Designing a Sociable Robot System for Weight Maintenance

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Abstract

Human-robot interaction research is maturing to the point where we can begin to build systems that interact with people in their daily lives and provide support for particular needs. We propose a sociable robot system to help people who are losing weight or maintaining their target weight to better track their progress. We describe related work in sociable robotics and ubiquitous computing and define the term sociable robot systems *as systems that comprise a sociable robot, other technological devices, methods for interaction, and methods for relationship creation and maintenance. The system that is currently being implemented is described as well as the plans for testing the system in a real-world setting.*

1. Introduction

Researchers in robotics and human-robot interaction (HRI) are beginning to think about applications for interactive robots that are capable of assisting humans in a variety of situations. Companies are starting to capitalize on the use of robots for entertainment, such as the Sony Aibo robotic dog or Hasbro's My Real Baby, and to perform simple household chores as in the case of iRobot's Roomba and Electrolux's Trilobyte vacuum cleaners. Several Japanese companies have developed robots for therapeutic purposes as well, including the NeCoRo cat from Omron and Paro (the "Seal Type Mental Commit Robot") from Intelligent System.

Both the NeCoRo and the Paro are meant to create a bond between a person and the robot, but it is unclear how this is accomplished thus far. However, the fact that this kind of robot is interesting both to these companies and to consumers is one factor that motivates our work towards designing a robot that can create a relationship with a human partner and use the benefits of that relationship to provide advantages to the person, such as helping with health care treatments, as a result. We believe that there could be a great benefit from creating robots to help people in a variety of situations that could not be achieved through other kinds of systems.

Sociable robots offer advantages not found in on-screen agents or technology embedded in the environment, such as an increased sense of social presence in an interaction [11] and the capacity for touch and physical interaction. When there is a physically present, interactive robot, it opens up the possibility of creating a complex relationship which can provide the social support which has been shown to be useful in a wide variety of situations. This can be done in animated agents as well, but our earlier work shows that some of the important relationship factors are stronger in a robot [11]. Social support encompasses feelings of caring, loving, and belonging; we define it more fully in section 2.2. The robot is a part of the system, serving as the interface with the sensors, and actuators, and other people that encompass the remainder of the system. The most important aspect of the sociable robot component of the system is that it has the capability of creating a particular kind of relationship with the user to enable it to address health care goals or behavior change desires.

2. Background

The work that we propose in creating this sociable robot system draws on several existing areas of research. The two main technological fields that are an integral part are those of human-robot interaction and ubiquitous computing (an overview of each can be found in [7] and [1], respectively). Important work also comes from psychology, social psychology, computer science, and artificial intelligence. We also draw from work done in the fields of bariatrics, nutrition, and behavior change.

2.1. Related work

Recent work in human-robot interaction has begun to move towards building systems that address specific problems, rather than only working on general-purpose robots in the laboratory. Several examples of this type of robot were given earlier, but none of these capture what we mean by a social robot system. They are concerned with the robot and the interaction, but do not typically integrate other pieces of technology nor the embedding of the system into a social network.

The strength of existing work in HRI is the knowledge that has been gained about how to create an interactive robot that has an internal model of itself, the world, and its interaction partner; has the ability to interact with people by reading and expressing human (or human-like) conversational gestures; and can express some of its state to the users with which it is interacting.

The field of ubiquitous computing has achieved many successes in nearly a decade and a half of work (many outlined in [1]) in domains such as the classroom [5], office [20], and the home [13]. Abowd and Mynatt argue that the field of ubiquitous computing should focus on making computing available at any time in any location [1]. While ubicomp researchers may focus on the computing capabilities of the environment, we consider the interaction with the overall system through an embodied agent.

2.2. Social support

The main reason for having a sociable robot as part of this system is that it can provide social support to the user. The term "social support" has been interpreted in somewhat different ways, but we are referring here to Cobb's use [6] describing social support as knowledge that leads to a person feeling that they are cared for, that they are loved and thought highly of, and that they are a part of a social network that will reciprocate their feelings and actions. The kind of interaction described in this and other work on sociable robots (e.g. [4]) leads to a robot that is capable of providing this social support. This can be provided through the creation of a long-term relationship, which we discuss in the following section.

The benefits of social support are clear and have been demonstrated for a variety of situations, such as higher cognitive functioning in the elderly [21], general cardiovascular performance [10], and general daily functioning [15]. A list of the kinds of social support that can be provided include emotional support, network support (being a part of a helping group), esteem support (increasing belief in the self to provide help), functional support (in our case, the actual physical task that the robot or system performs), informational support (for the type of systems we describe, assistance in working towards the health care goal for example), and the chance to help another (could be providing some regular service to the robot to feel needed as a part of the system).

3. Sociable Robot Systems

Breazeal defines a sociable robot as a robot that participates in social interactions with people in order to satisfy some internal goal or motivation [4]. She notes that sociable robots rely on cues garnered from interactions with humans in order to function. These robots "model people in social and cognitive terms in order to interact with them." In this work, we posit that these sociable robots will use their interactions to fulfill a particular purpose. The purpose varies depending on the system being developed, but each implementation of the type that we describe will be designed so that the robot (and the entire combination of devices) has a purpose that can only be met through interaction with the user.

We have defined a *sociable robot system* as a set of technological artifacts that can communicate with one another, a robot that engages people in a social manner, the means of interaction, and the network of people involved in the interaction [12]. The design of such a system embeds a sociable robot and other technology into an existing social system. Thus we intend to augment and build upon current means (technological and otherwise) of addressing problems rather than replacing them with robotic methods and implementations.

The most important aspect of developing the sociable robot in this system will be creating the means of interaction. For us, the *means of interaction* encompasses what the robot knows (i.e., the information that it has access to or can gather with its own sensors), how it can process that information to present to the user or affect its interactions with the user, and what strategies it uses to create and maintain a relationship with the user over time.

In addition to the technological components of the system, this system must fit into an existing ecology of human social and medical support. The system can not (and should not) be built in isolation from current methods of treatment, rather it should be integrated into the existing methods of treatment in a way that can support and augment these methods. This may be the ideal way to get the system to be accepted for use: integrate and extend the existing model so that the user can easily comprehend and see the benefits of adopting the system.

4. Obesity and Weight Maintenance

In the United States, the National Center for Health Statistics at the Centers for Disease Control and Prevention report that 65% of the adult population is overweight or obese (31% obese and 34% overweight, calculated using the body mass index, or BMI) [8]. According to the World Health Organization, this is an international problem, with over 1 billion of the adult population overweight, with 300 million of these considered obese [18], and they state that "almost all countries (high-income and low-income alike) are experiencing an obesity epidemic" [19]. It is also known that of those who do lose weight, 90 to 95 percent are unable to keep the weight off long-term [9].

4.1. Current treatment methods

We have talked to a physician whose work consists of treating overweight and obese patients and spent time in a clinic with these patients during initial and followup visits with the physician [3]. This has allowed us to better understand issues confronted in practice when treating patients who are trying to lose or maintain weight.

A current leading weight management method has patients meeting with their physician on a regular basis (typically once a month, but the frequency can differ based on the situation) to discuss their diet, exercise, and progress. ([2] and [17] describe recommendations to physicians on treating obese patients that give further details of current treatment methods.) In the periods between meetings, patients are asked to keep a written record of what they have eaten and how much they exercise. One difficulty with this is that most patients tend to grossly underestimate their caloric intake and overestimate their exercise time even when trying to keep accurate measurements [16]. Another problem encountered in our observations is that very few patients actually keep up with these records, even though physicians believe that this behavior is correlated with a better outcome from treatment.

4.2. Our solution

We are creating a sociable robot system that will assist people who are losing weight to manage the process or who have recently lost weight in maintaining their target weight. The system that we propose has two purposes. The first is to help in automating some of the current treatment methods in order to improve patients' ability to track their own progress and behavior. The system allows patients to more easily and more accurately track their behavior. Automation of some record-keeping, such as time spent exercising or calories consumed, will allow individuals to keep a running total of these times without having to manually record every instance. A system that helps keep track of their eating and exercise will allow them to share this information with their doctor, which is a currently accepted method of improving record keeping. Having their health care practitioner review their eating and calorie logs helps them to more accurately make estimates in the future.

The second purpose of the system is to take advantage of the benefits we have described in coming from sociable robots to engage the patient more in their care and make them more aware of their own progress. We believe that a sociable robot will be able to create a relationship with the person that will allow them to become more engaged in their own long-term progress. The biggest challenge for people who have lost weight is to keep the weight off. A large majority of people who take off weight lose motivation for keeping it off and subsequently regain the weight [9]. One goal in our design is to have the regular interaction with the robot engage the person and help them to track their long-term progress.

In this system as described, the robot has both a functional and a relational rôle. Functionally it will serve as a "mirror" of the person's behavior. Relationally, the robot will interact with the person on an ongoing basis, providing some of the social support interactions we described earlier.

5. System Implementation

We are in the process of implementing a prototype version of the system that will be tested out and refined before being given to individuals who are in the process of weight loss or maintenance. We are considering many factors that have been learned from interactions with patients in the design of the system and are concerned with the seamless integration of the several components so that users have a successful experience when interacting with it. Here we describe each of these components of constructing this system.

5.1. Design principals

As when designing any system to be used in real-world situations, we must take into account our target population. Many of the patients that we have seen in a local clinic are not computer literate and, like most of the population, have no experience interacting with robots. Because of the particular problem that we are addressing, many potential users in our target population are not ambulatory. Standard user interfaces on handheld devices and even traditional computer interfaces such as keyboard and mouse may present challenges to some people because of physical constraints and lack of familiarity. Thus a guiding principal throughout our design of this system has been to create intuitive interfaces, both in hardware and software, that keep as much of the complexity of the system and its components away from the user as possible.

We want the system to be adopted and used regularly on a continual basis. Therefore we must give the user a clear motivation for using the system and provide ease of use in all interactions. The relationship and social support motivations were discussed previously, but the system also provides benefit by helping the user to more easily record, view, and share information related to their weight management.

Finally, the seamless integration of the many system components is an important aspect of the user's experience with the system. Because we are introducing several pieces of complex technology to people who may not be familiar or comfortable with technology, we must make all parts of the system work together in ways that minimize user involvement and frustration with the workings of these components and their interdependence on one another.

5.2. System components

The system design includes the robot, other sensors, technology, and ways to interact with the system for the user and their physician. We are using a commercial, off-the-shelf robot (the Sony Aibo™ as shown in Fig. 1) to create the interactions between the person and the robot. We are using a wireless pedometer on the person's shoe to track exercise occurrences and durations. A wireless-enabled bathroom scale allows the user to enter their weight into the system on a regular basis. There is a PDA-based form that can be carried with the user for recording everything they have eaten. All of the devices can communicate via wireless technology (both Bluetooth and 802.11), giving the robot access to all of the information it needs for its interactions with the user. The main interfaces for the user are through the robot and a television screen.

There is a central computer that manages the interactions among all pieces of the system. This machine maintains a database of user preferences (including exercise and calorie goals set in conjunction with the physician), all user interactions, and the user's health-related history (calorie count and exercise time). Three types of data are entered into the system: there is the system information that comes from interactions with the doctor (daily calorie goals, daily exercise time, and an overall weight target), weight-related information input an ongoing basis (either manually by the user or automatically by the pedometer or bathroom scale), and information collected during user interactions with the robot. Based on the first two types of information, the system decides how the robot should interact with the user, which is described in the following section. Based on parameters determined by the physician and the experimental evaluation of the system, users are asked for additional information on an occasional basis, including using the scale to get their weight weekly and being asked questions about their experiences with the system.

Figure 1. The Sony Aibo™ robot used in our implementation.

5.3. User interaction

After establishing an initial relationship with the user, the robot will perform two functions. It will serve as the "face" of the system; the portion with which the user can engage and maintain an ongoing relationship. This is its relational rôle. We believe that the interactions that we are using from the Aibo and the interactions that we are creating will create engagement between the user and the robot. Users will be asked to interact with the robot at least once a day and perform some "caregiving" tasks for the robot, such as recharging it. These are aspects of the interaction that will be measured through a long-term interaction experiment that we will perform.

It will also serve a functional rôle, demonstrating to the user how he is doing at meeting his exercise and and calorie goals on a regular basis. The person and robot will carry out a routine interaction each day where the robot serves as a "mirror" to the person's behavior. The user will be able to choose from a set of interactions to perform each day, such as playing fetch with the robot's ball or having it chase its bone. The nature of the interaction itself is not the important part, rather it is how the interaction is carried out that has more meaning in the interchange.

When the user is meeting his goals that have been set, staying within the calorie limit and getting the prescribed amount of exercise, the robot will interact with him in a lively and energetic fashion and will make noises that sound happy [14]. If, however, he has not achieved the daily exercise goal or exceeded the self-imposed calorie limit, the robot will then perform this interaction in a more lethargic fashion, moving slowly and emitting sounds that are more sad. These interactions are intended to demonstrate the longer-term effects of the user's short-term behaviors to make them more easily understand the consequences of their actions (or lack thereof) and allow them to regularly reflect on these actions.

Another interaction that will be provided through this system is the enabling of better communications with their physician. Patients are currently asked to keep paper records of their eating and exercise, but few of them do so. One feature of this system will allow them to easily save their information to a portable medium that they can take along to an appointment with their physician. We think that this will make it much more likely that a patient will bring along their information to review with their physician at each appointment.

6. Conclusions and Future Work

We have presented our sociable robot system to help people manage their weight loss. Relevant background research and design considerations are laid out and the design of our system is introduced with a description of how interactions with the system will occur.

We are currently constructing the prototype of the entire system. We will run an initial experiment to determine whether the robot's actions are readable and iterate the experiment and behavior creation until they are. We then plan to run a pilot study of the entire system before introducing it to our target population to determine its effectiveness in a longer-term study.

The addition of a sociable robot into this system will provide benefits beyond those that can be achieved simply through the automation of the record-keeping and communication processes. The robot can help to encourage the user to become more engaged and remain engaged longer with their own care than would otherwise be the case. We hope that this work can inform the creation of other sociable robot systems to help solve real-world problems.

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