ANTY : The development of an intelligent huggable robot for hospitalized children

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Abstract: **This paper reports on the concept for the development of an intelligent huggable robot named ANTY (Fig.1) that will interact with hospitalized children to distract and support them during their stay in hospital. This robot is subject of a multidisciplinary project covering research opportunities not only in mechanical design, vision, speech and AI, but also in sociology and psychology. The main goal of the first phase is the development of the head of the robot. By moving its head (2 DOF), eyes (3 DOF), eyelids (2 DOF), eyebrows (2 DOF), ears (2 DOF), trunk (3 DOF) and mouth (3 DOF) it will be able to express its emotions.**

Keywords: **huggable robot, hospitalized children, emotions**

I. Introduction

A hospitalization is a serious physical and mental occurrence. It brings children in some situations which are completely different from home. In hospital, children's experiences are more limited due to the closed and protective environment. Hospitalized children are confronted with many difficulties and special needs [1]. We can take a look at the effect of animals on humans. In medical applications, especially in the United States, animal-assisted therapy (AAT) and animal-assisted activities (AAA) is becoming commonly used in hospitals [2]. AAT and AAA are expected to have useful psychological, physiological and social effects. For example, a hospitalized child who was in significant pain because of his disease was afraid to get up and walk around. However, when he was asked to take a therapy dog for a walk, he immediately agreed and walked off happily, as if all his pain diminished. Moreover, the dog acted as a medium for interaction between him and other children [3]. In another case, a boy who, as a fetus, was exposed to crack cocaine could not speak and walk. However, trough interaction with therapy dogs and birds, he improved both his linguistic and motor ability [4]. Now also robots, like the seal robot Paro, instead of real animals are used for pediatric therapy at university hospitals [5][6], termed robot-assisted therapy (RAT).

The purpose of the ANTY robot is to bring solutions to those problems and to help their attendants taking care of the children's special needs. These needs have led towards the goals and specifications that were set to define this project. Some of those specific needs are listed below together with some derived characteristics for the design of the robot.

Fig. 1. 3D-model of the ANTY robot.

A. Distraction

The robot must be able to distract children, in such a way that children can forget their presence in hospital for a while. Children must really be involved in the happening, with a maximum of interaction.

Characteristics : humor & game – interaction &creativity – loyal & honest – adorable & nice

B. Communication

Due to the closed and protective environment a child's social life is more isolated and its normal level of communication is diminished. Using technologies for distant communication, the robot can serve as an interface providing children a way to enhance their communication. Currently there are several pet-type robots developed as real communication media or as test beds to investigate the possibility of coexistent with humans [7], [8].

Characteristics:
Communication with: parents - classmates - friends - similar hospitalized children.
Communication about: interests - diseases - dreams - everyday stuff.

C. Information

Children's fear is sometimes due to lack of information. The better children are prepared what they will see, hear and feel, the less fear they will have to face the surveys and examinations accompanied with their illness.

Characteristics:

Explanatory information about: examinations - diseases - hospital environment and equipment.

Access to information about everyday stuff (news, gossips,…) and specific interest.

D. Curiosity

Children are in a stage of life where they want and need to discover the world around them. They use and explore all of their senses to understand the environment and their own possibilities.

Characteristics:

See – Hear – Feel – Smell

E. Motor skills

Children explore the environment by manipulating objects and gathering valuable information about physical characteristics. This eventually provides perceptual information necessary to make future judgments without the need for physical contact. Through a matching of perceptual and motor information, children can interpret the characteristics of the environment more efficiently. Proficiency in fine-motor control allows children to develop skills that will have consequences immediately and in later life [9].

Hospitalized children have to be motivated to develop their motor skills. When a child stays in a protective environment, the robot can be used to stimulate motor skill development during the stay in hospital.

Characteristics:

handcrafts – painting & drawing – molding

II. The Project Goals

The ANTY project will be used to accomplish four important goals concerning different areas of interest.

A. For children in hospital

The ANTY robot will be a friend visiting children and letting them experience an enlightened moment. Children must look forward to the next visit of the robot and even build up a confidential friendship with the artificial being. Therefore it is important that the robot really has the looks and feeling of a living being, so it can become a soft huggable understanding friend. The robot will be assisted by a counselor at all times for control and guidance. The robot has a screen in his belly that can be used as an innovative and child friendly interface to contribute to the improvement of the child's condition. There are three main concepts associated with the robot as a tele-interface.

1) Tele-interface – entertainment

The robot will be used to entertain children when it has a need for distraction. The robot will act as a clown and try to put a smile on the child's face. A young child has the needs to develop its senses and to expand its creativity. The robot must try to motivate the child to use all of its senses to explore the world around itself. This can be done by playing interactive games. Here the robot has more advantages in comparison with regular computer games because it can react emotionally towards children.

2) Tele-interface – communication

Because children are sometimes placed in a social isolated environment, they miss their friends and family. They can use the robot as an interface to connect to the internet. From here the child has the ability to use applications allowing them to communicate with other ANTY robots or with all other computers connected to the internet. The cameras in ANTY's head will serve as a webcam during video-communication. In that way children can stay in touch with their friends, and their family at home.

3) Tele-interface – medical purposes

To reduce the fear for medical examinations, the robot can prepare the child by informing it about the oncoming examinations. The unknown environment will be first explored and examinations will be described in a child friendly manner. By using predefined scenarios with pictures and sounds ANTY can pre-experience, by using its emotions, the medical inspection together with the child. A good preparation before the examinations will give the doctor better results when assessing the child's pain factor without fear.

B. As a research platform

ANTY can be used as a "social robot". The robot itself has a concrete goal towards children in hospital but at the same time ANTY is part of a much more ambitious project. Because of the multidisciplinary characteristics of that project, a prototype will be first build to support the further growth of the project. Alongside the technical research possibilities the prototype will be used to examine the opportunities for using ANTY in medical, social and psychological research. These researches will provide relevant feedback to optimize the prototype towards a useful "social" robot.

1) Technical

In the first phase of the project the focus will be on the design and the construction of a mechanical prototype satisfying the constraints on safety and hygiene regarding hospitalized children. This prototype must be a solid platform for other research groups to implement and test their technologies in the robot.

The technical challenges of building the prototype will be discussed in chapter 4.

2) Medical

The robot will be tested with social isolated children. The healing and therapeutic effects on children will be investigated. Human interactive robots are already used in

hospitals, in institutions, and in homes for the elderly people [10]. In robot-assisted therapy, children's moods can be improved by interaction with a robot. Moreover, the robot Paro [11] encouraged children to communicate both with each other and with their caregivers. In one striking instance, a young autistic patient recovered his appetite and his speech abilities during three weeks of treatment when a robot was at the hospital [12]. Another example is the Pet-type robot (AIBO, Sony Inc. Japan), that is expected to serve to maintain and improve quality of life among patients or handicaps [13].
The robot could perfectly be used as a part of studies with autistic children [14], [15]. These studies compare the effect that human-like features may have on the interest that children with autism show in interacting with another agent.

3) Social/Psychological

From the interactions between the robot *Infanoid* and normal children observed by H. Kozima & C. Nakagawa we can conclude the following stages unfolding toward the emergence of social interaction. First, children recognize the robot as a moving thing and then, they observe the dynamic movements in the robot's posture and expression and recognize that the robot is an autonomous, subjective system that possesses attention and emotion as a source of the physical movement. Second, they find that the robot's response (in terms of attentive and emotive actions) has a temporal relation with what they have done to the robot, and they recognize the robot as a companion with which they coordinate their attention and emotion [16]. Our robot will be tested in robot-child communication, looking at the social and psychological aspects. There will be a specific focus on the emotional communication. We will see how good the robot will be able to generate emotions according to psychological models and social scenarios. On the other hand we will also see how the emotions expressed by the robots are experienced by children.

C. For educational purpose

The robot will serve as a platform for small projects, which will be outsourced to local high schools or universities. In those projects the students can work on a specific element of the project, knowing that their work is part of a bigger concept. In this way the project is a great approach to motivate students and to stimulate new technological innovation.

III. Operational Concept

This section describes how the robot will be used in operational mode. We have to take in account that the development is divided into different phases. In a first phase the robot will be used as an interface between an operator who will control the robot and the child that will interact with the robot.

A. The interface-layer

At first, the robot will be used as an intelligent interface between researchers and children. We call it a Robotic User Interface (RUI) (fig. 2). Later on, the robot will become more and more autonomous. The researcher can load scenarios and choose a specific behavior of the robot. Children can interact with the robot by speech, vision and touch.

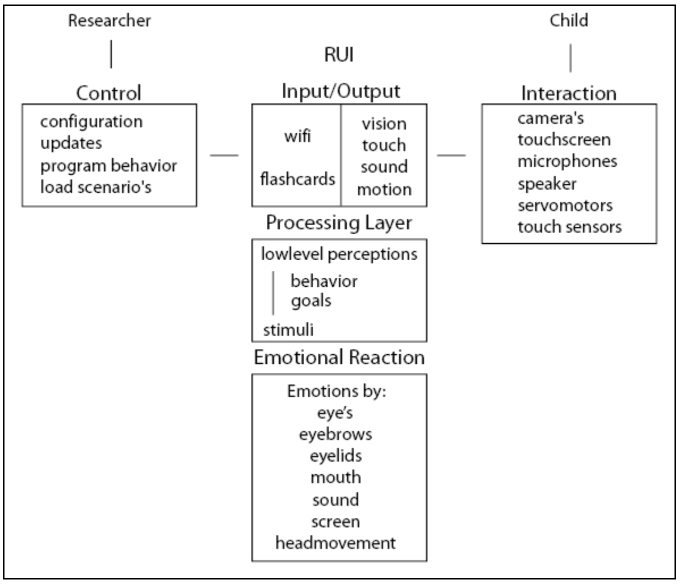

Fig. 2. Robtic User Interface (RUI) for ANTY

B. The processing-layer

Depending on the configuration and settings done by the researcher, the robot processes the information from his inputs (audio, visual, touch) to generate the appropriate action and emotional status. One of the actions will focus the head and eyes on the preferred point of attention. The method of processing is controlled by the behavior system that is controlled by the researchers. A specific behavior-based framework will be developed to obtain this system. The framework will be based on earlier work of Ortony, Norman and Revelle [17], who focus on the interplay of affect, motivation and cognition in controlling behavior. Each is considered at three levels of information processing: the *reactive* level is primarily hard-wired and has to assure the quick responses of the robot making it look alive; the *routine* level provides unconscious, un-interpreted expectations and automotive activity; and the *reflective* level supports higher-order cognitive functions, including behavioral structures and "full-fledged" emotions.

C. Emotional Reaction

To obtain a good communication between robot and child there is a need for emotions. In our daily life we rely on face-to-face communication and the face plays a very important role in the expression of character, emotion and/or identity [18]. Mehrabian [19] showed that only 7% of information is transferred by spoken language, that 38% is transferred by paralanguage and 55% of transfer is due to facial expressions. Facial expression is therefore a major modality in human face-to-face communication. Several theorists argue that a few select emotions are basic or primary—they are endowed by evolution because of their proven ability to facilitate adaptive responses to the vast array of demands and opportunities a creature faces in its daily life (Ekman, 1992; Izard, 1993) [20][21]. The emotions of anger, disgust, fear, joy, sorrow, and surprise are often supported as being basic from evolutionary, developmental, and cross-cultural studies (Ekman and Oster, 1982) [22]. The emotions will be expressed by the robot using his facial expressions and the production of sounds. The idea of the emotional expression is to process the inputs from the sensors and translate them into perceptions. Those perceptions are evaluated by the behavior, the current emotion and the current drive to trigger the corresponding emotion.

D. Social Learning

The robot as an interface will become more autonomous and self-learning. The operator which controls the robot will evolve to an instructor, teaching the robot how to improve its skills in social interaction. For this functionality we will use neural networks and reinforcement learning.

IV. Mechanical Systems

A first prototype of the robot will have an actuated head and trunk. It will be able to focus on a point of attention with its eyes. And it will use eyebrows, ears and eyelids to express moods and feelings. Next step is the development of our prototype, it must fulfill the specifications to operate in a hospital environment and to interact with children. The intrinsic safety when dealing with child-robot interaction is of very high priority. Children expects a huggable friend that hasn’t the intention to hurt them. The use of flexible materials and compliant actuators is a must with regard to these constraints. Because of the high requirements on hygiene applied in hospitals, the fur of our robot can be easily replaced and washed. The fur can be replaced before the robot visits children. The prototype will measure about 66cm in height and no more then 32cm in width. Some specific mechanical systems will now be discussed.

A. The Eye System

The eye system will consist out of 2 eyeballs moving in a natural way together with the movement of the head. An eyelid on each eyeball will make it possible for the robot to blink and close its eyes, and will be used to express the mood and emotions of the robot. Above the eyes, eyebrows and ears will be added to reflect the feelings of the robot. The eye-system for the robot is already designed, based on an anthropomorphic model, with eyes supported in an orbit. Bowden cables and hobbyist servos are used to actuate the eyes and eye-lids. The eyes can pan separately and tilt together. Pretended tension springs secure an intrinsic safe mechanical design [23].

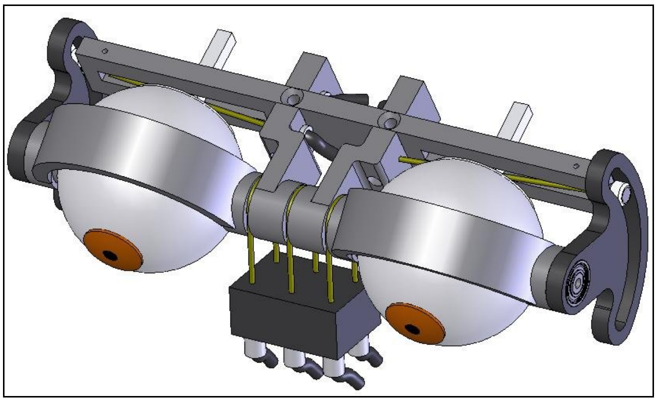

Fig. 3. Preliminary design of the eye-system for the intelligent huggable robot ANTY.

B. The Mouth System

The mouth of the robot will be used to express its feelings going from a happy smile, to neutral and to a sad mouth position. The mouth (Fig.4) will also be used to simulate lip movements while the robot is producing sounds with the speaker placed in the mouth. This way the sounds are more accepted as being the voice of a living being rather than from an artificial speech synthesizer. The mouth exists from 2 movable lips. The upper lip is attached to a fixed point in the middle, which will be attached to the trunk. The outer lip points of the upper and lower lip are attached at two clamps moving the points up and down. The lower lip can also be moved with a clamp to open and close the mouth. The outer fur will be attached on the lips to obtain a nice integrated mouth and a lifelike moving fur.

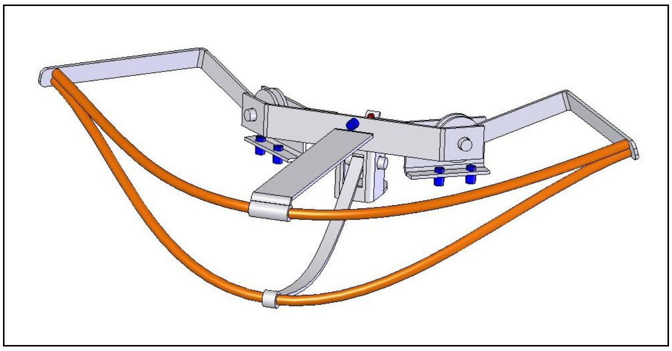

Fig. 4. Mouth System.

C. The Trunk System

The trunk or proboscis of our robot is the most attractive element according to the children and is used to maintain the child’s attention to the robot. That is why the trunk has to be made very soft but durable and be able to move in a natural way. The trunk consists out of a foam core with segmented extension discs and three extensible cables. When the cables wind up the trunk will curl in the direction of the cable. By means of three cables the trunk can move in every direction.

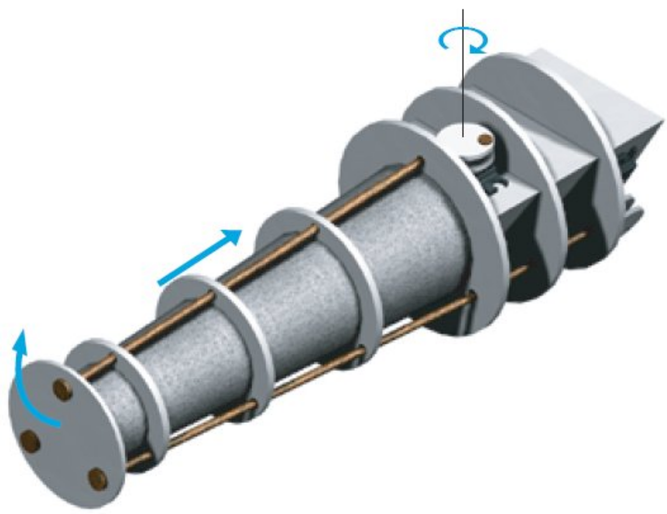

Fig. 5. Trunk System.

D. The Fur

The fur together with the underlying foam will give the robot its "soft touch" to make it huggable, and give it the looks of a living being. The use of a fur makes it harder to fulfill the strict specifications imposed by hospital hygiene. The fur will therefore consist out of special materials to make it more resistant against bacteria. The fur can also be easily removed and washed with a disinfectant, like H.A.C., to assure there can be no danger in transferring bacteria's from one child to another.

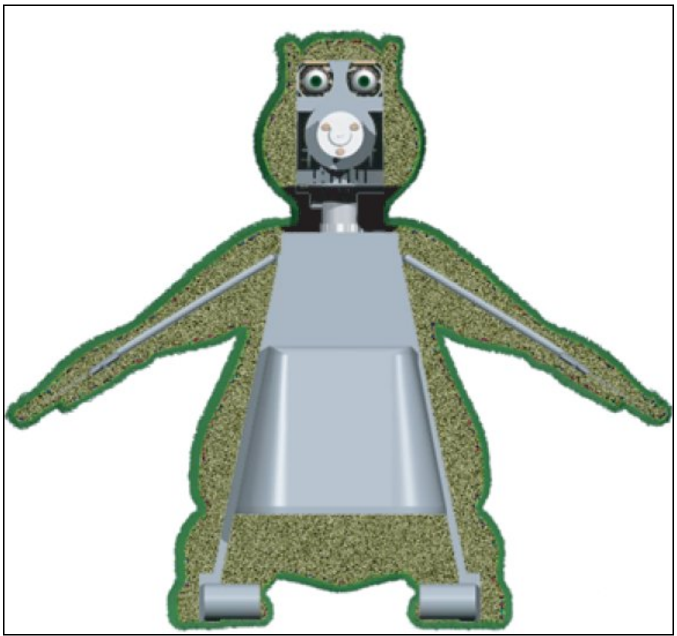

Fig. 6. Section view. The fur and foam protect the internal robot.

E. The Traction

To obtain a flexible movement of all the parts, a special traction system will be used. The moving axis is connected with the motors by using two parallel wires. The wires are connected with a reel and will pull the reel to provide a rotation around the desired axis. The advantage of this working method is that the motors can be placed anywhere in the robot thus saving space excluding the motors from the head of the robot. Another advantage is that we can easily reduce the noise of the motors when placed together in an isolated box. To assure an intrinsic safe interaction, the actuators should take certain compliance into account, therefore springs are placed in the wires.

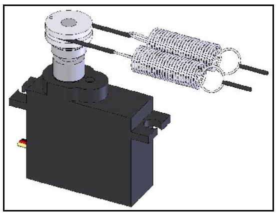

Fig. 7. Compliant servo assembly.

V. SUMMARY AND FUTURE WORK

The concept as described here will be further developed, starting with a first prototype focusing on the mechanical construction of the head and a software design of a flexible framework to implement the different aspects of operation with specific attention on the behavior and emotional aspects.

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