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Abstract. YOTARO is a baby-type robot developed to create a new communication perspective between robots and humans through interaction experience based on the reproduction of a baby's behaviors and user actions. YOTARO exhibits different emotions and reactions, such as smiling, crying, sleeping, sneezing, and expressing anger. It is controlled by an emotion control program that executes in response to inputs such as touching its soft and warm face, touching its stomach, and shaking a rattle. The output is in the form of interactive reactions such as emission of sounds, change of expressions, limb movements, sniveling, and variation in skin color. In addition, we used questionnaires to observe the impression on users before and after their experience with YOTARO.

Keywords: interaction, communication, virtual reality, physical contact.

1 Introduction

The relationship between humans and robots, as well as the communication between them, has garnered increasing attention as robots and virtual reality (VR) systems will play an important role in family lives in the future.

Previous research on this subject, Infranoid [1] and Keepon [2], tried to clarify human communication. Kismet [3] is an example of emotional reactions and turn-taking conversations in robots. Another case refers to a media artwork, Neuro-Baby [4] with emotional reactions. There are also robot types whose main objective is creating long-term relationships with people, such as the mental-commit robot Paro [5], AIBO [6] the pet-type robot, and mobile games such as Nintendos [7] and Tamagotchi [8].

This research aims to create a new communication perspective through a baby-type robot, YOTARO. The kindness toward babies is inherent in humans and the baby is the most conspicuous example of human instincts, in which everyone cares for and is tender toward the baby.

The actions of caring for a baby, such as to lull a baby or to wipe a runny nose create a strong connection with the baby. A similar connection can be established in the relationship between humans and robots. YOTARO aims to create a feeling of satisfaction in people through only a few minutes of interaction with the baby. Fig. 1 shows the physical appearance of YOTARO.

Fig. 1 Physical appearance of baby-type robot "YOTARO"

2 Experience

YOTARO has six elements that correspond to the interactions with a baby.

- Baby's peculiar transient behavior
- Unconsciously touching its ruddy and soft skin
- Slightly higher body temperature (peculiarity of babies)
- Help to wipe snot
- Rattle as an example of communication using tools
- Movements that stimulate touching a partner.

The experience booth is the interior of a child's room and includes a baby bed; the users stand beside the bed and play with YOTARO.

The user starts by waking up the sleeping YOTARO merely by touching its face. Next, the user can perform actions such as touching its stomach, shaking a rattle, and touching its face. YOTARO reacts by changing its expressions and skin color, sniveling, sneezing, emitting sounds, and moving its limbs. In this process, the user performs various actions to make YOTARO happy, and the pseudo experience of taking care of a baby is improved when the user wipes the snot.

YOTARO wakes up in a bad humor and its reaction is inconsistent. However, its humor gradually gets better and laughter is heard. While users are enjoying this experience, the reactions slowly get worse. YOTARO does not react pleasantly to actions as it had done until now, and it is now almost crying. This situation occurs when a baby is getting tired and being fretful. Based on this condition, the users can understand how to take care of a baby as every action now is likely to make the baby more fretful. In this case, after a short while of doing nothing, YOTARO sleeps again. The experience ends with completion of this cycle. Fig. 2 shows a simplified image of YOTARO's structure.

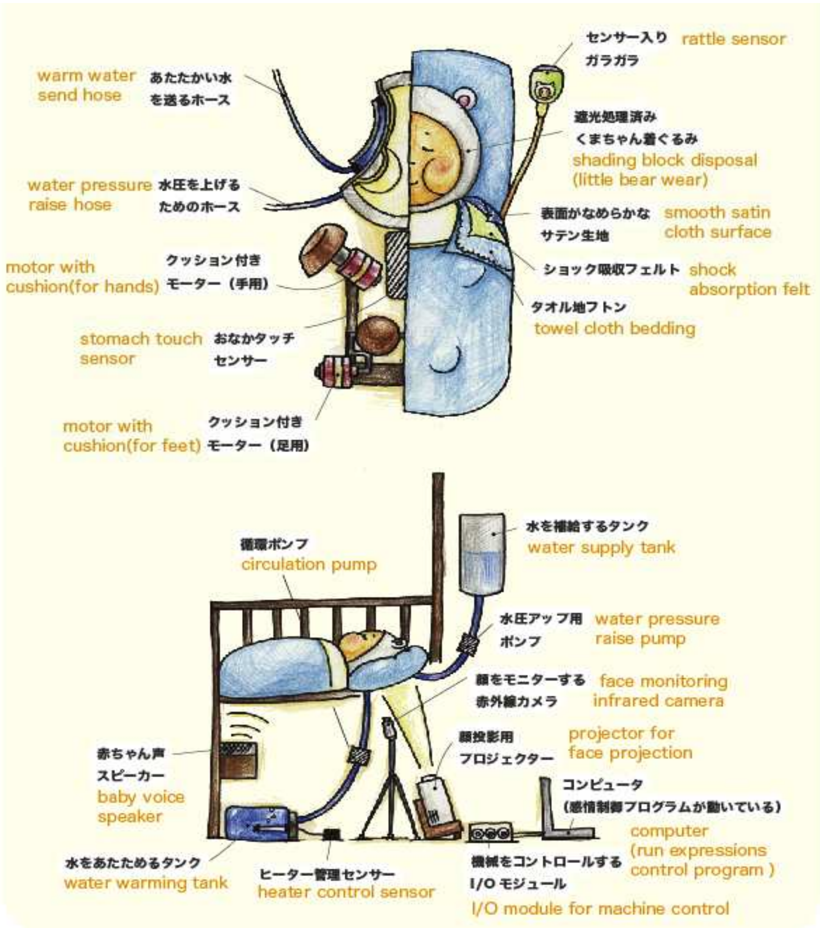


Fig. 2 Structure of YOTARO

3 System

3.1 Summary of System

The YOTARO system is presented to better understand the general structure and its interactive reaction. The system is divided into three parts: input, controller, and output. The user action input is captured through various sensor devices; the controller transforms the input data into various reactions, and the system then produces output actions such as sounds, tactile sense, snivelling, and movements to interact with users (Fig. 3).

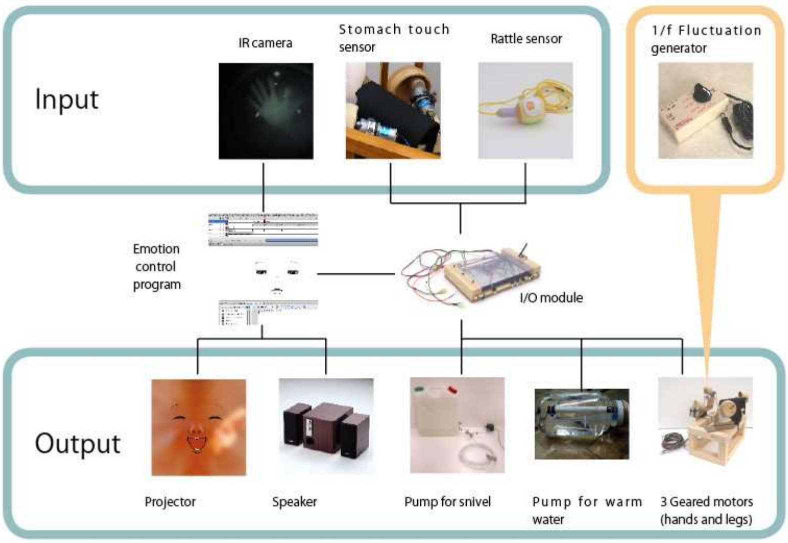


Fig. 3 Relationship between system configuration and Input/Output

3.1.1 Input

The virtual experience of contacting a baby happens when users touch YOTARO's face. It is necessary to distinguish which part of the face was touched. Three devices compose the inputs: near-infrared camera, touch sensors, and rattle sensor.

First, the near-infrared camera is installed on the backside of YOTARO's translucent face; it detects the position of the hand by infrared ray reflection. Next, touch sensors detect actions such as tickling the stomach using a photodiode switch. For rattle, piezoelectric elements are sewed and connected via a cable. Upon shaking the rattle, values of the sensor change and this change is detected via an analog recorder.

3.1.2 Controller

These three kinds of inputs are controlled through the I/O module and an emotion control program that reads the input, processes the data, and outputs the reactions. The emotion control program controls the changes of expressions; for example, when its nose is touched, YOTARO sneezes; when its cheeks are touched, it becomes happy. Thus, the baby promptly changes emotions and the output responses from the sleeping state, to waking up, being happy, being fretful, and then sleeping again.

3.1.3 Output

The outputs are produced in real time through the following types of methods: a video projector that plays an animated movie, audio speakers, geared motors, a snivel pump, and a warm water pump. The video projector is used to project changes in the baby's expressions. The speakers emit a real baby's sounds that are sampled and emitted in connection with expressions. A group of three motors moves the hands and legs; there is one motor for each hand and one for both legs. The motors produce irregular movements by rotation under the blankets; a 1/f fluctuation is reflected on the movements. In most cases, the rhythms of the natural world have a 1/f fluctuation, such as in a small river stream or the chirping of insects. YOTARO moves its limbs as naturally as possible, and fluctuations were added to motor's rotation.

The pump for the snivel comprises a warm water pump and a tank. The nose area has small holes, and when the pump increases the pressure, drops of warm water start to flow. The water is warmed in the reserve tank by a thermostat and heater; the water circulation inside the face portion of the robot is performed by the water pump. The warm water is maintained inside the face at temperature that is near the normal human body temperature.

3.2 Emotion Control Program

YOTARO is a robot that can express emotions. In this section, previous research about robots that can display emotions was investigated as a base to develop the emotion control program for YOTARO.

Some cyclical aspects were noticed, such as the process of a sleeping baby waking up, the slow movements and reactions going into an awakened state, becoming tired after a while, sleepy, and in a bad mood, and finally sleeping again. This cycle was summarized as: sleep mode → doze mode → in a good mood mode → fretfulness mode → sleep mode, to represent it more closely to the emotion mode loop.

3.3 Methodology to Create Face for Projection

The baby's facial reactions are presented by animation, as shown in Fig. 4. Inside the face, the nose is the most difficult part to change expressions. Upon creating the baby's image, the nose is added. Over this, the emotion control program determines expressions and composes skin color changes. The near-infrared camera detects movements by capturing every frame and bitmap, and after that it compares them with the previous bitmap image. In instances where there are huge differences, skin becomes light yellow, while in small places, it becomes red. Through these effects, the pressured place creates the illusion of color change. Finally, the face composition is projected to form a final image at the translucent silicon face.

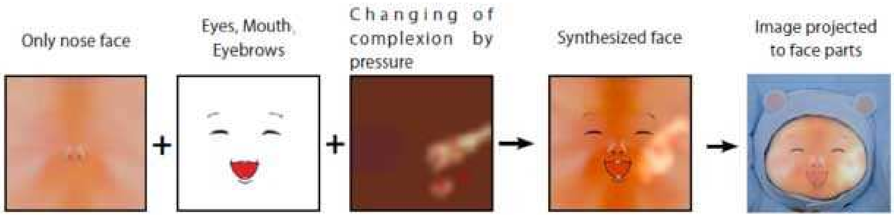


Fig. 4 Image formation of face

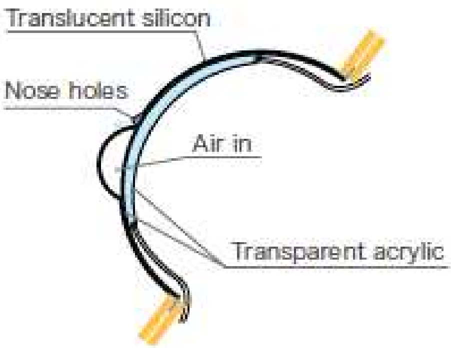
3.3 Structure of Face

The face portion of YOTARO has diverse functions: soak water, maintain soft and curve surface, and detection of the user's hand position. The face portion is a new type of back projection display. In addition, an approach was followed to maintain the user's interest while in the experience booth. These simple cycles when combined became more complex to keep the user interested in playing with YOTARO.

Fig. 5 shows the structure of the face. It was made using 2-mm-thick translucent silicon film, which covers a water system comprising two acrylic hemispheres.

The snivel flow control was realized by opening minute holes through the silicon film and acrylic surface. It works as a valve owing to silicon's elasticity, and changes internal pressure by on/off of the pump, thereby controlling the snivel flow.

The acrylic water system has four connectors for hoses. The connector on the top (Fig. 5-a) is to suck air, the one on the right (Fig. 5-b) is for the pump to send water from the tank, consequently elevating the pressure and causing the snivel to flow. The remaining two connectors (Fig. 5-c, d) are used to circulate warm water from the external source to the internal water system. This circulation permits the water temperature control inside the acrylic water system, and the surface temperature becomes similar to a baby's temperature.



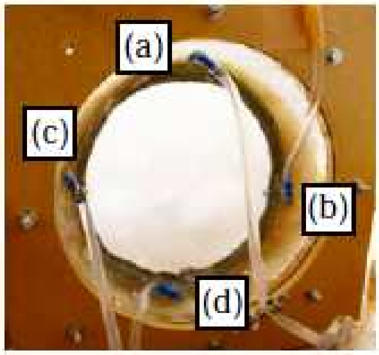


Fig. 5 Face structure

4 Variation and Considerations

During the exhibition of YOTARO at Laval Virtual 2009, data was collected from 75 people through a questionnaire (in English). The questions comprised five stages, at the first contact and after playing with YOTARO. The stages were as follows: “Very Good,” “Good,” “Whatever,” “Bad,” and “Very Bad.” Moreover, the questionnaire inquired whether they have children.
The valuation of user’s impression of YOTARO was presented in two averages: before and after play (Fig. 6). The average of user’s impressions was compared between before experience and after experience cases, and it varied from 3.72 to 4.08.

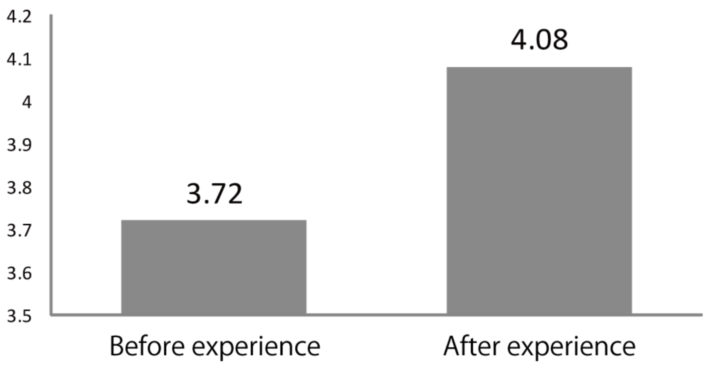


Fig. 6 Evaluation of impression of YOTARO

It was observed that the user’s average of impression before experience had the tendency to rise than that of after the experience. Thus, it is possible to consider that the action of taking care of the baby robot significantly influences the affection of the doer..

5 Conclusion

This study was conducted on the hypothesis that the actions of taking care of babies create a strong connection with them. As an outcome of the materialization of an artificial baby, it became possible to develop a baby-type robot, YOTARO. Through the responses in questionnaires, it was observed that the impressions of users changed significantly before and after the contact with YOTARO. In addition, the hypothesis of "action of taking care" significantly influenced the affection with the "subject of this action" was supported through the results of the questionnaire data. Based on the presented arguments, to leave an impression more effectively from users to the robots, it is necessary to approach a situation where a robot needs to be taken care of and users are in a position to support this action.

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