Believable Agents, Engagement, and Health Interventions

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Abstract. In this article we review some of the main contributions that the *believable agents* community has brought about and we review some of the main believable agent architectures existing to date. We also discuss the enormous potential that believable agents can bring in the domain of health, including health communication, health promotion, health counseling and psychotherapy. We discuss some of our work-in-progress aimed at building believable agents with dialog abilities to conduct supportive healthcare interventions for the management of chronic diseases and addiction issues.

1 Introduction

The term "believable agents" was originally coined to refer to autonomous artificial entities or agents, that are believable in a similar way that characters in movies or animation are believable (Bates1992; Bates1994; Bates & Loyall1997). For example Mickey Mouse is believable as an animated character in that its viewer can suspend his or her disbelief and experience that Mickey Mouse is real. Similarly, Rick - portrayed by Humphrey Bogart in Casablanca (1942) - is an equally believable and engaging character whom we believe is the irrevocably cynical owner of the Café Americain (irrevocably until he meets the kid that is).

In order to accomplish this illusion of life, believable agents do not need to be realistic (realism can even be proscriptive), but rather be carefully and artistically crafted to exhibit personality.

Although believable agents have mostly co-evolved for and from the arts and entertainment applications, their desired abilities and features are very similar to what appears to be necessary to build engaging and effective computer-based health interventions.

Indeed, although there is a crying need for computerized healthcare (Blumenthal2009) to facilitate access to prevention and/or chronic disease management programs (particularly for underserved populations), few patient-centered computer-based health care systems are available today. Furthermore, most of the existing e-health programs are mostly passively informative, presenting a variety of factual knowledge to their user, and consequently suffer from very high levels of attrition.

In contrast, believable agents are designed to foster high levels of engagement with their users. Building healthcare delivery systems with believable agent architectures can

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therefore potentially lead to successful health care programs, increasing accessibility of care (and ideally its quality as well). Believable agents can be created and integrated in the design of health communication strategies to communicate educational health literacy material in an engaging manner, and to deliver a wide variety of patient-centered tailored health-promotion interventions.

In this article we review some of the main contributions that the believable agents community has brought about and we review some of the main believable agent architectures existing to date. We also discuss the enormous potential that believable agents can bring in the domain of health, including health communication, health promotion, health counseling and psychotherapy. We discuss some of our work-in-progress aimed at building believable agents with dialog abilities to conduct supportive healthcare interventions for the management of chronic diseases and addiction issues.

2 Believable Agents

The believable agents community has been evolving over the last decade, since Joe Bates **Oz** project seminal paper on the role of emotions in believable agents (Bates1994) (portrayed very effectively and simply on the "woogles" shown in Figure 1).

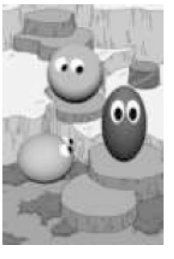

Fig. 1. Woogles in the Edge of Intention (from (Bates1994))

A variety of influencial believable characters can be recognized in the Sims (Wright2000), the Tamagotchi (Yokoi & Maita1996), Dogz (Stern1995), Nintendogs (Mizuki2005), or Touch Pet Doges, to name a few.

AI-based believable agents are becoming increasingly powerful. **Hap** is an agent-language developed in the Oz project at CMU to construct non-linguistic believable agents. Hap provides mechanisms that support writing behaviors for characters, where a behavior is a piece of activity which can be high-level (a behavior for "having fun"), or low-level (a behavior for moving the character's body when they open a door). An extension to Hap to support natural language text generation was also built (Bates & Loyall1997). The extension allowed to integrated text generation with the agent's actions, perceptions, inferences and emotions. As a result the agents could then use language and action together in order to best communicate, vary generated text based on emotional state or to express a specific personality, and issue text in real-time with desirable pauses, restarts and other timing effects.

Façade on the other hand, (created by one of the members of the Oz group) is a real-time 3D interactive narrative simulating being on stage with two live actors who want make a dramatic scene happen (see figure 2) (Mateas2003; Mateas & Stern2005). Facade is implemented using the ABL reactive planning language (based on the Oz Project language Hap mentioned above) which is designed specifically for authoring believable agents. In the case of Façade, the characters play roles in an interactive dramatic story world (inspired by the Edward Albee's play *Who's afraid of Virginia Wolf?*) (Mateas1999; Mateas2001; Mateas2003; Mateas & Stern2005).

Fig. 2. Facade (from (Mateas2003))

Another approach to building believable characters is found in Twig, inspired by the world of very fast robotic behaviors.

Twig is a fast, AI-friendly procedural animation system that supports easy authoring of new behaviors (Horswill2009b). The system is particularly interesting for building novel scenarii because it provides a simplified dynamic simulation that is specifically designed to be easy to control. Characters in Twig are controlled by applying external forces directly to body parts, rather than by simulating joint torques. Twig's puppetry-style of control provides the simplicity of kinematic control within an otherwise dynamic simulation. Although less realistic than motion capture or full biomechanical simulation, Twig produces compelling, responsive character behavior (see figure 3).

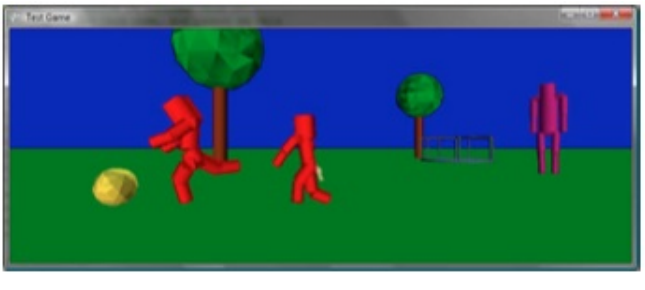

Fig. 3. Twig playground (from (Horswill2009a))

It is also fast, stable, and supports believable physical interactions between characters such as hugging, punching, and dragging, and makes it easy to author new behaviors (Horswill2007; Horswill2008; Horswill2009a).

3 The Need for Computer-Based Approaches to Health Communication and Intervention

Mental illness has been identified as the second leading cause of disability and premature mortality in the developed world. Yet the majority of people suffering from treatable mental health disorders do not have access to the required treatment. Similar statistical data can be found about at-risk people (e.g. substance abuse, HIV/AIDS, obesity), or people suffering from chronic condition (e.g. diabetes).

Computer-assisted health interventions might be able to address this imbalance (Coyle *et al.*2007). If designed properly, believable agents could become very engaging therapeutic computer-based social companions aimed at promoting healthy behaviors by complementing regular therapeutic sessions. Patients could interact daily (or as needed) with their artificial agents who (or which) are personalized to their specific disorder(s), between the scheduled weekly sessions with their therapist.

One type of intervention documented for treating substance abuse is referred as *motivational interviewing (MI)* (Miller & Rollnick1991). Although it was originally designed to treat alcohol and substance abuse, it has since then proven helpful for a wide variety of health promoting behaviors (Burke, Arkowitz, & Menchola2003). Unlike more traditional confrontation-of-denial counseling, motivational interventions are intended, through support, to increase the likelihood that people will make changes in their behavior toward healthy habits. It typically involves a brief assessment followed by feedback about the assessment results (Burke, Arkowitz, & Menchola2003). Such health promotion interventions (e.g. sexual risk reduction interventions) have proven most beneficial if they can individually tailor behavior change messages.

Tailoring involves the use of the participants name (*personalization*), characteristics of the user such as gender (*adaptiveness*), or self-identified needs of the user (*feedback-provision*) (Strecher1999;Lustria *et al.*2009). Tailoring can also be *dialog-based* by asking the user about their goals and by recommending choices about how to best achieve these goals. The key is that the personalized, adaptive, or feed-back-based tailored messages are more effective in promoting attitude and behavior change than the generic one size fits all content delivered by print or to groups (Strecher1999). Although additional studies are needed, a brief individualized computer-delivered sexual risk reduction intervention study (Kiene & Barta2006) has documented the risk reduction potential of interventions via computers for adolescents.

These computer-based interventions might also prove particularly useful when dealing with sensitive private information (e.g. homosexual preference in non-supportive culture, secret excessive drinking patterns). When revealing sensitive private information, participants have been found to be more candid with automated data collection systems than when interacting with a human interviewer (Evans, Edmundson-Drane, & Harris2000) (Plutchik & Karasu1991).

3.1 Talk-Based Health Interventions with Believable Agent

Based on the need for computer-based health interventions described above, and the latest progress in believable agents, we posit that believable agent-based health interventions might be ideal to assist in delivering tailored health information to various populations (including at-risk populations). Believable agents created for health interventions will need to:

- have a believable personality and remaining engaging,
- be able to express empathy convincingly,
- be personalized to a user with a user- model,
- be highly adaptive in terms of characteristics (e.g. gender, race, culture, language),
- gather, remember (or learn from) feedback given voluntarily by a user,
- be able to engage in meaningful dialog,
- on a specific domain of expertise (since the full unconstrained natural language processing research problem is still unresolved).

In a previous article we described how believable embodied conversational agents (ECA) can be designed to conduct motivational interviews with participants (Lisetti & Wagner2008). ECAs are given predetermined scripted questions to elicit private information from the teenager, record the results, calculate the statistics (as an expert system connected with relevant databases) to be discussed during the feedback by the therapist. ECAs can then generate an animated feedback movie based on the therapists feedback that the teenager can keep and replay as needed (Lisetti & Wagner2008).

Our ongoing work continues the implementation of agent-based motivational interviews, a system we refer to as Mobile and Accessible Telehealth Personal Avatar (MATPA).

3.2 Believable Agents in Virtual (Game) Environments for Health Interventions

Another type of therapy involves *exposure* to disturbing stimuli or events at various increasing levels of intensity to address problems such as post-traumatic disorders, anxiety and phobic responses (Silverman & Kurtines1996).

By being an active participant in the simulated reenactment of a traumatic or fear-inducing situation, the patient can gain a sense of mastery by acting in a situation that previously paralyzed them. They learn to differentiate their perceptions of and reactions to such situations in ways that allow them to separate realistic and unrealistic elements in their cognition.

Virtual environments are particularly efficient for example for treating phobias such as fear of spiders, fear of flying in planes, or fear of heights (Alcaniz *et al.*2006). In addition they have also been used to treat post-traumatic disorders, as for soldiers coming back from Iraq and troubled with PTSD.

More recently, progress in ECA technology has made it possible to turn attention to problems involving human- human interactions or social phobias for which interaction with virtual interactive anthropomorphic avatars appears as a potential asset (Glantz, Rizzo, & Graap2003). Successful examples include suggestions for the treatment of public speaking anxiety (Pertaub Mel Slater & Barker2002), panic disorder and agoraphobia, and for a variety of other mental health problems (Riva2005).

Fig. 4. Simulated attachement behavior in Twig (from (Horswill2008))

These type of interventions could be very well designed within the Twig architecture, to design relevant interactions for children in the Twig environment and characters as shown in figure 4 (Horswill2009b), where the simple form and expressiveness of the characters can be manipulated to be quite engaging to children. Such games could also sense the child's level of anxiety or stress using non-invasive bio-sensors or bio-feedback during the game session (Lisetti *et al.*2009). Such physiological readings could enable the game to adjust the level of exposure or difficulty of the game based on the stress that it generates and ensure that the exposure never becomes uncomfortable for the child.

4 Conclusion

We have described how the current progress of in the field of believable agents can be relevant to enable the creation of computer-based health care interventions, for a variety of interventions and a variety of populations (e.g. culture, age, gender). Believable agents nowadays can be designed to possess enough intelligence to be engaging to users of a different groups and populations. Believable agents can be coupled with Artificial Intelligence techniques (e.g. user-modeling, expert-systems), for the development of meaningful and helpful computer-based interventions.

Computer-based interventions are much needed are much needed to complement health care practioners and physicians' work in a wide range of different contexts. For example, access to literacy material and interventions for underserved populations has been identified as seriously missing both in terms of actual access and of appropriate literacy level; some populations are pointed to computer-based material that does not match their literacy level (be it reading literacy, arithmetic literacy, or health literacy), resulting in poor or null level of impact and effectiveness. Similarly, access to chronic disease management material or interventions while at the home could substantially reduce the disabling effect of some chronic conditions, yet this access is quasi non-existent. Computer-based approaches could address this gap.

We have tried to demonstrate that believable agent-based interventions are much needed for health care, and that this work is feasible, given some careful artistic and AI design of believable agents. Much more research is needed in this area.

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