Towards Plan-based Health Behavior Change Counseling Systems

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Abstract

In this position paper we outline our preliminary work and future directions in building behavior change counseling systems that manage dialogue on the basis of explicit representations of concepts and techniques from behavioral medicine.

Introduction

In the area of automated natural language dialogue-based health behavior change interventions, all systems that have been evaluated in large-scale randomized clinical trials to date have used relatively simple dialogue management techniques (Bickmore and Giorgino to appear). These techniques include various forms of scripting; representing dialogues as linear sequences of dialogue moves, finite state machines, and augmented transition networks, exemplified by VoiceXML. These systems also have very shallow computerized knowledge representations of the application domain and the behavior change theories they are based on. While this approach has proven adequate for building relatively small applications, it has fundamental limitations in scalability and tailorability (human script writers can only keep a small number of variables and dialog fragments in mind at one time) as well as portability and reusability. Moreover, in scripted interventions it is difficult to directly tie intervention messages to theory.

Dynamic dialogue planning frameworks overcome these deficiencies and enable message-to-theory linkages to be explicitly modeled. The resulting systems provide reusable frameworks in which what is said and done are more perspicuous to the developers of the system as well as more natural for the addressee. To date, some research has been done in dynamically planning dialogue for the application of clinical guidelines (Beveridge and Millward 2003), for the automatic generation of reminders for older adults with cognitive impairment (Pollack, Brown et al. 2003), for medication advice (Ferguson, Allen et al. 2002), and in a few other areas. Of particular note, Grasso, et al, developed a dialogue planner for nutrition counseling using an argumentation theory framework (Grasso, Cawsey et al. 2000). However, the automatic generation of health behavior change counseling dialogue—spanning the elicitation of information from a patient, negotiation of treatment plans, motivation, goal setting, tracking progress over time, and the timely deployment of a broad range of counseling techniques—has yet to be demonstrated.

In this position paper, we outline our plans for developing a plan-based system to automatically generate health behavior change counseling dialogue based on explicit representations of behavior change theory. We first provide a description of the initial theoretical frameworks we plan to implement, and brief descriptions of the dialogue planning framework and interaction modality we are using.

Health Behavior Change Theories

The Transtheoretical model (TTM) has been developed over the last 20 years by Dr. James Prochaska and his colleagues and is one of the leading theories of health behavior change.(Velicer, Prochaska et al. 2000) The TTM uses "Stages of Change" as an organizing framework. People are classified by their readiness to change into one of 5 stages: Precontemplation, Contemplation, Preparation, Action, and Maintenance (DiClemente, Prochaska et al. 1991; Velicer, Prochaska et al. 1992). Precontemplators are not intending to change in the next 6 months. Contemplators are intending to change in the next 6 months. People in Preparation are planning to change in the next 30 days and have typically made previous attempts to change. People in the Action and Maintenance stages have changed, with those in Action having changed within the last 6 months.

Motivational interviewing (MI) is a brief, directive, client-centered counseling method for enhancing intrinsic motivation to change by helping clients explore and resolve ambivalence (Miller and Rollnick 2002). The method includes a number of conversational strategies for eliciting "change talk" from clients in order to increase their motivation to and confidence in changing their behavior. MI was originally developed for use in the treatment of substance abuse disorders but has also been successfully used in physical activity and diet promotion. MI integrates well within the TTM, and has been identified as a particularly effective mechanism for health care providers to adopt in assisting individuals to move from the Precontemplation and Contemplation stages of change through Preparation and into Action.

In our work we are developing a counseling system based on TTM- and MI-based health behavior change concepts and techniques as applied to physical activity promotion. Participation in moderate amounts of physical activity has important health benefits, including beneficial effects on risk factors for disease, disability, and mortality,(LaPorte, Adams et al. 1984; Stewart and Haskell 1993; Young, Haskell et al. 1993; Bouchard and Stephens 1994; Services 1996) yet a substantial proportion of the U.S. adult population remain underactive or sedentary.(Services 1996) In addition, we have experience developing and evaluating script-based physical activity promotion systems (Bickmore, Gruber et al. 2005; Bickmore, Caruso et al. to appear). We are modeling constructs specific to TTM and MI and how these relate to physical activity-specific interventions, focused on Precontemplators and Contemplators, but also including some concepts and counseling techniques for patients who have moved on to Action (e.g., goal setting and positive reinforcement).

COLLAGEN

COLLAGEN is an application-independent dialog planning framework developed over the last ten years at MERL (Rich and Sidner 1998). COLLAGEN is based on the SharedPlan theory of Grosz and Sidner (Grosz and Sidner 1986; Grosz and Sidner 1990), Grosz and Kraus (Grosz and Kraus 1993; Grosz and Kraus 1996), and Lochbaum (Lochbaum 1998), which provides a well-specified computational theory that has been empirically validated across a range of human domains. The theory, in turn, is based on the notion of *collaboration*, in which two or more participants coordinate their actions toward achieving shared goals. Dialogue, from this perspective, is fundamentally a collaboration between two people, who must coordinate the start, end and maintenance of the interaction, negotiate topics, turn taking, and other conversational actions (Clark 1996). Collaboration is also an especially appropriate theoretical foundation for medical and therapeutic dialog given the recent focus on patient-centered medicine (Bensing 2000), therapeutic alliance (Gelso and Hayes 1998), and shared decision making between physicians and patients.

Relational Agents

The importance of good communication and quality relationships between health care providers and their patients is now widely recognized as a key factor in improving not only patient satisfaction, but treatment outcomes across a wide range of health care disciplines. The use of specific communication skills by physicians—including strategies for conducting patient-centered interviews and relationship development and maintenance—has been associated with improved adherence to treatment regimens, improved physiological outcomes, and increased patient satisfaction (Roter and Hall 1993). In psychotherapy, the positive effect of a good therapist-patient relationship on outcomes has been demonstrated in many studies, and has even been hypothesized to be *the* common factor underlying the many diverse approaches to psychotherapy that seem to provide approximately equivalent results (Gelso and Hayes 1998).

These results indicate that effective automated health behavior change interventions must not only be able to deploy appropriate intervention messages at the appropriate time, but must also address social and relational issues in their communication with users. In scripted dialog systems, human script writers tacitly address these issues in the scripts they create. However, if computers are to take over more of the dialogue authoring task, the rules underlying these relational factors must be explicitly codified into the system. Relational agents are computer agents that are designed to do this, and use these techniques to maintain long-term relationships with users over repeated interactions (Bickmore and Picard 2005), essential for maximizing the effectiveness of behavior change interventions that typically last months or sometimes years in duration. Although relational agents could be constructed using a wide range of media, embodied conversational agents (Cassell, Sullivan et al. 2000)—those which simulate face-to-face conversation through the use of computer animated characters that use hand gesture, gaze, facial display and other nonverbal modalities—are particularly effective given that face-to-face conversation is the primary modality used to build human relationships (Duck 1995), and that many of the relational strategies that humans use within conversation are nonverbal (Andersen and Guerrero 1998). Embodied agents also provide additional channels that can be used to communicate emotional state (e.g., through facial display),

Figure 1. Relational Exercise Advisor Agent

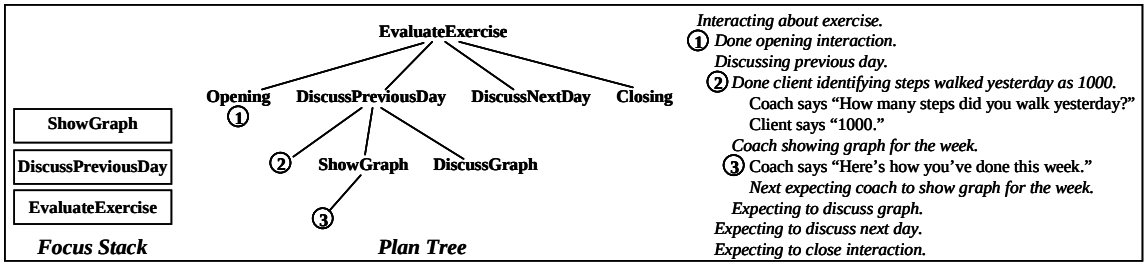

Figure 2. State and Segmented Interaction History for PA Example

which many researchers have cited as an important but understudied aspect of argumentation systems.

A relational agent that plays the role of an exercise advisor has been developed that is designed to conduct daily dialogues with users to help them increase their levels of physical activity (see Figure 1). This agent has been successfully evaluated in two randomized clinical trials involving college students (Bickmore, Gruber et al. 2005) and geriatrics patients (Bickmore, Caruso et al. to appear).

Current Status

We have implemented an initial prototype, Action-stage, physical activity promotion counseling system in COLLAGEN. A snapshot of the dialogue state during a consultation is shown in Figure 2. This system conducts a brief counseling session by first engaging in a greeting exchange (Opening), followed by a discussion of the client's exercise behavior on the previous day (DiscussPreviousDay), followed by a goal-setting dialogue for the following day (DiscussNextDay), and finally a farewell exchange (Closing). Exercise behavior is determined by simply asking the client how many steps they walked, and feedback is given based on whether the steps actually walked is greater or less than a previously-established goal. If the goal is met, positive feedback is provided ("You've met your goal for yesterday."), otherwise encouragement is provided ("Don't give up!"), and, in both cases, a tip is given (e.g., "You'll find it easier to meet your goal if you walk at the same time each day."). The goal-setting dialogue consists of the agent reminding the client of what their long-term goals are and prompting them to set a goal based on their current level of activity and their long-term goal. The dialogue is structured hierarchically on the basis of a decomposition of task goals shared between the agent and client. For example, the DiscussPreviousDay goal is partially satisfied by presenting and discussing a self-monitoring graph depicting exercise progress over time (ShowGraph, DiscussGraph).

COLLAGEN's discourse state consists of a stack of goals, called the *focus stack*, and a *plan tree* for each goal on the stack. The top goal on the focus stack is the "current purpose (goal)" of the dialog. A plan tree in COLLAGEN is an (incomplete) encoding of a partial SharedPlan between the user and the agent (Grosz and Sidner 1990). For example, Figure 2 shows the focus stack and plan tree immediately following the discourse events numbered 1—3 on the right side of the figure.

The annotated, indented execution trace on the right side of Figure 2, called a *segmented interaction history*, is a compact textual representation of the past, present, and expected future states of the dialog. The numbered lines in a segmented interaction history are simply a log of the agent's and user's utterances and primitive actions. The italic lines and indentation reflect COLLAGEN's interpretation of these events. Specifically, each level of indentation defines a *segment* whose purpose is specified by the italicized line that precedes it. For example, the purpose of the toplevel segment in Figure 2 is *Interacting about exercise*. Unachieved purposes that are currently on the focus stack are annotated using the present tense, such as *discussing*, whereas completed purposes use the past tense, such as *done*.

Finally, the italic lines at the end of each segment, which include the keyword *expecting*, indicate the steps in the current plan for the segment's purpose which have not yet been executed. The steps which are "live" with respect to the plan's ordering constraints and preconditions have the added keyword *next*.

Conclusion

Our general plans are to augment COLLAGEN with an ontology of concepts from health behavior change, ranging from theoretical constructs (e.g., stage of change) to specific counseling techniques (e.g., taken from motivational interviewing). We also plan to use the FitTrack relational agent as a front end for the system so that we can explore the generation of appropriate relational behavior (e.g., social dialogue, meta-relational communication, etc.) from first principles as well.

Currently, we plan to determine most information about the client's intention to change and level of motivation by direct questioning, either using questions from a validated instrument (e.g., (Marcus, Selby et al. 1992)) or techniques from motivational interviewing (Miller and Rollnick 2002). Inferring this information from less structured dialogue (as in (de Rosis, Novielli et al. to appear)) is an interesting direction of research, but not within our current plans.

Our objective is to demonstrate that health behavior change dialogue can be generated from deep, ontology-

based models of collaboration and behavior change theory, that the resulting models are readily reusable and extendable in new application domains, and to further the process of ontology development in behavioral medicine.

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