Design and Implementation of Infant Risk Detection System using Embedded System

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Abstract: - 'The Statistical Research on Cause of Death' by the National Statistics Office indicated that Sudden Infant Death Syndrome accounted for third-largest share of the number of infant deaths. The number is assumed to be higher if combined with the number of death among children. While the cause of sudden infant death is not identified, it is widely believed that prone sleeping increases the risks of infant death. Therefore, it is important to make sure pressure is not imposed on a part of a baby's body to prevent sudden infant death syndrome. In this regard, we used an embedded system to check the safety for baby. We designed and implemented 'Infant Risk Detection System' to help with child-rearing. The system identifies risks to prevent accidents in advance, and is equipped with various functions to help parents ensure safety while taking care of baby. We expected the system would help parents with child-rearing as low birth rate is becoming a serious problem around the world.

Key-Words: - Web Application, Mobile Application, HTML5, IoT, Embedded System, Arduino

1 Introduction

'The 2011 birth/death Statistics' of the Statistics Office showed that South Korea's fertility rate has been below 1.3 since it recorded 1.297 in 2001 [1]. Low birth rate poses a threat not just to maintaining social structure, but to securing national competitiveness [2]. Studies have been conducted in various fields such as Sociology, social Welfare Studies and Women's Studies to find the cause of low birth rate [3]. The trend of low fertility is more prominent Southern European countries, where the child-rearing duties are passed on families, not nation, as well as Asian countries with a strong patriarchal culture [4]. In addition, as more women enter the workforce, it becomes increasingly difficult for them to balance work and family [5]. Therefore, not just the government but society should come together to address the issue of low fertility.

'The Statistical Research on Cause of Death' by the National Statistics Office indicated that Sudden Infant Death Syndrome accounted for third-largest share of the number of infant deaths, followed by 'difficulty in breathing' and 'congenital abnormality' [6]. The number is assumed to be higher if combined with the number of death among children. Figure 1 shows the number of sudden infant death by year.

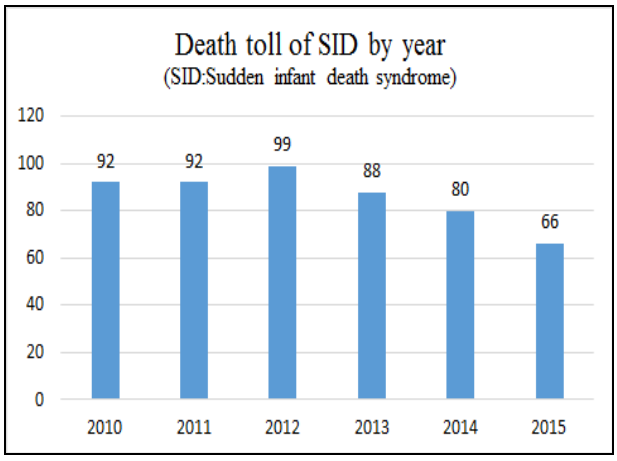


Fig. 1 Number of Sudden Infant Death by Year

While the cause of sudden infant death is not clearly identified, many experts who have analyzed sudden infant death believe that prone sleeping increase the risks for infant death [7]. Therefore, it is important to check in real-time to make sure pressure is not imposed on a part of a baby's body to prevent sudden infant death syndrome.

In this regard, we used an embedded system to design and implement 'Infant Risk Detection System' to check safety for infants and to help with child-rearing. The system identifies factors such as heart rate and physical pressure imposed on infants,

which are related to sudden infant death syndrome, to prevent accidents in advance. The system also checks baby's room temperature and humidity to help maintain pleasant child-rearing environment. The system is designed to play the voice of a care-giver or lullabies. We believe the 'Infant Risk Detection System' designed and implemented in this study would help parents by shortening child-rearing time and providing functions making sure safety for baby and assisting child-rearing. We expected the system would help busy parents with child-rearing as low birth rate is becoming a serious problem around the world.

2 Related Research

2.1 Embedded System

The advancement of information and communications industry has expanded the usage of existing home appliances and electronic goods. Besides performing their own functions, they are evolving to become information appliances and imbedded system [8]. Imbedded system refers to a computer system designed only for a specific task [9]. Imbedded system requires various functions such as mobility, wireless communications, electrical power consumption, user interface and security. Its operating system is designed to efficiently utilize limited resources and generate high performance in a complex environment. [8] Examples include home appliances such as DVD player, MP3 player, camcorder and digital camera and airplane, elevator, medical devices, and communications devices.

We used Arduino mega2560 to implement the 'Infant Risk Detection System' in the study. Table 1 shows characteristics and performance of Arduino mega2560 used in this study.

Table 1. Basic Feature and Performance of Aduino Mega 2560

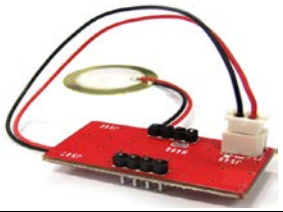
Item	Specification
Microcontroller	ATmega2560
Operating Voltage	5 V
Input Voltage	7 - 12 V
Digital I/O Pins	14
Analog Input Pins	16
Flash Memory	256 KB
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

2.2 Sensor

The development of IT technologies has led to state of the art devices equipped with various sensors and small-sized displays used in various fields [10]. Sensor is a device which detects external information such as physical, biological and chemical information to convert the information to electronic signals that computer or control device can understand [11]. Various kinds of sensors are developed and used to measure different types of physical properties.

Sensors include temperature sensor responding to changes in baby's room temperature; and humidity sensor measuring the amount of vapor in the air. Piezo sensor, which is also called pressure sensor, converts pressure to electronic signal or vice versa [12]. Table 2 shows various sensors used in this study.

Table 2. Used Sensors

	
Pressure Sensor	Buzzer Sensor
	
Sound Sensor	Temperature Sensor
	
Humidity Sensor	Heartbeat Sensor

2.3 Survey Investigation

Figure 2 to Figure 4 show the results of a survey on the effectiveness of the child safety system where an embedded system was used. The survey was conducted through a survey site from April 11, 2016 to April 18, 2016. A total of 110 people responded.

For a question, 'Do you consider baby's room temperature and humidity?' 84 respondents (76%) answered 'of course,' 16 (15%) 'a little bit,' and 10

(9%) 'not at all.' For a question 'How do you handle a crying baby?' 68 respondents (62%) said 'sing a lullaby,' 37 (33%) 'hug a baby,' and 5 (5%) 'check the diaper.' For a question 'Do you worry if your baby cannot breathe while flipping over?' 90 respondents (82%) said 'Yes' and 20 (18%) said 'No.'

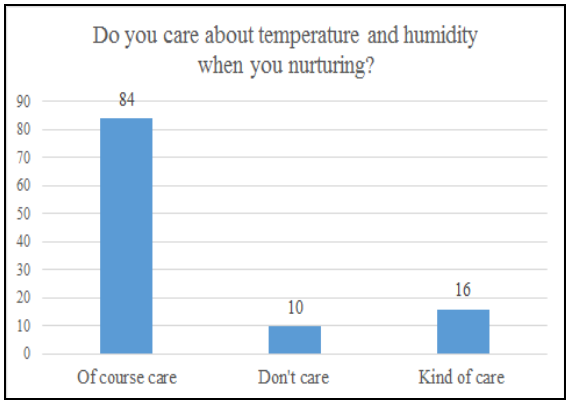


Fig. 2 Survey 1

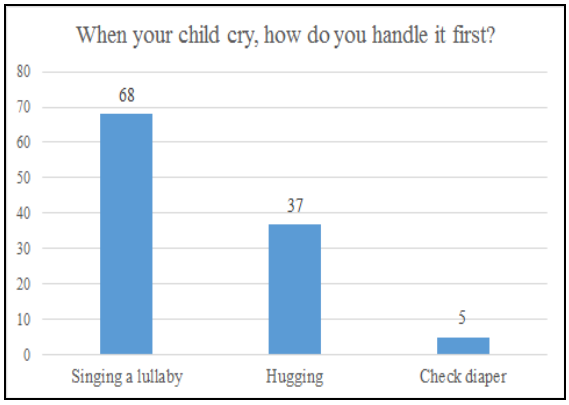


Fig. 3 Survey 2

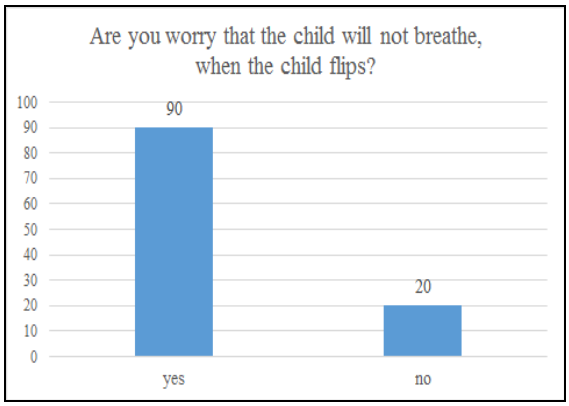


Fig. 4 Survey 3

The survey showed that parents consider baby's room temperature and humidity; and try to be prepared for any danger that may occur during child rearing. This shows that the implementation of applications, including the 'Infant Risk Detection System' designed and implemented in this study, equipped with child-rearing and safety functions (i.e. helping to maintain optimal room temperature and humidity as well as playing a lullaby when a baby is crying) has validity to be implemented. Indeed, 101 (92%) respondents of the survey said they were 'willing to use child-rearing application.'

2.4 Benchmarking

The widespread use of smartphones has led to the development of applications used in various fields. An increasing number of smartphone applications are developed for user convenience, so is the number of web services and applications relevant to child-rearing [13].

There are many applications and sites where parents keep a baby journal; and share practical information on child rearing and infant education.

To develop the 'Infant Safety System' described in this paper, we benchmarked existing applications: 'Infant Calculator' and 'Everything of Infant.' The 'Infant Calculator' provides basic information on child-rearing, baby photos, and reminders on important anniversaries. But it did not provide enough functions for child rearing. The 'Everything of Infant' provides reminder to parents on child's vaccination date as well as functions to keep baby journal and hospital visit records. However, it provided few safety-related functions. We found there were few applications for infant safety. In this regard, we designed and implemented a system which manages safety and child-rearing, together with functions provided by existing applications.

3 Design and Implementation

3.1 Design

The 'Infant Safety System' designed and implemented in this study uses various sensors to check the temperature and pulse of infants and to let users abnormal symptoms if any. It also checks baby's room temperature and humidity in real-time. In addition, it plays lullabies or a recorded voice when a bay is crying, and calls 911 if a baby is in danger. The 'Infant Safety System' implemented in this paper is named 'MAMAPAPA.'

Figure 5 shows the perspective view of 'MAMAPAPA' system. Users can use server information input through sensors by using the 'MAMAPAPA' system.

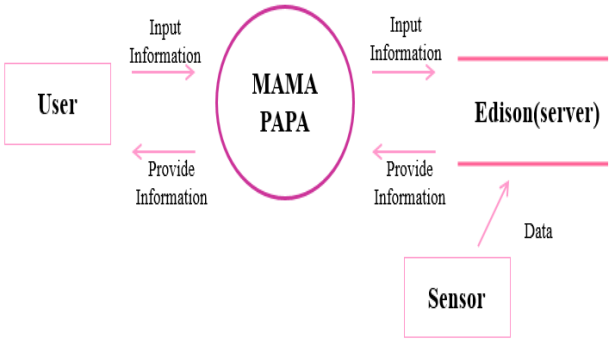


Fig. 5 DFD of 'MAMAPAPA'

Figure 6 shows the DFD regarding 'the input and output of baby information.' 'Name' and 'Month' are input. 'Body Temperature,' 'Pulse,' 'Humidity,' 'Temperature,' 'Sound,' and 'Pressure' are input in real-time through Arduino sensor.

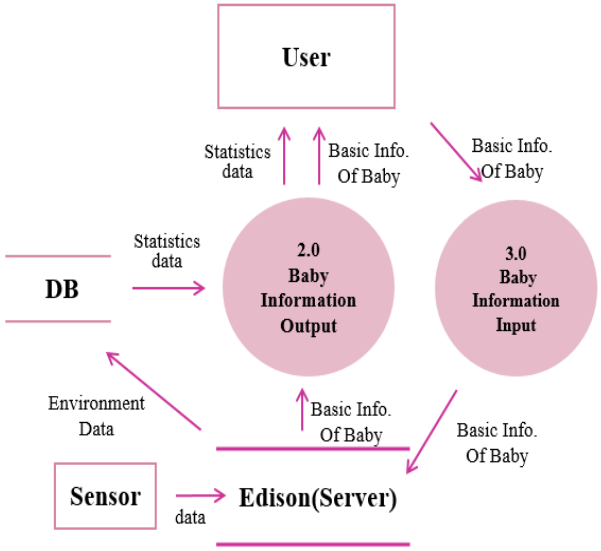


Fig. 6 DFD of Baby Information Input & Output

Figure 7 shows the DFD for 'Risk Detection.' Risk detection signal is set with Boolean value or '0' or '1.' An alarm is sounded when a risk is detected.

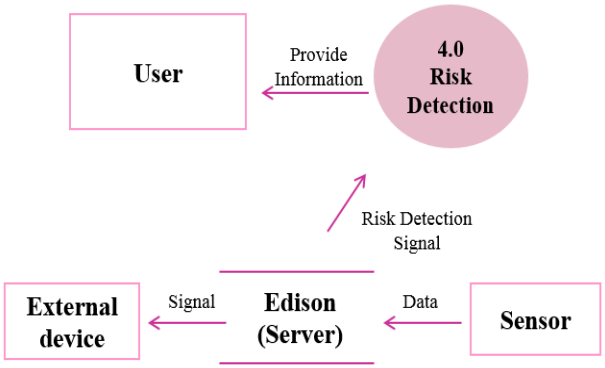


Fig. 7 DFD of 'Risk Detection'

Figure 8 shows the UI of 'Baby Information' page of MAMAPAPA. The average body temperature and pulse of a baby is displayed every day.

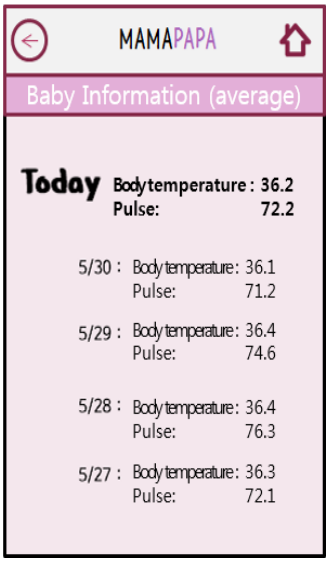


Fig. 8 Baby Information UI

Figure 9 shows pin-map for the MAMAPAPA system. It uses Piezo sensors to measure pressure imposed on infants. If a pressure goes beyond a risk level, Buzzer sensor is activated to inform the situation to parents or a care-giver. In addition, Temperature sensors are used to check the body temperature of a baby. Baby's body temperature is shown as Blue, Green or Red through RGB Led sensors. Baby's room temperature and humidity can also be checked.

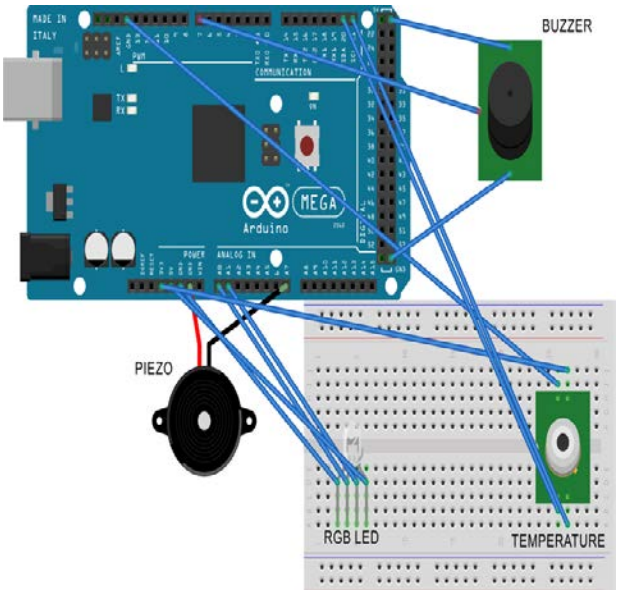


Fig. 9 Pin-map of 'MAMAPAPA'

3.2 Implementation

To implement the 'Infant Risk Detection System' described in this paper, the Breadboard of Arduino 2560 was used. The system was completed by connecting Piezo sensors, temperature sensing sensors, LED, buzzer and heartbeat sensors to Arduino and Breadboard. Figure 10 shows prototype of the 'Infant Risk Detection System' implemented in the study.

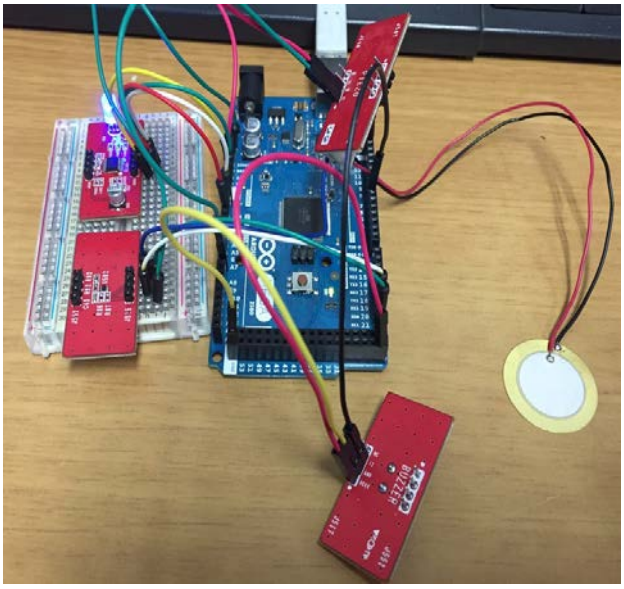


Fig. 10 Prototype of 'Infant Risk Detection System'

Piezo sensors were used to measure pressure imposed on babies to prevent excessive pressure from being imposed on a baby. Temperature measuring sensors were used to measure baby's body temperature and room temperature, and LED sensors were used to distinguish temperature conditions. Buzzer was connected to inform any danger to parents or a care-giver. Heartbeat sensors were used to measure baby's body heartbeat in real-time.

Circular-shaped sensor in figure 10 is piezo sensor. Buzzer is sounded when input value is larger than 0. Among sensors connected to breadboard, the upper one is LED sensor, showing baby's body temperature or room temperature. Prototype was coded to display room temperature. Green LED means room temperature is between 18 and 20 degrees; Blue, below 18; and Red, above 20. Simply by checking the LED color, parents or a care-giver can maintain appropriate room temperature.

Figure 11 shows a captured image of demonstration where the number of heartbeat is checked by heartbeat sensors of prototype. Figure 12 shows a screen where the number of heartbeat measured by LED colors depending on temperature.

Fig. 7 Checking Heartbeat with Heartbeat Sensor

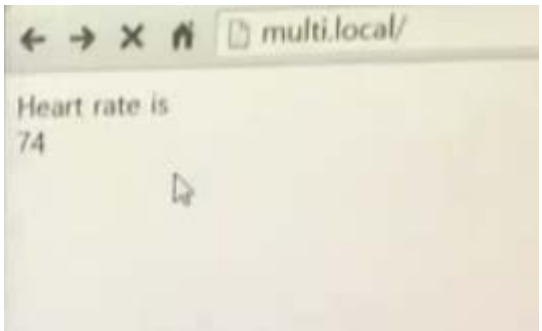


Fig. 12 Checked Heartbeat using Heartbeat Sensor

Figure 13 shows real-time measurement of temperature and changes of LED colors depending on temperature. The LED is green because the temperature is between 18 and 20.

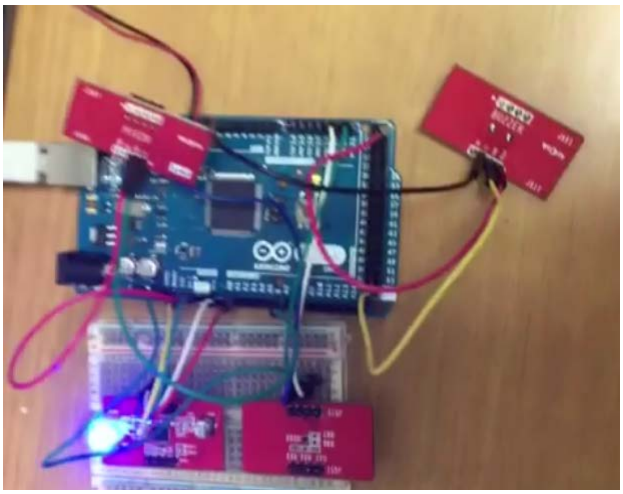


Fig. 13 Show Temperature on LED by Sensor

Figure 14 is a captured image of demonstration where pressure imposed on infant is measured by Piezo sensors. Instead of putting pressure on a baby, pressure was imposed on Piezo sensors by a hand. When pressure is imposed, an alarm is sounded through buzzer sensors.

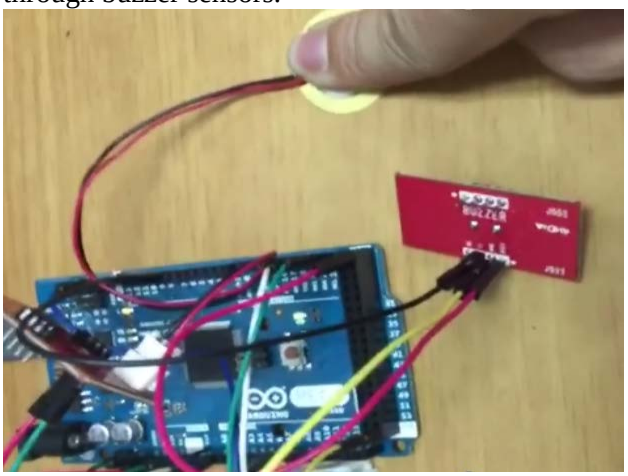


Fig. 14 Trial Performance of Piezo Sensor

Figure 15 shows part of codes that implemented a system described in this paper. Codes in figure 15 sense temperature and pressure; and take appropriate measures.

```
void loop(){
   int p = piezo.read();
   Wire.beginTransmission(TEMP_ADDR);
   Wire.write(byte(TEMP_REG));
   Wire.endTransmission();
   Wire.requestFrom(TEMP_ADDR,2);
   byte hData = Wire.read();
   byte lData = Wire.read();
   int tempVal = hData;
   tempVal = (tempVal << 8)|lData;
   tempVal = tempVal>>4;
   float tempflt = float(tempVal)*.0625;

   if(p>0){
       buzzer.On();
       delay(1000);
   }
   else{
       buzzer.Off();
       delay(2000);
   }

   if(tempflt>=18&&tempflt<=20){
       rgbLed.OnRgb(0,255,0);
   }else if(tempflt>20){
       rgbLed.OnRgb(255,0,0);
   } else{
       rgbLed.OnRgb(0,0,255);
   }
   delay(1000);
}
```

Fig. 15 Implementation Code

4 Conclusion

The development of IT technologies has led to the development of various sensors. The usages of existing home appliances and electronic goods have expanded to be used in various fields. In this regard, we designed and implemented MAMAPAPA, 'Infant Risk Detection System,' with embedded system.

MAMAPAPA system was implemented by utilizing the Breadboard of Arduino 2560 and various sensors. It checks baby's body condition and risks factors in real-time to prevent accidents; and checks baby's room temperature and humidity to maintain a pleasant environment. The system is designed to play the voice of a care-giver or lullabies when a baby cries to ensure safety and increase convenience for child-rearing.

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