Designing a Feeding Support System for Infants using IoT

Kyudong Park[1], Jiyoung Kwahk[2], Sung H. Han[2]
Department of Creative IT Engineering[1]
Department of Industrial and Management Engineering[2]
POSTECH
Pohang, South Korea
Email: {kdpark, kjy, shan }@postech.ac.kr

***Abstract*— The main goal of this on-going research is to design a feeding support system based on technologies with Internet of Things (IoT). For that reason, we conducted user observation and in-depth interview with three parents for developing the system based on better understanding of users. We found two pain points, which are the measurement of temperature and quantity of feeding milk, in current feeding behavior. Thus, designed prototype can measure the temperature and record the quantity of feeding automatically with sensors. The prototype consists of sensor client, representation client, and server. Sensor client obtains feeding amount and time information and sends them to the server via the internet. The server statistically analyzes the dataset and gives useful information about the baby. Representation client visualizes the stored data effectively and gets an alarm setting for feeding time. The next step of the research is to perform a user study to evaluate user experience and establish a strategy for analyzing data with machine learning approaches.**

Keywords-UX design; Feeding system for infants; Internet of Things

I. INTRODUCTION

Recently, technologies based on Internet of Things (IoT) have got a roaring attention of academic as well as the industrial field. Kevin Ashton proposed the first concept of IoT in forms of Radio Frequency Identification (RFID) in 1999 [1]. The ultimate objective of IoT is to construct more comfortable and convenient environment through exchanging the information seamlessly between objects [2]. Nowadays, IoT technologies are composed of 1) device for detecting and sensing an object, 2) network for connecting to the internet, and 3) platform for knowledge management considering semantics. These were mainly developed as separate technologies, but now, interdisciplinary approaches, such as human-computer interaction (HCI), ergonomics, cognitive science, and data science are vibrantly discussed and studied.

This paper is organized as follows. Section 2 presents the design process. Section 3 demonstrates the needs of users. Section 4 contains a detailed explanation of the proposed prototype. Section 5 draws conclusions and future work.

II. DESIGN PROCESS

In this project, we adopted human-centered design (HCD) process for developing a product based on better understanding of users. There are five main activities in HCD process according to the ISO 13407 standard as shown in Figure 1 [3]. We focused "understand and specify the context of use" and "specify the user requirements" activities to find users' needs. Based on the needs, the prototype was designed, but it is still under development. After producing design solutions, an evaluation will be performed with users.

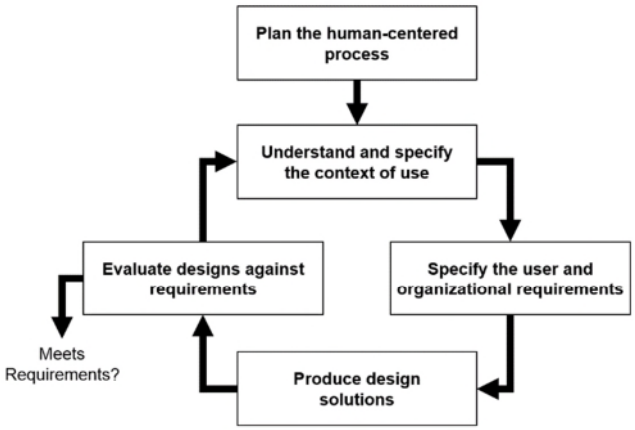

Figure 1. The human-centered design cycle [3]

III. NEEDS FINDING

A. Understand and specify the context of use

The topic with formula milk feeding has been steadily studied worldwide and regarded as important because it is directly related to the infant health [4][5]. In this study, we conducted user observation and in-depth interview with three parents to find needs.

Most feedings with formula milk use a baby bottle. Thus, parents and babysitter have to pay particular attention to air penetration into the bottle (causing diarrhea), and internal washing and disinfection of the bottle. Furthermore, when parents make a formula milk, they first boil tap water and pour the exact amount of water into the bottle. In this process, more than 70 degree Celsius water is necessary because of

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the sterilization of Cronobacter Sakazakii, which can cause bacteremia and meningitis with the use of powdered infant formula [6]. Then, add the right number of scoops to the bottle, give the bottle a good shake until all the powder has dissolved, and leave it to cool naturally. They have to test the temperature by tipping a little milk to the inside of their wrist. It should feel just warm, not hot. After feeding, they have to check the quantity of feeding and write it down in a notebook or mobile application by hand.

B. *Specify the user requirements*

We found two pain points in current feeding behavior. First is the measurement of temperature. Appropriate feeding temperature is 37 degree Celsius, but skin sensation using wrist is limited to measure the suitable temperature:

"If I give my son a slightly hotter milk powder than normal, he will have loose bowels"

Second is the measurement and record of the quantity of feeding milk. This is an essential process because weight, height, and quantity of feeding are important factors to check the infant's health. However, it could be a very tiresome to measure the quantity by the gradation on the bottle, and write the value in the note or mobile application:

"I have to remember the amount of milk powder in the bottle when I start feeding. After finishing, I subtract the remaining amount. Then, I write it down in my note."

Thus, we propose a product that can measure the temperature and record the quantity of feeding automatically.

IV. PROPOSED PROTOTYPE

The proposed system consists of sensor client, representation client, and server (Figure 2). Sensor client will obtain data including feeding amount and time, and send it to the server using a network. Data will be collected to the server and processed. The server will statistically analyze the dataset, and give useful information about the baby. Representation client, such as mobile application, will visualize the stored data, and get an alarm setting for feeding time and private data including baby's weight and height.

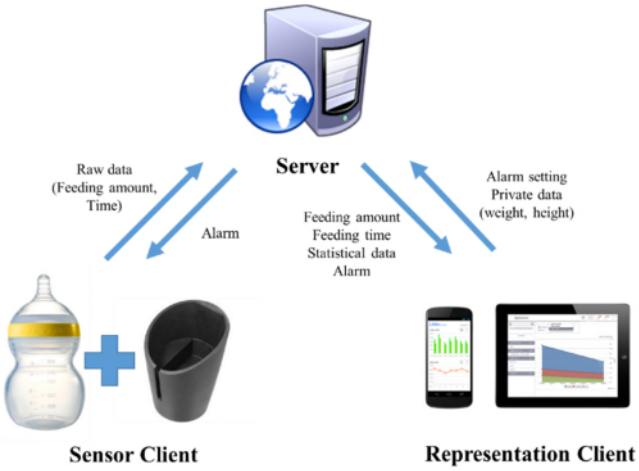

Figure 2. The overall structure of the proposed system

A. *Sensor client*

Sensor client has a form of the cup holder that user can put the feeding bottle on. There are sensors for measuring the weight and temperature located at the bottom of the holder. For measuring the weight of the bottle with powder milk, we use an amplifier (HX711) and load cell, which creates an electrical signal from measured force. Contactless temperature sensor using infrared light (MLX90614) is installed in the client. The main advantages of contactless approach are 1) measurement time is short, and 2) the sensor has a long life because it is not contaminated from the object.

We also adopt Arduino UNO board for receiving data from the sensor and transmitting the data to the server. Arduino UNO is a microcontroller board based on the ATmega328. And it has a small size and easy-to-use hardware and programming language based on Java so that it is efficient in satisfying users' changeable requirements. Internet connection will be supported by Wi-Fi shield (ESP-8266).

B. *Representation client*

Representation client performs visualization function that gives an effective way to communicate with processed data from the server through visual imagery in forms of mobile application. As shown in Figure 3, users can check feeding amount, time, and patterns of feeding behavior. Also, users can enter the weight and height of their baby for more detailed analysis and can set the timer for periodic alarm.

Figure 3. The prototype of representation client

C. *Server*

The server connects with sensor client and representation client by storing and transmitting feeding data. Basically, time (feeding start event and feeding finish event) and quantity of milk (at feeding start and at feeding finish) will be stored on the server. After collecting dataset from users, the server will be able to infer meaningful information about infants, such as feeding pattern, desired feeding time, the

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age-appropriate amount of formula milk, etc., by machine learning techniques.

V. CONCLUSION AND FUTURE WORKS

In this study, feeding support system for infants is proposed with IoT concept. Through the observation and the interview, we found two pain points; measurement of proper temperature and record of the amount of feeding milk. Considering them, the prototype is designed using IoT.

Further studies need to be carried out in order to evaluate its usability and user experience by a user study. More than 20 users including parents having a baby, as well as staffs in a postnatal care center will be recruited for testing our product and service. Participants will be asked to use our product to feeding with formula milk in terms of longitudinal study at least 2 weeks. Also, diary study would be adopted to capture user experience (UX) in daily context.

Further research should be undertaken to analyze the data collected from the server. Recently, novel services combining IT and healthcare, such as MI band by Xiaomi have been released. Mi band can detect and track how many steps users have walked and how much users have slept. It means Xiaomi now collects walk and sleep data of millions of users, and the data is key to create added value. In the same vein, collected dataset from our proposed service is also very important in perspective of business and research. In the academia, deriving meaningful insights from the healthcare-related data has been studied [7]-[9]. Marlin et al. [7] developed a probabilistic clustering model for finding patterns from physiologic time series data contained in e-health care records. Keogh et al. [8] detected abnormal signal from the time-series data in medical datasets. We could apply these approaches to develop an algorithm detecting meaning events from the feeding dataset.

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