Sociable Robot Systems 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 that *sociable robot systems* are systems that comprise a sociable robot, other technological devices, methods for interaction, and methods for relationship creation and maintenance. These systems can be designed as solutions to address particular needs such as health care or behavior change goals. We discuss the social support benefits of creating a relationship between a person and a robot and offer ideas for how this might be done. A system that is currently under development in our lab to help obese patients who have recently lost weight maintain their target weight is presented as an example of this kind of sociable robot system.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Evaluation/methodology

Keywords

Human-robot interaction, sociable robots, obesity

1. INTRODUCTION

Research in human-robot interaction (HRI) is maturing to the point where we can build systems that address real-world problems outside of the laboratory. Our interest is in applying HRI and ubiquitous computing (ubicomp) work to health care issues. In this paper we define this combination that we call *sociable robot systems*, discuss three important factors that must be considered in the creation of such a system, and present an example implementation that we are currently working on.

The concept of fitness encompasses many aspects of our lives. Many of these factors, such as eating a healthy diet, getting regular exercise, or controlling chronic medical conditions, require daily attention in order to be successful at managing them. While some people have no problem managing these on their own, many people could potentially benefit from a system to assist them in keeping up with these kinds of regular behavior. We believe that traditional ubicomp approaches for assisting people to collect and manage disparate data is a good approach and that it can be augmented with a sociable robot that plays two rôles: serving as the interface to the system and helping the user create and maintain a long-term relationship with the system.

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2. SOCIABLE ROBOT SYSTEMS

Social and sociable robots (for a definition, see [6]) comprise a relatively new field of scientific inquiry. In this paper, we propose creating a sociable robot system to assist in a particular problem, that of weight management for individuals who have lost weight and want to keep it off.

2.1 Definition

In [6], Breazeal defines a sociable robot as a robot that participates in social interactions with people in order to satisfy some internal goal or motivation. 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."

Here we define 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. 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 or not) of addressing problems rather than replacing them with robotic methods and implementations.

2.2 Relevant work

This work draws heavily on the fields of human-robot interaction and ubiquitous computing, but important work also comes from psychology, social psychology, computer science, and artificial intelligence. In any given application, it is likely that other fields will be necessary for creating a successful sociable robot system. As an example, in our obesity application, we also draw from work done in the fields of bariatrics, nutrition, and behavior change.

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) conver-

sational 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 [7], office [20], and the home [14]. In [1], Abowd and Mynatt argue that the field of ubiquitous computing should focus on making computing available at any time in any location. While ubicomp researchers may focus on the computing capabilities of the environment, we consider the interaction with the overall system through an embodied agent.

2.3 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 (in [8]) 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. [6]) leads to a robot that is capable of providing this social support.

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 [13], 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. CREATING A RELATIONSHIP

3.1 Important factors

There are three factors that are important when trying to create and maintain a helpful, long-term relationship between a person and a sociable robot system. The robot must be able to engage the user so that they will begin to interact with the system in the first place and then motivate the user to carry out particular actions once they are engaged. The system must also be worthy of the trust of the user, meaning that it can carry out the actions that it has "promised" that it can do.

3.1.1 Engagement

Engagement is the manner in which two or more parties begin, carry out, and end an interaction in which they recognize some connection to one another. In humans, we see this in any conversational encounter when two people attract each other's attention, begin and carry on a discussion, and then disengage. (This happens in other types of encounters and with multiple people as well; this is given as an illustrative example.) The ability to draw a person into an interaction and to successfully negotiate that interaction is of great importance for a sociable robot system. Without the ability to create and maintain engagement, no other aspect of the system will be relevant. In order to carry out any other abilities of the system, the user must be willing to carry on regular interactions with the robot.

There is work focusing on different aspects of how to extend this concept of engagement beyond human-human interactions. The work of Bickmore and Picard in [5] shows a good example of a model for drawing a human into repeated interactions with an animated agent and continuing these interactions over time. They discuss the relationship literature from the social sciences and explain how strategies that have been identified in interpersonal relationships can be applied to human-computer relationships. They then show how these theories can be applied to human-computer interaction in their implementation of a health-related behavior change application. This work shows some of the necessary aspects of long-term interaction that must be considered and tracked over time.

3.1.2 Trust

Once a person is engaged with the system, they must then initially believe that the system is going to work and then continue to believe that over the course of their relationship with the system. Thus the system must make its capabilities clear initially (the "promise" of what it can do) and follow through on this commitment over time. We do not want to develop systems in which users falsely place their trust, expecting it to do something of which it is not capable.

The concept of trust encompasses a number of factors such as reliability and credibility, which concern the function of the system over time and the quality of feedback from the system. Reliability relates to the system performing in the same way each time the user interacts with it. For these systems to be effective, we must go beyond laboratory prototypes that function most of the time; they must be completely reliable in order for a person to develop trust in them over time. Credibility has more to do with the information and feedback coming from the system. The robot must be seen as presenting correct information to the user, whether this is outside information (i.e. something it is programmed to have knowledge about) or data about the user or their interactions with the robot (health data that the system has observed over time, for example).

3.1.3 Motivation

Many of the issues that we would consider building a sociable robot system require that the user play an active part in its use. To do that, the user must be motivated to take part. There is work in understanding how to motivate a person for behavior change (smoking cessation or weight management, for example), some work in applying this to technological systems (the work of Bickmore and Picard cited above in [5] is one of the only examples we know of), but little work in applying this to sociable robots has been done.

3.2 How to create the relationship

In order to create the kind of relationship we describe here, we draw on what is known about interactions among people. The best of examples of this are in Bickmore's description of the Rea real estate agent and the more sophisticated Laura exercise advisor (both described in [4]). These systems encode the factors that need to be tracked when creating and manipulating a relationship over time. Main

variables tracked are trust and the working alliance inventory, a measure commonly used in therapy and other helping relationships that tracks trust and belief in a common goal of helping that the therapist and patient have for one another [12].

To be successful along any of these measures, a system must be explicit and clear on what benefits it can potentially provide to the user. When a sociable robot system is introduced to a prospective user, the workings of the system, the requirements expected of the user, how it is a part of a new or existing social network, and most importantly what it offers to the user. This is analogous to the beginning of a relationship between people or transition points in the relationship when they negotiate what the nature of the relationship is (friends, student/teacher, lovers), what is expected of each partner, and other aspects of their interaction [9]. Only when a user has a clear understanding of what the system is and what it can be expected to provide can there be an opportunity for the system to fulfill those expectations.

3.3 Long-term relationship maintenance

A very important, but little understood, aspect of the kind of relationships that are important in creating a successful ongoing interaction with a sociable robot system is the long-term nature of the relationship. In the literature on human-human relationships, this is referred to as relationship maintenance [9], but there has been little work on either implementing relationship maintenance techniques or measuring aspects of ongoing relationships between a person and a sociable robot.

The main factor that we must be concerned with is whether the system is keeping the user engaged and maintaining (or building) trust over time. Based on the human relationship literature, we believe that this largely has to do with the system fulfilling the promises it has made to the user. This means that the system must be able to carry through on the contract established between it and the user. It must also have means of expressing what it believes that it is accomplishing and getting feedback from the user so that a common understanding may be established.

4. APPLICATION: WEIGHT MANAGEMENT

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) [10]. 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 [11].

4.1 Obesity and weight management

We propose creating a sociable robot system that will assist people who have recently lost weight in maintaining their target weight. We have talked to a physician whose work consists of treating overweight and obese patients about issues confronted in practice [3] and have found that one of the leading current weight management methods has patients meeting with their doctor, nurse, or other health care worker on a regular basis (from once a week to once a month) to discuss their diet, exercise, and progress. (Refs. [17] and [2] describe recommendations to physicians on treating obese patients that give further details of current treatment methods.) In periods between meetings, patients keep a written record of what they have eaten and their exercise time. One difficulty with this is that most patients tend to grossly underestimate their caloric intake and overestimate their exercise time [16] even when trying to keep accurate measurements.

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. Our system will allow patients to more easily and more accurately track their behavior. Improvements can come in two ways. Automation of some record-keeping (such as time spent exercising) will allow individuals to keep a running total of exercise time 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, by having their health care practitioner review their eating logs accompanied by pictures and teach them to more accurately estimate calories consumed.

The second is to take advantage of the benefits we described in coming from sociable robots to engage the patient and to 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. In our system, the robot will have both a functional and a relational rôle. Functionally it will serve as a "mirror" of the person's behavior. (More details are provided in the following subsection on the implementation.) Relationally, the robot will interact with the person on an ongoing basis, providing some of the social support interactions we described earlier.

4.2 System design

A brief description of our design includes the robot, other sensors, technology, and people that comprise the sociable robot system. We are using a commercial, off-the-shelf robot (the Sony Aibo) to prototype the interactions between a person and the robot in our system. We are using a wireless pedometer on the person's shoe to track exercise occurrences and durations. 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.

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 some of the 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 might carry out a routine interaction each day where the robot serves as a "mirror" to the person's behavior. When they are meeting the goals that they have set for themselves, the robot will interact in a lively and energetic fashion. If they have not achieved their exercise goal or exceeded their self-imposed calorie limit, the robot will then perform this interaction in a more lethargic fashion, demonstrating the longer-term effects of the user's short-term lapse. The readability of these expressions is of utmost importance to the system, so we plan to iterate the design of the interactions until users report that they show what we intend.

4.3 Ethnographic research

We are currently conducting ethnographic research on current methods for treating obesity and the weight management process. We are working with a local doctor whose practice consists of treating overweight and obese patients. Now we are also starting to spend time in other venues to learn about the issues that are confronted both by those trying to keep weight off and those in the medical profession who are helping with this problem. In order to successfully build a system, it will be necessary to spend time with physicians on rounds, in clinical group settings where people discuss their progress in managing their own weight, and in non-clinical settings such as Weight Watchers groups.

4.4 Initial technical work

In parallel to the ethnographic work, we are working on implementing some of the necessary relational behaviors in the robot and integrating the separate pieces of the system. A first step in evaluating the usefulness of the system will be measuring the readability of the behaviors on the robot. In order to create the kind of relationship that is desired in this system, the robot must be able to express several states to the user. Before deploying this on a full test of the system, we are studying this aspect of the interaction to make sure that it works as we expect. Once all pieces of the system are integrated, we will also run short-term user tests to verify the technological aspects of the system before deploying in a long-term trial for its actual weight management use.

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