Intelligent Product Design for Baby Weighing Scale

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Abstract—The weight of infant is quite important for doctors, which is obtained initially to assess infant growth and to determine if the infant is well-nourished. For the parents, they are eager to know how heavy their babies are.

In this paper, we propose an intelligent design of baby weighing scale for the hospitals. A complete design process is followed by a series of procedures, which start from research on user focus and design context, then market analysis, idea generation, concept refinement, iterative prototype building and user tests, resulting in the final working prototype and conclusions.

To demonstrate the concept, a working prototype is built using pressure sensor and Arduino Uno. The scale has two separate parts. One is the main body with pressure sensor, which is covered with a changeable water-proof cotton. The other part is a remote display, which can be fixed anywhere ergonomic for end users (nurses or parents) to read the data of weight. The innovative point lies on the function that print out the date and weight automatically after weighing. Then parents and nurses can keep the "receipt" as record of infant's development.

From user tests of the prototype both in the hospital and during exhibition of the project, we receive positive feedbacks, which proves this design of baby weighing scale can improve the efficiency of nurses and strengthen the bonding between parents and babies.

Keywords—*infant weighing scale, prin*ting technology, *parental involvement*, industrial development

I. INTRODUCTION

Weight measurement is obtained as a part of the initial assessment on newborn infants and at each assessment throughout childhood [1]. The measurement is obtained for several purposes. It is obtained initially to assess fetal growth and to determine if the infant was well-nourished or experienced over- or undernourishment. After this baseline measurement is obtained, infants and children are measured during routine well and sick visits to monitor growth. Valid and reliable measurement is especially important for infants and children who experiencing problems that affects physical growth.

The Eindhoven University of Technology (TU/e) in the Netherlands has started a project on baby weighing scale in cooperation with the Máxima Medical Centre (MMC) in Veldhoven, the Netherlands. The goal of this project is to provide a better design of baby weighing scale, which can improve the working efficiency of nurses and strengthen the bonding between parents and infants.

We do research focused on users (nurses, parents, babies) and the environment.

• Nurses: The hospital nurses, as the frequent user of infant weighing scale, have high risk of suffering health problems like low back pain. Several studies have indicated an unusually high prevalence of back disorders in nurses, and this is widely attributed to the manual handling that the job entails. Nurses are frequently required to undertake heavy lifting, often with a bent or twisted posture [2]. Take the current baby weighing scale in MMC for example, it has the buttons and display on the side. It is inconvenient for the nurses to operate, cause they have to bend to press button or read the data. Iterative such posture will cause high risk of suffering back disorder. The new design should be ergonomic for using to decrease this kind of health risk for users.

• Parents: Parental involvement in their child's care becomes important. Over time, the family has the greatest influence on an infant's health and well-being [3]. NICU nurses have been at the forefront of research and innovative practice in supporting parental role development in the NICU setting. A family-centered approach to care giving has been adopted by most NICUs in which promotion of the parent-infant relationship and family involvement in the infant's care are of central importance [4]. It is helpful to involve parental role in NICU, including the design for baby weighing scale.

• Infants: Because of the physiological factors of infants, especially the preterm infants (i.e. neonates), there is special point we have to consider before generate an idea for baby weighing scale. It is about the material used for the scale, which should be easy to clean and comfortable for the infants. The barrier function of the premature infant's skin is very limited, and permeability seems to correlate inversely with gestational age. The skin of the premature infant is at risk of physical and mechanical injury because of the incompletely developed stratum corneum and the decreased number of fibrils that connect the epidermis to the dermis [5]. The material contacted directly by the infant should be soft, comfortable and easy for cleaning to avoid infection.

• Environment: Another aspect designers should note is the environment temperature when nurses are weighing neonates. There is a narrow range of ambient temperature within which the metabolic rate and oxygen demand of neonates are minimal [6].Without outside help the preterm baby behaves like a classic poikilotherm, its temperature reflecting that of its surroundings [7]. The provision of a neutral thermal environment with incubators and overhead heaters is an important feature of neonatal intensive care [8].

Every morning from eight o'clock to nine o'clock, Nurses in MMC wash the neonates and then weigh them one by one. These routine nursing procedures are carried at least once daily, took about 20 minutes to complete but could vary from 15 to 45 minutes, depending on the nurse and the tasks required. There is significant meaning for the nurses to improve the efficiency of this routine nursing procedure, because an important alteration in the environmental temperature with consequent thermal stress to the infants that may make infants get annoyed or cry, although there is a overhead heater above the scale in MMC.

In this paper, we report a design exploration on infant weighing scale. It is based on the hospital scenario in MMC. The purpose of the project is to design a new baby weighing scale, which improves the efficiency of nurses and strengthens the bonding between parents and babies.

A working prototype embedded with intelligence is built using force sensor [9], mini printer module and Arduino Uno [10] (microcontroller) to demonstrate the design. Software is developed for ensure the correct data transmission, print and display. User tests were carried out both in the hospital and during exhibition. A large number of users including nurses and parents tested the prototype, and provide positive feedbacks and suggestions for improvement. Further developments will be carried on various aspects, for example, extending design of the "receipt" (the paper containing the date and weight of infant). In the paper, design process, design concept, prototype, and user testing will be described.

II. DESIGN PROCESS & CONCEPT

A. Design Process

Figure.1 shows the design process, which starts from research on user focus and project environment at the NICU of MMC, then current market analysis, idea generation, concept refinement, followed by iterative prototype building and user test, resulting in the final working prototype and conclusions.

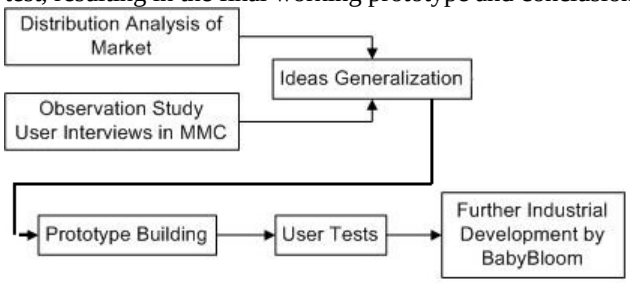

Fig. 1. Design Process

Initially, research is focused on nurses' problem, importance of parental involvement at the NICU, the physiological factors of infants and the suitable environment needed for weighing. Practical experience is also gained through questionnaires and interviews toward the end users(nurses and parents). Due to considerations that arise from the results of the research, we are able to draw a set of requirements:

- Be ergonomic for users operating to decrease risk of suffering back disorder
- The material contacted directly by the infant be soft, comfortable and easy for cleaning to avoid infection
- Shorten the time spend on weighing task to decrease alteration in the environmental temperature with consequent thermal stress to the infants that may make infants get annoyed or cry
- Involve parental role in NICU

These requirements above become the guidelines through the whole design process. The final proposal of concept is also followed by these requirements.

Then we search similar products in the current market, find the key buying factors and get inspirations from the different product features.

B. Concept

With previous research and market analysis, the design concept comes out as "keep daily record of every development of baby", especially designed for the parents to keep the record of their child's weight. The weight can be kept for clinical using as well as family memory. Final proposal for the baby scale includes these specific features:

- Printable data: This innovative function helps the parents involve more in NICU. The scale will print out the specific date and weight of infant automatically after weighing. Nurses and parents can keep the "receipt" as record of baby's development. It is useful not only for clinical observation, but also for the family's precious memory.
- Remote display: According to the research mentioned before, nurses have high risk of suffering back disorder, and this is widely attributed to the manual handling that the job entails. In order to make the position of display and buttons ergonomic for users (nurses or parents), we extract the display out of the main body of scale. Now the display is an independent part, which can be fixed anywhere on the wall. User can choose a suitable position and height to fix the display, so that they can avoid bend themselves to operate and read the weight.
- Changeable cover and mattress: Because of the high standard of cleanliness in hospitals, the cover of the scale should be changed frequently. We design a flexible cover and mattress for baby weighing scale. They can be removed or put on easily. Water-proof cotton: As mentioned in the previous research, the skin of the premature infant is at risk of physical and mechanical injury. The material contacted directly by infants should be soft, comfortable and easy for cleaning to avoid infection.

We try to keep balance of the needs both from infants and nurses. Here we use a special material, water-proof cotton.

- the printable function. It means there is a mini printer module behind the display, printing out the date and weight automatically after weighing. Then parents and nurses can keep the "receipt" as record of infant's development.

The baby weighing scale has two separate parts. One part is the main body of the scale, which the pressure sensor. The main body is covered with a changeable water-proof cotton, for practical use in the hospital. The other part of the scale is a remote display. It can be fixed anywhere ergonomic for end users (nurses or parents) to read the data of weight.

III. PROTOTYPE

The final prototype is a complete product design. The baby weighing scale has a heart-shaped display, representing the parental love. The heart can be fixed on the wall, with a four-digit display and a slot, from which the printable data comes. The main body of weighing scale is covered with a water-proof cotton, with suitable pin color for the hospital environment.

In Figure.2 The flow of information from one end of the system (the pressure sensor) to the other is visualized. Through multiple steps, the analog data output of pressure sensor is converted to digital data. The digital data, added with date, becomes the weight information. Finally the information is showed on display and mini printer module, seen by users.

Fig2. Information flow

A. Hardware

The major components needed for the hardware building are Arduino Uno, mini printer module, pressure sensor and digit display.

The mini printer module is a highly integrated printing module, communicated with computer through RS-232 serial port (TXD/RXD). The pressure sensor can measure absolute gas pressure from 20 to 250 kpa with maximum error of ±1.5% [9]. The pressure Port outside Diameter Min/Max is 2.8mm / 3.3mm, which is small and flexible to be fixed under the main body of scale. The pressure sensor needs two pins of Arduino board to support: (1) Ground pin (2) analog input pin to receive the data from pressure sensor. We use two red dual 7-segment LED to make a four-digit display [11].

B. Software

The software is an integral part of this concept. It enables the different hardware components to cooperate in the way best suitable to the demands of the working prototype of infant weighing scale. Our aim was to achieve a prototype program that would be able to properly transfer data from the pressure sensor and send it to display and printer module after processing.

In terms of programming implementation, we use Arduino program to demonstrate the concept. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments [12]. Translated to software, these requirements include:

- Code length must be minimized where possible.
- Errors should be kept at minimum.
- Coding should be dynamic and easy to adapt for future

Development.

Initially, we write separate programs to realize the basic function of different components. When all the programs work well, we then combine the codes to create a single program. There are mainly two parts in the final program, one is for realizing the function of display, the other is for sending correct data to mini printer module.

With regard to the display, We use two red dual 7-segment LED with four 74HC595 shift registers to avoid running out of pins on our Arduino board [13]. We set three digital pins as datapin, clockpin and latchpin respectively. The code is based on two pieces of information in the datasheet: the timing diagram and the logic table. The logic table is what tells you that basically everything important happens on an upbeat. When the clockPin goes from low to high, the shift register reads the state of the data pin. As the data gets shifted in it is saved in an internal memory register. When the latchPin goes from low to high the sent data gets moved from the shift registers aforementioned memory register into the output pins, lighting the LEDs.

With respect to the mini printer module, we take Software Serial Library [14] for reference. We use two digital pins as TXD and RXD. The Software Serial library has been developed to allow serial communication on other digital pins of the Arduino, using software to replicate the functionality [14]. Take the function Software Serial (rxPin, txPin) for example. A call to Software Serial (rxPin, txPin) create a new Software Serial object, with rxPin to receive serial data and txPin to transmit serial data.

The end result is not yet a code suitable for commercial products, but rather proof that the prototype we have built is able to meet the requirements we pose to it.

C. Model

When making the model, We focus more on the material and shape of infant weighing scale. It has a heart-shaped display, representing the parental love. The heart can be fixed on the wall, with a four-digit display and a slot, from which the printable data comes. The main body of weighing scale is covered with a water-proof cotton, with a suitable pink color

for the hospital environment. We try to find a water-proof material suitable for the changeable cover. One face of this material is made of rubber, and the other face is made of cotton. It is water-proof. So we keep balance of different needs from infants and nurses.

D. User Test

We user test both in MMC and in the exhibition held by The Eindhoven University of Technology(TU/e), where a large number visitors can test the working prototype of baby weighing scale. The user test is divided into three parts. The first one is for nurses, the second one is for parents and the third one is open to the exhibition.

The purpose is to test whether this design has improved the working efficiency of nurses, strengthened the bonding between parents and babies and kept a memorial record of development of babies. After each user test, we will make a short conversation with users, then we can get some feedbacks, which finally prove that the prototype coincides our original concept.

IV. DISCUSSION

Some meaningful research on anthropometric measurements is investigated, which gives us the inspiration to combine body length measurement with infant weighing scale. On the next step of design, we can add function of length measurement. They are both important for assessing neonatal growth and determining if the infant is well-nourished or experienced over- or undernourishment.

With regard to the feedbacks received from the test users, it is interesting to see the users have developed their own ways to keep the “receipt”, although most of them do not have the experience to take care of baby. They appreciate the printable data, and want to find a good solution to keep it longer. users suggested make the wall be like a memory board, with many pictures and “receipts” on it. Someone also have an idea to make a book with date, and then stick the weight on it daily. Maybe we can focus more on extension design on the printable function.

V. CONCLUSION

In this paper, we report a design exploration on infant weighing scale. It is based on the hospital scenario in MMC, the Netherlands. The purpose of the project is to design a new baby weighing scale which improves the efficiency of nurses and strengthens the bonding between parents and babies.

A working prototype is built using force sensor[9], mini printer module and Arduino Uno (microcontroller) [10] to demonstrate the design. Software is developed for ensure the correct data transmission, print and display. User tests were carried out both in the hospital and during exhibition of the project. A large number of users including nurses and parents tested the prototype, and provided positive feedbacks and suggestions for improvement. Further developments will be carried on various aspects, for example, extending usage of the “receipt” (the paper containing the date and weight of infant).

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