A Virtual World for Coaching Caregivers of Persons with Alzheimer's Disease

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Abstract

We present the design of a system for coaching caregivers on techniques for having social conversations with persons with Alzheimer's Disease (AD). Through an avatar in a virtual world, the caregiver practices interventions by eliciting autobiographical stories from a virtual character. Our system extends previous AI research in interactive drama and conversational agents in two areas: generation of autobiographical stories and modeling the effect on the conversation of successful and unsuccessful interventions by the caregiver.

Introduction

According to the Alzheimer's Association (2002),

> One in 10 persons over 65 and nearly half of those over 85 have Alzheimer's disease… Caregivers are affected by this disease, too. In a national survey, 19 million Americans said they have a family member with Alzheimer's disease …

The goal of our research is to develop an interactive virtual world for coaching caregivers on techniques for having social conversations with persons with Alzheimer's Disease (AD). More specifically, these techniques are intended to assist persons with AD in telling autobiographical stories. Researchers in gerontological narratology have discussed the psychological benefits to the elderly of recounting their life stories (Mills and Coleman 1994; Golander and Raz, 1996). Researchers have suggested that, although they are usually well-meaning, caregivers may not be attuned to attempts by a person with AD to communicate autobiographical memories (Small et al. 1998; Davis and Moore, 2001). However, with skilled conversational assistance a person with AD may be capable of telling autobiographical stories, and these "co-constructed" stories are similar in many ways to stories told by elderly persons without Alzherimer's dementia (Shenk et al. 2002). (For an example of a co-constructed autobiographical episode elicited from a person with AD, see Figure 1.) Our proposed coaching system will provide a caregiver with an opportunity to converse, through an avatar in a virtual world, with a character simulating a conversational partner with AD (we will refer henceforth to this character as the ADC). Through this simulated conversation, the user can learn and practice conversational techniques for interacting with and eliciting reminiscences from persons with AD.

A virtual world is a graphical user interface presenting a depiction of a 3D world that is dynamically updated in response to user commands to spatially navigate through it and manipulate its objects using standard input devices such as a mouse. Our motivation for adopting a virtual world interface is to provide the anticipated benefits of immersive training (e.g., Johnson et al. 1999): student engagement and transfer of skills to real-life situations. Our proposed system adapts artificial intelligence (AI) techniques from interactive drama (e.g., Rousseau 1996; Marsella et al. 2000) and embodied conversational and pedagogical agents (Cassell et al.. 1999a). Use of AI will help maintain the student's engagement by providing novelty and variety in the simulated conversational interaction, e.g., by enabling different stories to be told about the same events based upon the personalities of the storyteller and audience.

Furthermore, use of AI will enable the system to evolve in several ways. First, by making use of models of conversational interventions for the caregiver and of cognitive-linguistic deficits of persons with AD, it will be easier to modify the system to reflect new research or address the needs of other groups that could benefit from similar types of cognitive/linguistic stimulation. Second, by using foundational models of linguistic and paralinguistic communication, the system will be better able to incorporate advances in related technologies such

as speech recognition and will be easier to modify for delivery in other languages than English (Calloway et al. 1999). Third, by using foundational models of conversational narrative, it will be easier to change the stories that are generated to reflect different life experiences and cultural assumptions.

In the next section, we summarize system requirements derived from research on discourse of speakers with Alzheimer's Disease. In the section following that, we summarize related work in computer systems. Then we present the main contribution of this paper, the external and internal design of our proposed system. We conclude with a description of the current status of the project and our future plans.

System Requirements

Speech-language pathologists have identified certain direct intervention techniques to improve or maintain the functioning of AD patients "that capitalize on spared neuropsychological abilities to compensate for impaired abilities" including cognitive-linguistic stimulation (Mahendra 2001). The CAPPCI process (Perkins et al. 1997) has been designed to help a normal conversational partner to analyze the linguistic strategies employed by a person with AD as a step towards learning interventions for improving communication with that person. Features of the person's conversational abilities that are inventoried include: turn-taking skills (e.g., the ability to initiate conversation, the failure to respond when selected as next speaker, failure to hand over conversational floor), topic management skills (e.g., ability to initiate new topics, ability to maintain topics), memory ability (e.g., failure to remember family or events discussed in conversation), and linguistic abilities (e.g., failure in word retrieval, overuse of pronouns, production of circumlocutions).

Research on features of discourse of Alzheimer's speakers has revealed a number of communicative coping strategies that may be used by a person with AD to maintain conversational fluency such as use of frozen phrases and pronominal reference for topic management and use of exophoric pronominal reference to circumvent the inability to access lexical resources (Davis, Moore, and Peacock 2000). By learning to recognize such features and accommodating for them, the conversational partner can provide the person with AD with an opportunity for social interaction and validation of himself or herself.

To summarize basic system requirements motivated by this body of research, the system should provide training in three areas. First, the normal conversational partner needs to provide cues that signal interest and engagement in the conversation, e.g., by means of head nodding, gaze, or verbal feedback. Second, the partner needs to recognize the communicative coping strategies of the person with AD and react appropriately. Third, the partner can provide linguistic cues to help the person with AD recall information in episodic memory and to help prime lexical access. Thus, the system will model the conversational behavior of a person with AD through the ADC, enable the learner to influence the behavior of his or her avatar in a simulated conversation with the ADC in the virtual world, and thereby observe the success or failure of his or her actions on the simulated conversation.

Related Work

Computer-based role-playing training systems are starting to become available commercially (e.g., www.extempo.com). The systems derive from research on synthetic characters that improvise their behavior, within the constraints of a stereotypical scenario such as dining at a restaurant, using AI models of personality and emotion (Rousseau 1996). Those and other researchers have stressed the importance of modeling human personality and emotion in order to make synthetic characters believable and engaging (Elliott and Brzezinski 1998; Loyall 1997).

Carmen's Bright Ideas is a prototype instructional health system designed to allow mothers of pediatric cancer patients to improve problem-solving skills by learning a set of techniques, the Bright IDEAS method, through an interactive drama (Marsella et al. 2000). The animated multimedia drama portrays a session between a counselor and Carmen, the mother of a pediatric cancer patient. At points in the story, the user is allowed to choose from a set of thoughts and feelings that Carmen might be experiencing at the moment, which causes Carmen to act accordingly. The developers focused on the problem of controlling the plot and meeting pedagogical objectives while allowing the user to influence the behavior of the Carmen character.

GrandChair, a system using the ECA architecture (Cassell et al. 1999b), is designed to record stories told by elderly persons (Smith 2000). To encourage an elderly user of the system to tell stories, the system presents an animated child character that appears to listen to the user. The system uses cues such as intonation, body motion, and keyword spotting as the basis for generating the synthetic listener's responses.

While our system will build upon much of the above work, it must address additional problems. In contrast to GrandChair, for example, the intended user of our system is a caregiver who wishes to learn techniques to *elicit* stories. Thus, our system must be able to *create* autobiographical stories that will be told by the ADC in the course of a simulated conversation with the caregiver's

avatar. Furthermore, the ADC's generated discourse must model the discourse of a person with AD. Finally, the ADC's conversational behavior must model the effects of successful and unsuccessful interventions by a caregiver on conversation with a person with AD.

System Design

This section presents the external and internal design of our proposed system, shown in Figure 2. (Components in the figure appear below in bold font.)

User Interaction in Virtual World

The intended user of the system is a caregiver (**Live Student Caregiver**) who wants to learn or practice interventions for encouraging a person with AD to tell autobiographical stories. The 3D graphical user interface presents a **Virtual World** set in a sitting room that includes (1) an animated character representing a caregiver (**Caregiver Avatar**), (2) an animated character representing a person with AD (**AD Character)**, i.e., the ADC, (3) and **Secondary Characters** that appear from time to time such as unexpected visitors and health care workers. The simulated dialogue is presented using sound. From time to time, the user is offered a choice of several interventions that the avatar could perform at the present moment, depicted in menu form over **Caregiver Avatar's** head. The user indicates his selection by a mouse click. In addition, the user can control the avatar's backchannel dialogue actions by mouse movement while the ADC **(AD Character)** is talking.

Internal Design

The **Caregiver-coach Agent** and **Conversational Storyteller Agent** are the "brains" of the **Caregiver Avatar** and **AD Character**, respectively. They each send instructions to the **User Interface Director & Event Detector** for controlling their respective character's linguistic and paralinguistic (facial expression, etc.) actions. The **User Interface Director & Event Detector** is responsible for translating these actions into animation and audio instructions in the virtual world. (Audio instructions include playing segments of recorded speech.) In addition, this **Director** coordinates system-generated events in the virtual world, controls the lighting and the "camera's eye", and generates the actions of the secondary characters. In addition, whenever the user performs an input action this component records the event in the **Dialogue Model**.

Since interpretation of linguistic and paralinguistic actions is a difficult problem that need not be addressed for our purposes, our design avoids the requirement for the **Caregiver-coach Agent** and **Conversational Storyteller Agent** to interpret what the other's realized dialogue actions meant. Instead, the function and form of expression of each agent's actions is encoded by the generating agent in the shared **Dialogue Model**. (This shared data structure should not be confused with a representation of the characters' shared beliefs, which only comprises one element of the **Dialogue Model**, the **Common Ground**.) In other words, while the dialogue is simulated in the interface for the user's benefit, no interpretation need be performed in our system because, unlike in the real world, both agents have access to information stored in each other's "brain".

However, in order to support the generation of the agents' dialogue, it is necessary to maintain a rich **Dialogue Model**, whose components are motivated by previous work in discourse analysis, conversational narrative (e.g., Polanyi 1989), and computational models of emotion (e.g., Rousseau 1996; Velasquez 1997). In particular, it includes a (1) **Discourse Model**: the Textual, Ideational, and Interactional levels of the dialogue (Georgakopoulou and Goutsos 1997); (2) an **Emotion-Personality Model:** the affective state of the Storyteller Agent (3) a **Narrative Model:** structural and episodic information from the story; and (4) the **Common Ground** (Clark 1996): information conveyed in previous conversations, shared knowledge of events and objects in the current conversational setting, semantic associations between lexical items, and shared knowledge of famous events

The **Caregiver-coach Agent** is composed of three modules that operate in sequence. Initially, the **Action Proposal Module** selects the set of possible actions from the caregiver's Action Repertory that are relevant with respect to the current **Dialogue Model**. Next, the **Action Selection Module** decides whether to let the user select the next action from the set of possible actions; if the user is not granted the choice, then this module chooses the most appropriate action; in either case the choice is sent to the **Dialogue Realization Module**. Finally, the **Dialogue Realization Module** decides how to express the selected action in language and/or through paralinguistic actions such as facial expression, gesture, intonation, etc. The advisability of architecturally distinguishing dialogue *function*, corresponding to the level of representation in the Action Repertory, from dialogue *behavior*, corresponding to the level in the **Dialogue Realization Module**, has been argued for by Cassell et al. (1999b).

The **Conversational Storyteller Agent** also consists of three modules operating in sequence. Initially, the **Action Proposal-Selection Module** selects the agent's next action from the set of actions in this agent's Action Repertory that apply given the current **Dialogue Model**. If the selected action is a storytelling action type, story content is supplied next by the agent's **Storytelling Action Refinement Module**. This module makes use of

information in the agent's **Life Episodes Model**, a representation of the agent's autobiographical memory. Also, the state of the **Dialogue Model** may influence the selection of an episode or details from an episode in order to achieve narrative goals. Finally, both non-storytelling actions and refined storytelling actions are expressed by the agent's **Dialogue Realization Module**.

The design of the **Conversational Storyteller Agent**, as described so far, does not account for how the system can provide a believable simulation of conversational behavior of a person with AD. First, in the **Action Proposal-Selection Module**, the agent's inclination to begin or to continue telling a story depends on the state of the Discourse Model and the agent's Emotion-Personality Model. These models are influenced by the actions of the caregiver in the preceding dialogue and by the perceived success or failure of the storyteller's own attempts to communicate in the preceding dialogue. Second, the **Storytelling Action Refinement Module** is influenced by what storytelling routines and what parts of the **Life Episodes Model** are accessible currently. Accessiblity is influenced by the presence of triggers in the **Common Ground** of the **Dialogue Model**. These triggers arise from events and objects in the current conversational setting or from semantic priming from the preceding discourse. Third, the **Dialogue Realization Module** will be restricted in lexical choice and production of referring expressions. Lexical choice will be limited by what parts of the agent's lexicon are accessible currently, where accessibility is influenced by the triggers described earlier. Referring expressions will be limited to pronominal forms. In addition, certain types of pragmatic functions will be realized using strategies characteristic of Alzheimer's discourse, e.g., using frozen phrases to signal topic closure.

Conclusion and Future Work

We have presented the external and internal design of a system for coaching caregivers on techniques for having social, autobiographical conversations with persons with Alzheimer's Disease. Currently, we are developing a rapid prototype using a 3D Virtual Worlds authoring tool, Alice (www.alice.org), for the user interface. The purpose of implementing the prototype is to get user feedback on the design of the user interface such as input actions to control the avatar's head nodding action. Later, after the Conversational Storyteller agent has been implemented we plan to ask researchers who study discourse of persons with AD to evaluate the believability of its conversational behaviors.

After the fully implemented system is deployed, we plan to perform several types of evaluation with different objectives. The first type of evaluation will be to analyze logs of student usage of the system to determine to what extent students' selection of correct interventions improves over time. One goal of this type of evaluation is to discover whether particular interventions are not being learned so that the system's approach to teaching them can be redesigned. In addition, questionnaires will be used to evaluate subjective factors such as user satisfaction. However, these methods cannot tell us whether the training will transfer to real-life situations, and whether the interventions being taught truly are effective in improving communication between caregivers and persons with AD. Thus, field trials will be conducted by geriatrics experts to compare the communicative effectiveness of caregivers who have been trained by our system to those who have had no training.

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Glory: I just lived in a regular farm home. Farmed cotton, corn, eh-everything you … grow on a farm.
BD: That's right.
Glory: I had a big ol' cotton bag tied around me, pickin' a hundred pounds of cotton … UhhmmHmm.
BD: A hundred pounds? An' you so tiny!
Glory: Huh?
LM: You're a tiny person to be carrying that much cotton.
Glory: I decided one day I'd pick a hundred pounds. Guess how much!
LM: How much?
Glory: A hundred and three.
LM: Oooohh.
BD: Wow.
Glory: I went over.
BD: That's fantastic.
Glory: A hundred and three -- you've got to grab it to … get a hundred and three pounds of cotton in one day.

Figure 1: Transcript of conversation between Glory, an elderly nursing home resident with Alzheimer's disease, and two visitors (LM and BD) in which Glory is encouraged to talk about her life as a young woman (Shenk et al., 2002).

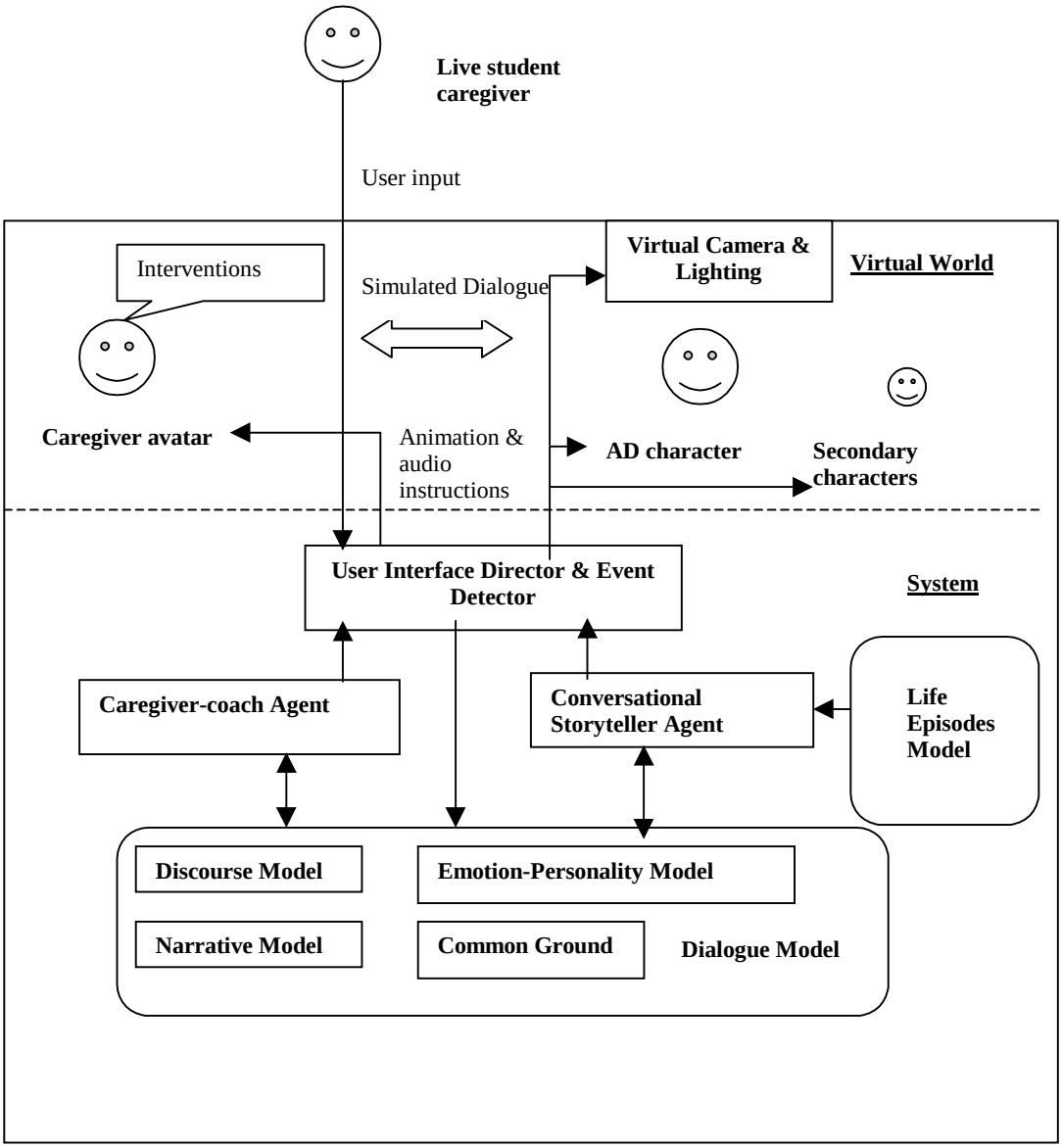

Figure 2: External and Internal System Design.