Kid's Friendly Wearable Device for Children's Daily Safety

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Abstract— **This study introduces the development of a practical product based on Kansei simulation of children's behavior and physiological reaction against anxiety. It started in 2006 with children under 6-years-old who had few experiences of accidents or events, and less linguistic communication skills with their parents. The reliability of heart rates to detect fear and anxiety was tested to know if it could be one of the functions on this device. The heart rates and behaviors of children while watching simulated movies showing dangerous situations was analyzed. With the support of the Ministry of Internal Affairs and Communications, a device named "Onigiri Machine" was developed to keep children safe while their parents work during daytime. It was highly evaluated by scientists worldwide through conferences papers, newspapers, and magazines. Now, keeping track of children and elderly in shopping malls or in hospitals became an issue in Tsukuba, Japan. For this reason, the device was refined to update the functions and qualities for practical uses in public services. Finally, this study shows how the device can be used to keep children and elders safe in public spaces, and how it delivers personal based data in an easy interface for their companions.**

Keywords- wearable device: kid's friendly design; information sharing; children's safety.

I. INTRODUCTION

The idea of this study was based on personal interests in security for children between 0 to 6 years old in nurseries or kindergartens while parents work during daytime. For the development of the device, a basic research on physiological data from children between 1 to 6 years was needed to detect unconscious states in children through their heart rate.

Generally, regular working mothers should stay with their children at least for 8 hours a day, and should communicate with them, face to face, for 4 - 5 hours a day in average. It is hard to say that this is enough to know what is happening to their children's growth, both physically and mentally. Furthermore, the linguistic communication ability of 0 to 6 years old children, before elementary school, is not enough to be correctly understood by adults. In this regard, the author had some frustration to communicate and get information on her child, meaning that the only way to understand was to keep watching her behavior and reactions during limited moments. On the other hand, children under 6 years old get most of their influences from people around them while imitating their behaviors naturally. As such, there must be a clever way for working parents to know and feel their children.

This study introduces the development process from researching on children's behavior and emotional reactions to the final stage of making a practical system for real users in public places. In order to develop a device that can detect children's conditions in anxious or emergency situations, the following components were selected: heart rate measurement device, GPS, camera, 3D accelerometer, XBee network, and a microcontroller for connecting and controlling the sensors. The most outstanding progress of this study was done between 2009 and 2011, with the aid of the Strategic Information and Communications R&D Promotion Program (SCOPE) funded by the Ministry of Internal Affairs and Communications. Based on the children's heart rates experiments started in 2006, a device named "Onigiri Machine" was developed and updated to support information sharing of children and elderly who cannot communicate satisfactorily with people.

The structure of the paper is as follows. In Section II, the basic research used as a base for this study is introduced. In Section III, a design approach based on behavioral aspects of children concerning safe construction of form, namely "Kid's Friendly Design", is presented alongside advanced technologies to detect a variety of situations. Section IV details the experiment conducted for this study. Finally, Section V concludes this research.

II. BASIC RESEARCH

This study uses as base a foundation research done in 2006 concerning heart rate measurements on children during stressful situations combined with the Kansei approach of design.

A. Kansei

Kansei is a Japanese term that implies subjective perception and reaction based on experiences. It involves emotion, preferences, and learning of daily habits. People react to an event depending on their personal experience, including knowledge and intuitive response from image matching of the past. Kansei reaction is more important for surveying behavioral habits, in addition to being more creative in finding new solutions for design development.

B. Heart rate Experiments

Heart rate is one of the elements in measuring unconscious feelings of anxiety while facing new

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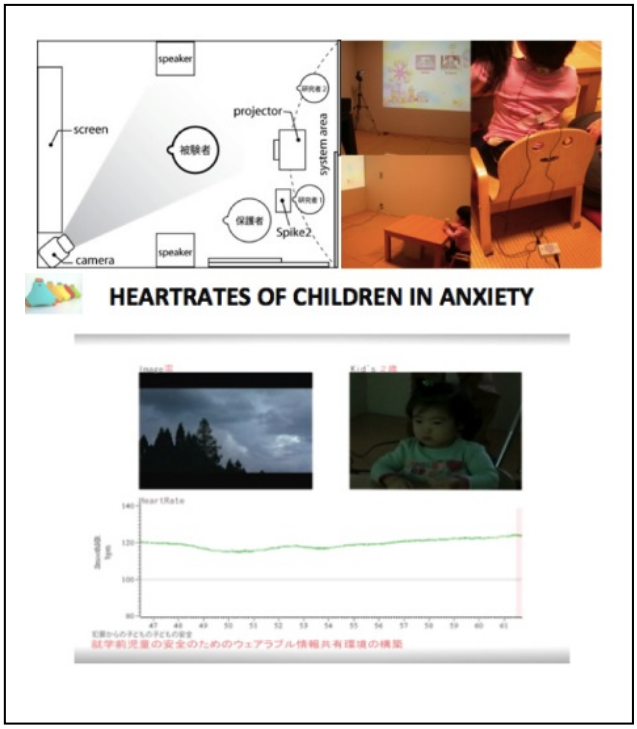

Figure 1. Physiological test of anxiety for Children under 6 years old

experiences or any uncomfortable situation. The purpose of the experiment was to know how heart rate relates to emotional prediction in children while the device detects their conditions during any situation. Figure 1 shows the setup for the experiment. Children in a nursery from 1 to 6 years old participated. Simulation films which entail dangerous and anxious situations from an adult standpoint were prepared. These movies were originally edited with royalty free copies. All the participants' parents agreed with the Institutional Review Board (IRB) of University of Tsukuba while the safety of the experiments for testing the heart rates was thoroughly checked. The result of the experiment was that children's Kansei is generally expressed around 2 - 3 years old with practical experiences and learning from their parents or people around. Therefore, their emotional reaction gets closer to an adult's.

III. DESIGN DEVELOPMENT

For the development of the "Onigiri Machine", a unique approach was proposed. To make children attracted to, and willing to, wear the device, a fascinating shape was designed before deciding on the technological components. As shown on Figure 2, this approach was denominated "Kid's Friendly Design".

A. Maintaining the Integrity of the Specifications

For "Kid's Friendly Design", the first step was to decide on the weight and size of the device, followed by how and where to wear on a child's body. Graphical design and decoration was the last step. The main goal is to create a fascinating appearance for kids to keep wearing it while the

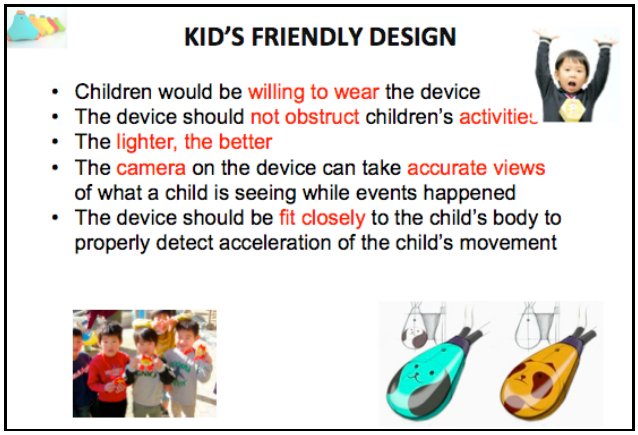

Figure 2. Kid's Friendly Design Approach

necessary information is read from their chest. Emotional and cognitive behavior could be detected by 3D acceleration and heart rate measurement, in order to share their status with their parents online, complemented with an image from the child's point of view.

B. Weight and Size of the Device

In accordance to the Research Institute of Human Engineering for Quality Life of Japan, which has a database of the average body size for Japanese children between 0 and 12 years old since 2005, the size of the device was decided. The width of a 3-year-old child's chest is 164mm and for a 5-year-old is 176mm. Based on this information, the device should not exceeded 100mm in diameter. Moreover, most of the objects that can be attached on child's neck weight between 30 to 50 grams, while on their waist are less than 100 grams. Additionally, a survey among mothers in the kindergarten reveled that 75 percent of them would allow devices under 100 grams to be attached to their children. For reference, an alarm buzzer weights between 45 to 60 grams, likewise mobile phones for children range between 130 and 150 grams.

C. How and Where to Wear the Device

To attach the device on an appropriate position on

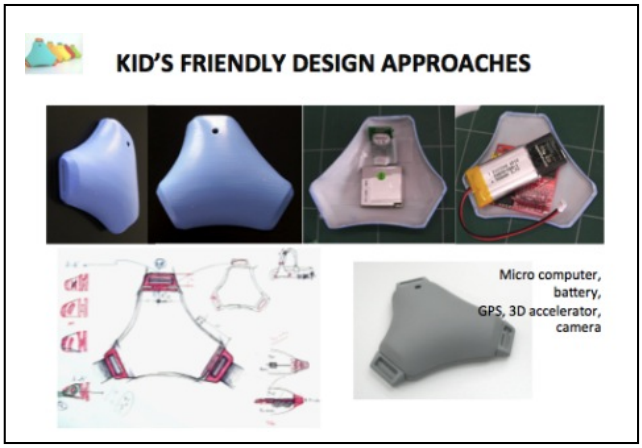

Figure 3. Kid's Friendly Design Approach

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Figure 4. Implementation of Onigiri Machine

children's body, a survey of the sizes of desks and tables in the kindergarten was conducted. The machine should not disturb the activities of the kids in the classroom or in the playground. At the same time, the camera on the device should be set at a stable position on the chest, so as to allow them to actively run around.

D. Building the Prototype

Based on shoulder sac types of design, the built of the sensors followed the concept "B-3", presented in Figure 3. The total weight of the built-in sensors had to be at most 90 grams. Notwithstanding, a necklace type of design was rejected from the candidates, due to the burden generated on the children's neck. From a pool of four ideas for shoulder types, "B-3" offers a relatively high position for the camera, while being easy to wear. An updated sketch of "B-3" was prototyped using a 3D printer to verify the size of the device. Furthermore, the layout of the sensors was tested. What is more, small connection parts were created on the corners for the straps attached to the body. Finally, an on-off switch was placed on the rear side in a tiny hole, as to be securely turned with an originally designed stick, thus preventing unwanted manipulation.

Figure 4 shows the final device 'Omusubi' (=Onigiri), which means 'rice ball' or 'connection' in Japanese. A 'rice ball' is a traditional snack between lunch and dinner popular among all ages in Japan. 'Connection' is also a meaningful concept within this study, as information is not only shared between children and parents, but also with local caretakers.

IV. EXPERIMENT

For the experiment, 12 hand-made devices were built with a setup of over 30 relay sensors to monitor the position of the devices every 10 meters inside the kindergarten. For the final user test, 50 children were selected through an ethical research pre-survey with their parents. The subjects were in average ten children per age. To observe the behavior, and check both physical movements and digital data of the children with the devices, 5 selected personnel attended the test.

Complementary to the device, a website for parents, shown in Figure 5, was made available at the beginning of the experiment. With this tool, they could monitor the movement of their children inside the kindergarten, besides watching their point of view constantly. Nevertheless, for everyday use, these shots are meant to be taken when a child registers a sudden change in heart rate or shifts his/her position up and down rapidly.

A. Extension of the Experiment

One of the biggest shopping malls in southern east Japan adapted this system to prevent children getting lost while shopping in the facility. In addition, with the function of measuring heart rates, shops can get information on when the children got excited in relation to certain products, making this feedback useful for the store to promote their products or events practically. On the other side, for detecting the position of lost children, a GPS was implemented in the device. However, as indoor measurements were not accurate, and XBee mobile network was deployed at the shopping mall for every 30 meters for monitoring and controlling the devices. Figure 6 shows the setup and positioning of the XBee mobile network inside the mall.

V. CONCLUSION

To develop a new device concerning children's safety, emotional and physical growth with new experiences are the most important points. Those aspects were treated using an approach with Kansei, physiological data, and behavioral movements sensed by highly technical solutions. For practical uses of the device, fascinating and reasonable design, fitting children's preferences, was highly evaluated. Currently, real production of the "Onigiri Machine" is being prepared based on the behaviors and preferences of children and elderly. In this regard, it will increase its potential: not only as a tool to prevent lost people, but also as a mean to

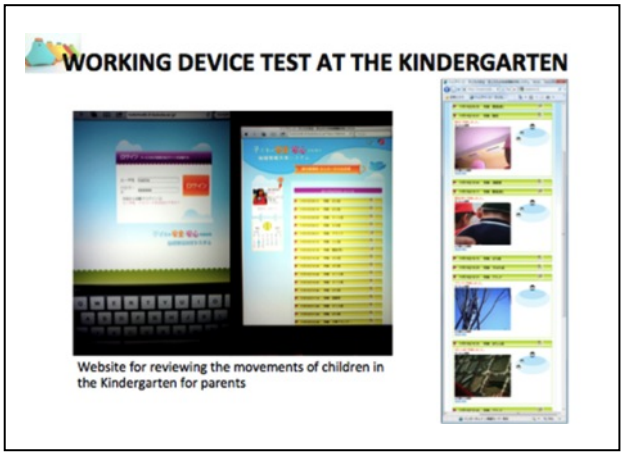

Figure 5. Online Website Interface for Onigiri Machine

Figure 6. Signal receptors position in the mall

know the user's Kansei in various situations, regardless of age. With the mechanical engineering and information technology developed, this concept, that started from a personal need to prevent loss or kidnaping of children, brought more possibilities for the improvement of Information and Communication Technology for the future.

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