



Fig. 1: Embodied Conversational Agent

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Thank you for your reviews.

Designing Health Conversations with Relational Agents

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Abstract

Automated dialogue systems represent a promising approach for health care promotion, thanks to their ability to emulate the experience of face-to-face interactions between health providers and patients. In this position paper we describe our framework for designing health dialogue systems using embodied conversational agents, and discuss our strategies for building health counseling dialogues and maintaining user engagement in longitudinal health interventions.

Author Keywords

Health dialogue; conversational interfaces; relational agents; embodied conversational agents.

ACM Classification Keywords

H.5.2. Information interfaces and presentation: User Interfaces – Evaluation/Methodology; Natural Language; Interaction Style.

Introduction

Over the last three decades, there have been increasing research and commercial interests in the adoption of automated dialogue systems for health care. Health dialogue systems are designed to simulate the one-on-one, face-to-face conversation format between health providers and patients, which is widely

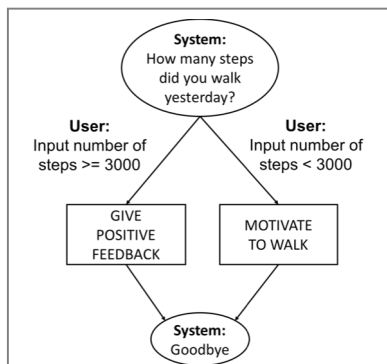


Fig. 2: Example hierarchical transition network [2]

Counseling Dialogue Recipe:

1. Greeting
2. Social Dialogue
3. Review Tasks
4. Assess Current State of Behavior
5. Counseling
6. Negotiate New Tasks
7. Farewell

Fig. 3: High-level structure of a typical counseling dialogue

considered as the “gold standard” for health education and promotion. In these interactions, health providers have the ability to finely tailor their utterances to patient needs, and patients have opportunities to ask clarifying questions and request further information of interest. Unfortunately, many patients cannot or do not get as much access to health providers as they would like, due to cost, convenience, logistical issues, or stigma. Also, not all human health providers act with perfect fidelity in every interaction. Automated health dialogue systems can address these shortcomings. A number of telephony and embodied conversational agent (ECA) systems have been developed to provide health education, counselling, disease screening and monitoring, as well as promoting health behavior changes [6]. Many of them have been evaluated in randomized clinical trials and shown to be effective.

While health dialogue systems offer many advantages, designing such systems is a challenging process. Health dialogue has a number of unique features that make it different from the more typical information-seeking conversation supported in conversational assistants such as Siri, Alexa or Cortana [2]. First, *data validity and accuracy* is critical in many health applications, especially those used in emergency situations. Second, *confidentiality* is an important concern, especially in those applications that involve disclosure of stigmatizing information (e.g. HIV counselling). Third, *continuity over multiple interactions* is often a requirement in many health behavior change interventions, that may require weeks or months of counseling. Finally, just as therapeutic alliance is critically important in human-human counseling interactions, the management of the *user-computer relationship* through dialogue could be a key factor in

increasing adherence and patient satisfaction in automated systems. These features need to be taken into account in the design decisions of input and output modalities, methods for prompting and error handling in dialogue-based data collection, as well as conversational strategies to establish user-computer therapeutic alliance and the maintenance of user engagement and retention in longitudinal interventions.

In the following sections, we introduce our framework for designing health conversations, and discuss our approach to health counseling dialogues and strategies for maintaining long-term user engagement.

The Relational Agent Framework

Termed by Bickmore and Cassell [1], relational agents are computer artifacts, such as humanoid animated characters (Fig. 1) or social robots, that are designed to form long-term social-emotional relationships with users through conversations. These agents often use speech and nonverbal behavior to simulate the experience of human face-to-face conversation with their users.

In our framework, the agent communicates with the users using synthetic speech and synchronized nonverbal behavior. The agent is capable of displaying a variety of nonverbal behavior, including beat hand gestures and eyebrow raises for emphasis, directional gazes for signaling turn-taking, posture shifts to mark topic boundaries, and facial expressions of affect. Most of these behaviors are generated using BEAT [5].

Human-agent dialogues are scripted using a custom scripting language based on hierarchical transition network (Fig. 2). User input to the conversation is

Fig. 4: Sample Counseling Dialogue for Skin Check Promotion between Agent (A) and User (U)

A: Hi Mark. Nice to see you again!
U: Hi, Tanya. Nice to see you too.
A: How is it going?
U: Good. How are you?
A: Same as usual. So, how's the weather out there today?
U: It's pretty cold.
A: I hope it gets warmer soon. Are you tired of the cold yet?
U: No, I actually like cold weather.
A: Me too! That's why I enjoy living in New England!
U: Same for me!
A: So, the last time we talked, you set a goal to do a complete skin check at least 2 times every 3 days.
U: Yeah, I remember that.
A: So, in the past 3 days, how many times have you had a chance to do a complete check of our skin?
U: None, but I'd like to try.

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obtained via multiple choice selection of utterance options or fully-constrained ASR, with user choices updated at each turn of the conversation. In our experience, this dialogue modeling approach is intuitive enough to be usable by medical experts with non-technical backgrounds, who often collaborate with us on the authoring of dialogue content. This conversational format also works well for the thousands of patients of varying health and computer literacy who have interacted with these agents.

Our framework has been used to develop a number of conversational agent systems for a variety of health issues, from exercise and diet promotion, to chronic disease self-care management, to preconception care. These systems vary in a number of factors, all of which need to be carefully considered when designing the conversation structure and content:

- **Usage settings:** during hospital stay [3] vs. during hospital discharge [4] vs. home-based [10,11] vs. community center kiosk [8];
- **Deployment platforms:** web-based [10] vs. desktop [3] vs. mobile platforms [7];
- **Frequency of contacts:** single interaction [4] vs. multiple interactions over extended periods of time [3,7,10,11];
- **Length of each interaction:** brief check-ins (e.g., for symptom reporting) [7] vs. in-depth counselling on health behaviors [10,11];
- **Interaction trigger:** patient-initiated [10,11] vs. system-initiated vs. mixed-initiative [3];
- **Content trigger:** patient-selected content [10] vs. timed content [11].

Dialogue systems designed using our framework have been evaluated with users from different language backgrounds, who have varying levels of physical, linguistic, cognitive abilities and literacy skills.

Health Counselling Dialogues

Counseling dialogues are the center of many health behavior change interventions developed with our framework. These dialogues are often designed based on a behavior change theory, social cognitive techniques (e.g. goal setting, positive reinforcement, problem solving), and motivational interviewing [9]. Fig. 3 shows a high-level structure of a typical counseling dialogue, which combines both therapeutic dialogue and social dialogue to build rapport and working alliance with the user. Fig. 4 shows a fragment of a counseling dialogue designed to promote skincare management for individuals with spinal cord injury.

Strategies for Longitudinal Interventions

Maintaining a long-term alliance and user engagement is critical to increase adherence in longitudinal interventions. Here we outline three conversational strategies to address this issue:

- **Variability:** In our previous studies, content repetitiveness has been identified as a significant cause of decreased engagement. Thus, we have explored several methods to increase variability, including authoring multiple variations of agent responses, adding various social chat topics, or incorporating storytelling in the conversations [3].
- **Self-disclosure:** is important to build rapport and trust with the user. Thus, in our past system [10], we have explored the integration of the agent's back stories as a self-disclosure method.

A: It's great that you are thinking about it. Starting something new can feel overwhelming, even if you want to do it. Are there any skin check issues that you would like to talk about now?

U: I often forget to do skin checks.

A: I'm glad you mentioned that. Some people I know have come up with a reminder plan [...]
[...]

A: So, could you do me a favor and try to check your skin at least 2 times every 3 days?

U: Sure, I will try to do skin checks 2 times every 3 days.

A: That's awesome! I really believe you can do it.

- **References to past interactions:** In order to demonstrate continuity in the working relationship, it is necessary for the agent to maintain a persistent memory of the user and incorporate mechanisms for dynamically tailoring the current conversation based on previous interactions.

Conclusion and Future Research

We have described our framework for developing health dialogue systems and strategies for designing longitudinal counseling conversations. As a direction for future research, we plan to explore methods to incorporate speech input and natural language understanding capabilities into our framework while maintaining the high levels of data validity and agent feedback accuracy required for medical counseling.

Author Biographies

Ha Trinh is a research scientist in the Relational Agents group at Northeastern, with research interests in HCI, conversational agents, and accessibility.

Reza Asadi is a PhD candidate at Northeastern, with research interests in ASR and NLP.

Timothy Bickmore is the director of the Relational Agents group at Northeastern, where he leads the development of various agent-based dialogue systems.

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