corresponding to the steps in a task. These prompts are presented as dynamically generated HTML. The user can respond to the prompts using the Activity Assistant to indicate progress or difficulty. The Instruction Sequencer presents subsequent steps as the user progresses through the task, or alters the sequence of steps in response to problems.

Usability trials by clinicians familiar with instructional requirements are planned to assess the extent to which the Design Assistant is both functional and usable. Additional trials are underway to assess the effectiveness of the Cognition Manager and Activity Assistant in guiding clients through sample tasks. Results will be used to inform system revisions and guide enhancements. In addition to formal usability studies, informal usability testing will occur continuously throughout the project. This will include activities such as talking with caregivers and consumers about their needs, getting feedback on screen mock-ups and design ideas, and asking clinicians to use and evaluate the system.

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