A Sociable Robotic Aide for Medication Adherence

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ABSTRACT

In the United States, approximately 125,000 people die each year due to complications related to medication adherence, which costs the country approximately $100 - $300 billion dollars annually. The problem of medication adherence stems largely from people either having too many medications, causing confusion and making management harder, or taking larger dosages than prescribed. We propose a solution for improving medication adherence using a physically embodied social robot as a motivating factor. In particular, the robot's interaction will be similar to that of a digital pet game, except users will care for the pet by caring for themselves (i.e., taking their medication.) The robot will also leverage social-network support factors to promote the emotional and positive affective behaviors of patients.

Categories and Subject Descriptors

H.5.2 [**User interfaces**]: User-centered design; I.2.9 [**Robotics**]; K.4.2 [**Social issues**]: Health and affective behavior

General Terms

Design, Human Factors

Keywords

Affective behavior, assistive technologies, health technologies, social networks, social support, robotics

1. INTRODUCTION

Researchers in the field of user interaction design are currently exploring various means of supporting and promoting emotional and positive affective behavior using persuasive technology. Some researchers have employed robotics to aid in promoting weight loss and healthful behaviors [10], implemented various games and applications to promote health and medication adherence [2, 5, 11, 12], and created social networks specifically to provide emotional and social support

for individuals engaged in treatment or who have certain types of illnesses [1]. These various forms of support mechanisms aim to promote positive affective behavior for the individual, provide ways the user can be better integrated and informed about their health, and connect to others with similar situations as a form of support.

Many of these projects are typically evaluated for their effectiveness in improving the patient's emotional state during treatment, as well as the overall impact on their health. Many of these applications relate directly to the social aspect of the individual in dealing with their illness, and aim to provide an intuitive solution that is both easy to use, as well as serving as a motivating factor for better health management.

Inspired by previous work, we introduce a sociable robot, called Physic, designed to support medication adherence. Physic will capitalize on its physicality (due to its embodiment), encouraging greater user participation than a standalone 2D screen agent would. We also plan to encourage participation by leveraging the advantages offered in social games (in this case, a pet-like game much like Tamagotchi).

2. MOTIVATION AND BACKGROUND

Approximately 125,000 deaths per year occur in the United States as a result of complications with medication adherence, with cost estimates ranging in the hundreds of billion dollars annually [3]. Previous work has shown that there are many reasons why individuals do not take their required prescribed medication dose, including: forgetting due to taking too many different types of medications, taking too many in the hopes of speeding up recovery, and confusing names or prescribed dosages between different types of medication [8, 16]. Other factors affecting medication adherence show correlations between race, medication type, dosage, cost, and patient-physician communication as areas that affect medication adherence [15]. These associations may occur due to confusion between certain medications (including medication color), the rising costs of taking certain prescribed medications, prescribed dosages, as well as a lack of trust between patients and physicians. As such, the emotional state of these individuals in relation to these factors plays an important role in determining how to best mitigate problematic areas for disease management that may vary depending on a patient's demographic.
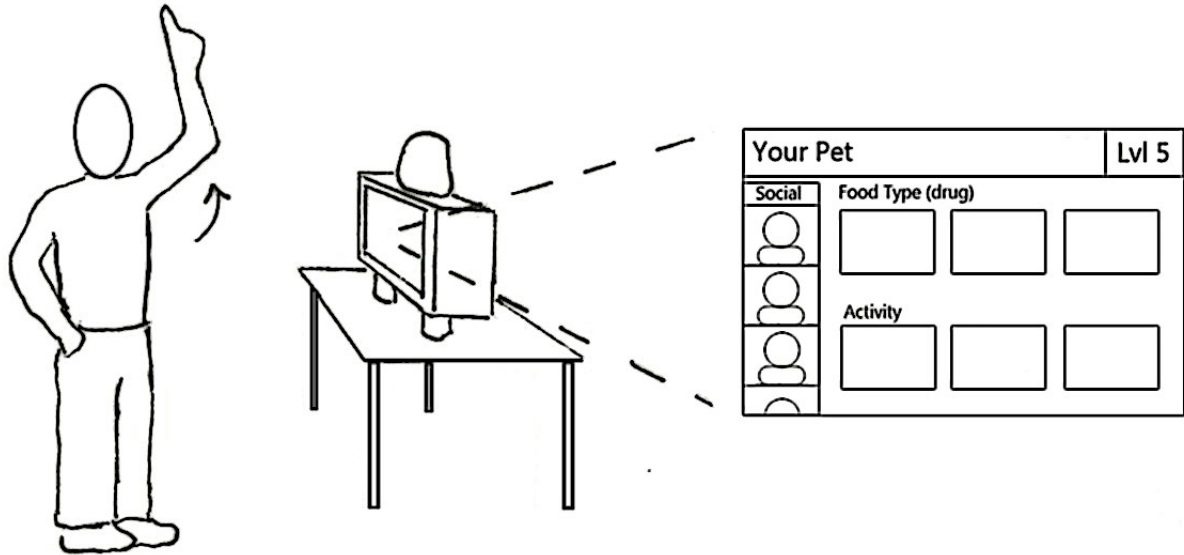
Figure 1: Example of multi modal interfacing with the robot, along with a view of the touch-based interface platform.

The intent of our work is to assess if using a robotic aide can be effective in promoting medication adherence through a social game. Previous research has shown that embodied agents, or an interface/physical object represented as a character rather than simply a graphical user interface, aid in promoting interpersonal relations, and by extension, provide better motivation for specific goals [10, 16, 19]. For example, research conducted by Wada et al. assessing the use of robots as social tools when characterized as pets show a correlation in reduced stress levels when tested in an elderly home [19]. The seal-looking robot, Paro, assisted elderly individuals in the home, and had the effect of reducing stress levels of both staff and elderly individuals, while increasing mood. Based on these findings, we predict pairing a physical embodied robot that encourages pet-like social game interaction may be an effective solution to improving the problem of medication adherence.

For over the last decade, various models of user interaction design have been assessed as approaches for persuasive computing in relation to medical applications, including social networks and support, computer games and software, as well as assistive robotic aides. As social support is paramount in aiding individuals with medical illnesses, it can be especially advantageous when a patient's social networks can be leveraged using emerging Web 2.0 technologies [1, 9]. One study showed positive results utilizing web-based social support in aiding those in serious emotional distress, including helping those contemplating suicide [1]. As such, the social support elements web technologies are capable of providing offer promising characteristics that could aid in the facilitation of emotional support, positive affective behavior, and better managed health care.

In addition to social technologies, research on the impact of video games and mobile applications in persuasive computing has shown promise in their ability to help motivate the player to take similar action in their own health, including treatment for their illnesses, coping emotionally with illnesses, medication adherence, and smoking prevention [2, 5, 11, 12]. This work showcases the promising potential offered via the use of persuasive computing technology in effectively promoting health-related behaviour change. In pairing these advantages, while leveraging the physicality of the device itself as a relational agent, we intend to further improve motivation of individuals in adhering to their medication regimens.

Whereas social networks and games are shown to be relatively effective motivating factors for positive health behaviour change, research in the area of sociable robotics suggests that robotic aides, characterizing a physically embodied agent, may be advantageous in motivating individuals to pursue their respective goals or as positive-affective agents [18]. Work currently being conducted by Diehl et al. [7] is looking at the utility of robots for improving communication with children with autism. In this work, Diehl and colleagues are breaking down the complexity of social communication with humans into smaller subsets, so that children with autism can better learn social communication cues. In another example, Autom, a robot developed by Kidd et al. [10] is shown to be a positive influencing factor in helping individuals in their weight management. In particular, Autom was shown to have an improved impact on the individual's participation in their weight management and weight loss regimen compared to paper-based or computer-based forms of tracking. As such, the embodied agent, in this case the robot Autom, was shown to have an overall positive impact

on the individual's maintenance of their weight loss regimen, indicating a possible response in favor of embodied agents over two-dimensional interfaces.

Other work also assesses the feasibility and benefits offered by robotics as a tool for medication adherence. In recent work, robots with a visual interface have been proposed that utilize a touch based interaction method for managing a patient's medication adherence [13]. This robot, named SKOTEE, is being designed to be capable of moving about a patient's household, and provide motivation via reminders and notifications, as well as attending to other factors of a patient's health such as exercise. While SKOTEE is somewhat similar in concept to the type of robot we propose, it is essentially different in the fact that it does not characterize the robot as a relational agent (that is, an element of technology designed to maintain a social and emotional relationship with the individual) rather than simply a tool for managing medication. This could be an influential factor in how well users continue to use a device based on the trust and rapport a patient may develop while using the robot [4].

In addition, other research conducted in this area has assessed the feasibility of using a robot as a medication dispenser, as well as utilizing network-based methods to relay information about a patient's medication adherence to a clinician via the web [17, 6]. This work also shows positive results in relation to the patient's medication adherence in using the robot, however, each instance of measurement was typically conducted under supervision, which may have been an influencing factor, and also does not implement a relational-agent based approach for interaction similar to our proposed robot. While different in approach, the aforementioned work shows promise in the use of assistive robotics with social and management capability as having a positive role as a persuasive technology for medication adherence.

3. DESCRIPTION

The robot we are designing for this project is intended to help people with chronic conditions who take daily medications. The robot will provide an interactive pet-like game, similar to a Tamagotchi, which can connect the user to other individuals utilizing the same or similar service. As such, the advantage of utilizing the agent to aid in a patient's medication adherence serves primarily to gain the benefits provided by an embodied device as a motivational and tracking platform. This is complimented by providing a platform to connect with other users using the same device who may also be undergoing treatment for the same condition. Provisions for multimodal interfacing with the device to provide a more intuitive interaction approach, including voice, gestures and a touch-based interface, as shown in Figure 1, will be implemented to provide an easy-to-use interface for patients.

The physical design components of Physic will consist of a tablet-based interface with an affixed head controlled via a camera utilizing face detection software. The robot is designed to sit on a table such that it is non obstructive to the patient's physical environment as a design consideration, as users of various ages and abilities may have specific mobility needs in terms of environment. The interface will be designed with a user-centric focus, which will be refined based on user-input from various demographics to be easy-to-use and responsive. The device is intended to be accessible to patients with various conditions to accommodate usability, and is intended to provide voice-feedback for on-screen items and text and voice-recognition for responses in addition to using the touch-based interface.

The "head" of the robot will move in response to the location of the patient to characterize the physical-embodiment of the device and will also be used to interpret gesture-based responses such as nods for input at the users' discretion. These multimodal response methods will allow for users of various conditions, such as blindness, to continue to interact with the agent as well as provide alternative methods users may choose to use in terms of comfort. The robot will leverage current mobile software technology to provide interfaces with the web for social support aspects and tracking of medication adherence. By extension, this will also provide capabilities for the user to perform other tasks and reminders, such as calendar events, video-conferencing with family, and other characteristics which may further influence their desire to use the device. This software will also be used as the foundation for building the "game" aspects of the device that will serve as the primary method for interaction.

In order to improve medication adherence, patients will play a game with Physic and also can optionally interact with their social network (to act as a form of support). "Feeding" the pet correlates to the taking of a specific type of medication for the patient, thus improving the overall "happiness" the pet would express. Thus, a typical use case will have the device perform a notification to the user that it is time to take their medication (or in the case of the robot, that is is "hungry"). This notification will be capable of calling the user by name, indicating which types of medications it is time to take, as well as the dosage requirement. Once the user takes their required medication, they simply respond to the device using their preferred input method, and the device will note their medication for that time as taken.

Utilizing the user's social network, the patient will be able view comparisons between their friends' or peer' pet's "happiness", and by extension, their own medication adherence. Similarly, the user's family will also be capable of viewing this to act as a form of social support for encouragement and motivation. This will provide the advantages of not only the support of the patient's extended network, but also the added capability of removing the issues related to managing their medication regimen, situating the task as a form of game. As online capability will depend on the user's environment, the robot will function similarly offline where the user themselves only manages their own pet and its response based on their adherence to their medication regimen. The data analyzing the patient's medication adherence can also be stored or sent to a patient's caregiver or family member if configured to further aid in motivating the individual via social support means. Following a user's interaction, Physic will simply go into a "sleep" mode until either the user chooses to interact with it again or medication needs to be taken again.

In leveraging the characteristic of the robot as a physically embodied agent, we predict that the user will be more proactive in taking care of their pet, and by extension, themselves. Motivating factors generated by the types of behaviors the robot/pet expresses will help promote the individual's response to better management of their medication regimen. This form thus not only aids in bringing social support, an easier to use interface, and a fun aspect to managing their medication regimen, but also brings tools doctors could use to better monitor a patient's actions and provide alternative forms of help or discussion if required, similar to work by Matthews and Doherty [12].

4. CONCLUSION

As the impact of medication adherence plays such a prominent role in the health, safety, and healthcare costs for patients, new methods for tackling the problem need to be developed that will help to motivate individuals to take a more manageable approach to taking their required medication. Doing so will help to not only lower the subsequent costs incurred from problems from nonadherence, but aid in allowing patients to better manage their medication regimen with less effort. Using this approach, we can leverage the advantages provided by the physicality of an embodied agent with the already useful areas of social support and gaming to provide an easy-to-use, fun motivational tool for medication adherence that can be cost-effective.

5. ACKNOWLEDGEMENTS

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