The Huggable: A Platform for Research in Robotic Companions for Pediatric Care

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ABSTRACT
Robotic companions offer a unique combination of embodiment and computation which open many new interesting opportunities in the field of pediatric care. As these new technologies are developed, we must consider the central research questions of how such systems should be designed and what the appropriate applications for such systems are. In this paper we present the Huggable, a robotic companion in the form factor of a teddy bear and outline a series of studies we are planning to run using the Huggable in a pediatric care unit.

Categories and Subject Descriptors
H.5.m [**Information Interfaces and Presentation (e.g., HCI)**]: Miscellaneous

General Terms
Design, Experimentation, Human Factors

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Personal robot, robotic companion, pediatrics

1. INTRODUCTION
For many children, a visit to the hospital can be a very stressful and scary experience. Hospitalization implies going away from one's own home, family, and friends and into an unknown environment in which they have difficulty understanding what is happening to them. This experience can generate sensations of abandonment, confusion, loneliness, fear, and powerlessness. The information of what will happen during hospitalization and the gradual introduction in the physical and psychological environment of the hospital and the doctors, nurses, and staff can help reduce these feelings. If the parents are involved with this process it can further lower the anxiety of the child and facilitate a cooperation with the treatment process.

We are particularly interested in exploring the potential for robotic companions to be used in this environment of pediatric care. Robotic companions offer the unique combination of computation, communication, data collection, embodiment, and character. Such systems can not only interact with the child but serve as an important link to the doctors and nurses. For example, as the child plays with the robotic companion, behavioral or medical data can be collected and then shared with the staff. Additionally, the robot can serve as a communication link between the pediatric unit staff and the child, relaying messages from the child to the staff or prompting the staff to check on the child in certain cases. But of equal importance, the robotic companion can be used as a communication channel between the family and the child allowing parents to play with their child through the robot in cases of physical separation due to distance or safety concerns. Thus, what emerges is not simply a dyad of child and robot, but rather a more powerful triad that consist of the child, the robot, and the family or the staff.

Previous work in the field of robotics and healthcare has explored the development of robotic pets (modeled on pet therapy) such as the Paro robotic seal [1]. However, in all cases these robots were simply a dyad. These robots do not feature data collection capabilities or allow for communication between child and staff or family members. Additionally, in many cases these robots are fully autonomous and thus limited in their current behaviors.

We believe that many interesting research questions exist today surrounding the growing field of robotics and healthcare for children. These questions concern (1) the hardware and software design of these systems, (2) the selection of domains and development of these systems, (3) the ability for the staff to use such systems, (4) metrics to measure performance, and (5) how these systems can be integrated in the daily life of the child in pediatric care.

To help understand the many research questions in this new field of robots in pediatric care we have been developing the Huggable robot research platform [2]. In this paper we will first describe a

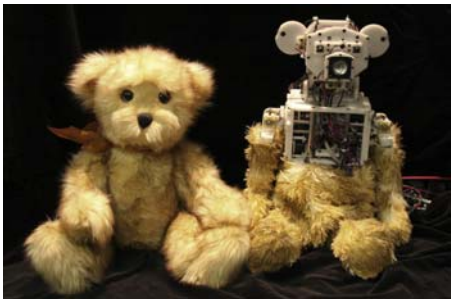

Figure. 1. The Current Huggable V3.0 Prototype (in development) (right) and the Concept Plush (left). In the current prototype only the underlying mechanics of the robot are shown. The sensitive skin system, soft silicone rubber beneath the fur, and final cosmetic fur exterior are not shown in this photo. When fully finished it will look like the concept plush at left.

brief overview of the Huggable robot. Next, we will describe previous work in combining technological systems with pediatric care at the San Raffaele Del Monte Tabor Foundation of Milano, Italy (HSR). Finally, we will outline a set of studies planned for the Huggable at HSR to answer these research questions.

2. THE HUGGABLE ROBOT PLATFORM

The Huggable is shown in Figure 1. It features a combination of technologies which make it a powerful research platform for companion robots. In the head of the robot is an array of microphones, two cameras in the eyes (one color and one black and white), and a speaker in the mouth. In the body, the Huggable features an inertial measurement unit (IMU), passive potentiometers in the hips and ankles for joint position sensing, and an embedded PC with wireless networking. The Huggable currently features eight degrees of freedom (DOF) – a 3-DOF neck (nod, tilt, and rotate), a 2-DOF shoulder mechanism in each arm (rotate and in/out), and 1-DOF ear mechanism. In addition, these degrees of freedom feature a quiet and back drivable transmission system. We are also developing a full body, multi-modal sensitive skin system [3] capable of detecting affective and social touch [4] Currently, the Huggable runs on a 12V power supply but will ultimately be wireless.

The Huggable is being designed to function along a spectrum of autonomy with varying degrees of human control from a fully human operated puppet to a fully autonomous robot. We believe that in the middle area between these two extremes, i.e. when the robot acts as a semi-autonomous robot avatar, there is much potential for interesting applications. Previous work in this domain has focused on communication applications [5] or Wizard of Oz studies, such as [6]. In these examples an expert knowledge of the system is required. In many real world cases the doctors, nurses, family members, or staff may only have a limited knowledge of the internal workings of the system, if at all, and thus may not be able to alter the robots own programming in the same way as the developers. Additionally, this approach opens the door to new types of collaborative research studies with people from different fields of expertise.

In our approach, the doctors, nurses, or pediatric unit staff can control aspects of the robot through a website shown in Figure 2. This website allows for operators to not only see and hear the

Figure 2. A Screen-Shot of our Current Web Interface. The lower left portion is the stale panorama. On the stale panorama, the blue window on the left side of the panorama shows the target position where the operator wants the Huggable to look next and the yellow window in the upper right shows the Huggable's current live camera feed. Across the top of the website from left to right are: 1.) a series of options (such as turning on face detection) which can be used by the operator, 2.) the play sound and text to speech audio functions which the operator can use to play back sound effects or talk to the user through the Huggable (in addition to using the worn headset microphone), 3.) the motion state animated 2D graphic which displays an animation based on the classified output of the IMU (i.e. rocking, picked up, bouncing, etc), and 4.) the virtual Huggable 3D WYSIWYG representation of the current motion of the Huggable robot as well as any interactions such as the user wiggling the Huggable's feet. Below the virtual Huggable are a series of animations which can playback on the Huggable with the operator's mouse click

child through the eyes and ears of the robot, but also to playback animations, sound files, and direct the robot's gaze to share attention. A virtual version of the robot also provides feedback to the operator of the current robots configuration as well as orientation and other sensor information. In addition to this website, a tangible Sympathetic Interface, a wearable IMU or gesture based system employing a Nintendo Wii controller can be used to control the robot's degrees of freedom. These additional systems allow for the robot to be used in rehabilitation scenarios, similar to the work of socially assistive robots [7], imitation scenarios with children in autism such as the work of [6], or for storytelling scenarios with the sympathetic interface used for gesture control. A full description of this website and the semi-autonomous robot avatar system can be found in [8, 9].

3. THE HOSPITAL OF THE SAN RAFFAELE DEL MONTE TABOR FOUNDATION (HSR)

San Raffaele del Monte Tabor (http://www.fondazionesanraffaele.it) is a private non profit foundation that runs one of the most important Italian hospitals (San Raffaele Hospital in Milan) and several outpatient facilities in Milan, as well as in Italy and abroad. In addition, HSR serves also as a University, a very active Scientific Institute, and as a very active Science Park, that enables technology transfer and tight co-operation with pharmaceutical, medical and technological industries.

Since 2007 Scientific Institute San Raffaele hosts the DRI, Diabetes Research Institute, the international center of excellence for the study and the treatment of diabetes. The San Raffaele Hospital Department of Pediatric and Neonatology (http://www.sanraffaele.org/62015.html, in Italian) is specialized in the diagnosis and care of pediatrics and adolescent diseases. It is a Center for Endocrinology of infancy and adolescence and Regional Reference Center for the diagnosis and cure of diabetes mellitus in pediatric and adolescent ages and it's staff includes all relevant stakeholders for the child's care.

Since 1997, HSR has added among its significant assets a specific unit oriented to the Information Technology applications in health domain. This unit, e-Services for Life and Health (http://www.eservices4life.org) is specialized in the delivery of services internally to the hospital infrastructure (person identification systems, process re-engineering) as well as oriented to innovative domains and disciplines (interactive television, educational games). The unit started to experiment with new interactive applications to strengthen the child's resources and limit the child's distress and discomforts. Among these initiatives are: 1) an interactive welcome cartoon explaining the hospital environment's spaces, tools and personnel, designed with one of the most famous Italian cartoonists; 2) a holographic tv; 3) a set of educational flash games and multimedia content; 4) interactive games for fruit and vegetables consumption promotion, and physical activity promotion. With a joint activity between doctors, psychologists and engineers, San Raffaele developed an innovative concept of "cognitive prescription", where contents and tools are tuned on the personal profile of each child.

4. APPLICATION SCENARIOS

In May of 2008, the authors met with a series of doctors, nurses, and staff of HSR to brainstorm a series of research scenarios in which the Huggable robot could be used with children in the pediatric unit. Here we present some planned research to be done within the next few years of our collaboration. Please note in all scenarios, the Huggable is being designed with removable exterior fur skins which can be washed to prevent infection or disease transmission and concerns of privacy and safety are central to our research, and though not explicitly stated in these scenarios, proper protections are being designed into these scenarios.

4.1 Diabetes Education

It is estimated that on an annual basis some 65000 children aged under 15 years develop type 1 diabetes worldwide. Type 1 diabetes places a particularly heavy daily burden on the individual, the family and the health services Nowadays, for people affected by diabetes, self-management education training is important since people with diabetes and their families provide 95% of their care by themselves This education can only be regarded successful if it helps people with diabetes to cope with this dilemma, reduces psychological distress related to the burden of intensive diabetes self-management, and prevents 'diabetes burnout' [10]

We believe that the Huggable can be used as a teaching tool in a semi-autonomous mode with a doctor or nurse serving as operator. In this scenario, the robot will rehearse the educational material provided by the professionals during daily lessons in order to help the young diabetic patient to understand what diabetes entails, will help the patient with his or her diet, will instruct the patient on the procedure of measuring blood sugar levels, recognizing symptoms of hyperglycemia or hypoglycemia and administering insulin. As the hospital stay for young patients newly diagnosed with diabetes is often long (up to 10 days), the robot will also play a crucial role in making the stay more pleasant for the young patient.

4.2 Companion and Confidant

In the Companion and Confidant scenario the robot will first fulfill the role of a trustworthy companion in which the young patient can confide. As in the previous example, the robot will run in a semi-autonomous mode for a first evaluation of this application. In informal user requirement studies at HSR, practitioners stressed how hard it is to form a relation with young patients and how this hinders getting information on which to base the treatment, like sources of anxieties or unexpressed reasons for non-compliant behaviors. This makes it difficult to gather information which is crucial for making an accurate diagnosis and for getting truthful feedback on how the young patient feels or how the therapy is proceeding. We believe that the form factor of the Huggable robot as Teddy Bear and its small size may cause the child to use the robot as an emotional mirror. The goal of this study will be to evaluate the level that a child will confide in the Huggable and the potential benefits to their health this may provide.

4.3 Needle Education

Injections are part of the treatment regiment in Type I diabetic children, for insulin shots, as well as in other pathologies. We are interested in exploring the use of the Huggable to teach children and their families how to properly execute injections. The Huggable, in a semi-autonomous mode, could play the role of the patient while a doctor or nurse described where the injection should be excuted, how much pressure to apply, what is the right angle, etc. Moreover, it's foreseen that a certain psychological support will also be provided, by mediating the scary experience through the robot. The injection training program could be targeted both to the children and to the parents (for very young patients); it has in fact been reported that most times the parents are the most scared ones, with a negative impact on the children.

4.4 Family and Friends Communication Channel

Many children who are in the hospital for a long time may loose contact with family members and their friends. Additionally, due the size of HSR it is capable of performing many complicated procedures not possible in local hospitals. As a result, children may travel a great distance from their family and friends for treatment. One important aspect of the Huggable's design is its focus on family communication [8]. In the triad of interaction in this scenario, the Huggable would be in the child's hospital room. A remote parent or friend could then use the website shown in Figure 2 or the control interfaces described in [8, 9] to see the child's face, hear the child's voice, and interact and communicate with the child through the Huggable. A monitor in the child's room would show the face of the family member of friend. This scenario could be another aspect of the daily set of interactions with the Huggable.

4.5 Other Applications

We believe that the Huggable could also be used to encourage social interaction between the children in the pediatric ward and provide entertainment. The Huggable could also be used in a play therapy scenario in which the behavior of the child (as recorded through the robot's sensors) could be documented and shared with the doctor for further analysis. We fully expect that as we run these first pilot experiments that further applications will become apparent and we will plan to test these scenarios in future work.

4.6 Data Collection and Transmission

Implicit in all of these scenarios is the Huggable's ability to collect data. This data can be behavioral in nature, such as touch, gesture, or other sensor information. This information could be integrated with other medical data via Bluetooth or WiFi communications on those devices. This data stream can be shared with the doctors, nurses, or staff in various ways for real time monitoring, off-line analysis, or providing an alert signal.

5. CONCLUSION

Personal Robotic Companions have the potential for many positive benefits for children in a pediatric care facility. Robots are still a very new and novel technology and they hold many interesting questions. In order to answer these questions we must conduct studies out of the lab in the actual environments that these systems will ultimately be deployed. In this paper we have presented our current work in developing the Huggable robot, specifically being designed to function as a portable research platform. The proposed research scenarios presented in this paper will allow us to analyze the benefits that such a system may have in pediatric care.

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