Baby care safety device using an integrated system of Arduino microcontroller and sonar sensor

A N M Sajedul Alam, FarhanAneesSakib, Md. RayhanHasanMahin, Sheikh Md.SalehJahurSiddiki, Md. Jahidul Hasan, Mazedul Islam, Sourav Saha Roy

Department of Computer Science and Engineering, BRAC University, Mohakhali 1212, Dhaka, Bangladesh.

{sajidcsebu, fasakib.140297, jhsny786, salehjahursiddiki, muhammodrayhan, Shaon.BRAC.eee,souravsaharoy007}@gmail.com

Abstract: Nowadays it is an alarming problem for a housewife to maintain her baby's safety at home all by herself. Baby care device is one of the most advantageous devices for maintaining a baby's safety. Hence, it becomes easier for a mother to know about her baby's well-being. This device is of great use for a mother to know about the location of her infant. However, we used sonar sensor, Arduino Uno R3, Sonar sensor, LEDs of three different colors, two different types of jumpers, buzzer to make this hardware device. Finally, we have used an open source Arduino IDE to burn our code instructions to Arduino microcontroller.

Keywords: Sonar Sensor, ArduinoUno, Buzzer, Obstacle detection, LED, Baby, Safety, Mother.

1 Introduction

There is an increasing need to have easily deployable and autonomous technical devices to support the safety and well-being of children at home, as well as in nurseries, daycare centers and primary schools. Additionally, and not negligibly, these new devices should also ease the burden of the mothers and respective teachers in their daily routines. Therefore, carefully designed solutions could provide more resources and time for the actual duties of mothers and teachers, instead of spending time on safety issues. There are already a great variety of sensors and devices deployed in schools, roads and at homes, and more are expected in the near future. However, utilizing these multiple sensors and the information that they provide is not straightforward, as often the data is not easily accessible or available. Also, difficulties arise, when managing the multi-sensor data in order to make intelligent reasoning, and to be able to draw conclusions about the children's safety and well-being. Our framework scenario here is to illustrate the different levels from collecting and providing the sensor data to be utilized by the end users' safety applications and services to make sure of a baby's safety. In our work a wearable safety vest, which is part of the presented scenario, would automatically provide information about the presence or absence of children from their restricted outdoor or indoor area. In addition, the vest would gather other sensor information about the overall well-being, behavior and activity of the children, through accelerometer sensors.

2 Background Study

The idea for a Baby Care Safety Device came from a very similar device known as the Arduino Distance Detector. The Arduino Distance Detector also uses an Arduino Uno, a breadboard, an HC-SRO4 Ultrasonic Sensor, a buzzer, two green LEDs, two yellows LEDs, two red LEDs, seven 330-ohm resistors, and a lot of jumper wires. [4]
In the older device, the ultrasonic sensors are great tools to measure distance without actual contact and used at several places like water level measurement, distance measurement etc. This is an efficient way to measure small distances precisely. In this project, we have used an Ultrasonic Sensor to determine the distance of an obstacle from the sensor. Basic principle of ultrasonic distance measurement is based on ECHO. When sound waves are transmitted in environment then waves are return back to origin as ECHO after striking on the obstacle. So, we only need to calculate the travelling time of both sounds means outgoing time and returning time to origin after striking on the obstacle. As speed of the sound is known to us, after some calculation we can calculate the distance. [5]

3 Related Work

In recent years, there has been a growing interest in research and development into different wearable and monitoring systems for children. However, most of the developed solutions aim to answer certain dedicated health, activity and security issues, but a large scale system, suitable for common use for children, teachers, parents and school nurses is missing. A description of the trends and potential challenges in developing monitoring systems for ubiquitous care for children is presented. Their system, UbicKids, focuses on three main aspects, such as children's awareness (e.g. location or any physical information related to the child), assistance (guiding the child on the road, etc.) and advice (umbrella reminder, etc.). [7] The focus is on the design of a wearable device for kids under six years old. The system gathers biological and physical information such as heart rate, body movements, and it also includes GPS and a camera. KiMS is a monitoring system for the early detection of symptoms for various diseases, as well as encouraging children towards healthy habits and activities. [8] Wearable acoustics sensors are used to detect audio signals, such as coughs, sneezes, and crying. In addition, body temperature and pulse rate sensors are combined into the system. In8 the use of spectral analysis techniques for multiple sensor data for a child's activity recognition is proposed. An accelerometer, air pressure sensor and gyroscope are utilized to detect walking, lying down, running, climbing stairs, falling and standing up. A similar wearable device with a camera, accelerometer, GPS and a heart rate monitor is developed to detect activity modes. The third popular area in child monitoring, besides the health and activity issues, is safety. The design also monitors potential emergency situations by searching for a child with a different activity mode from that at other nurseries. A similar design of a system for detecting dangerous situations in children's school routes is described. The architectural implementation of the system is described. The work describes a device to detect isolated children on field trips based on RSSI values. The focus is on a protocol development of a location-based child safety care service with privacy issues, and an extended description of this system can be found in14. There are also applications and devices to monitor children's safety and well-being that are already available on the market. Some of the latest solutions include: RFID tags for school

uniforms 15, GPS wristwatches, sensors measuring human emotions (q-Sensor) 16, communication and location devices and school bus and child safety tracking systems.

4 Proposed Model

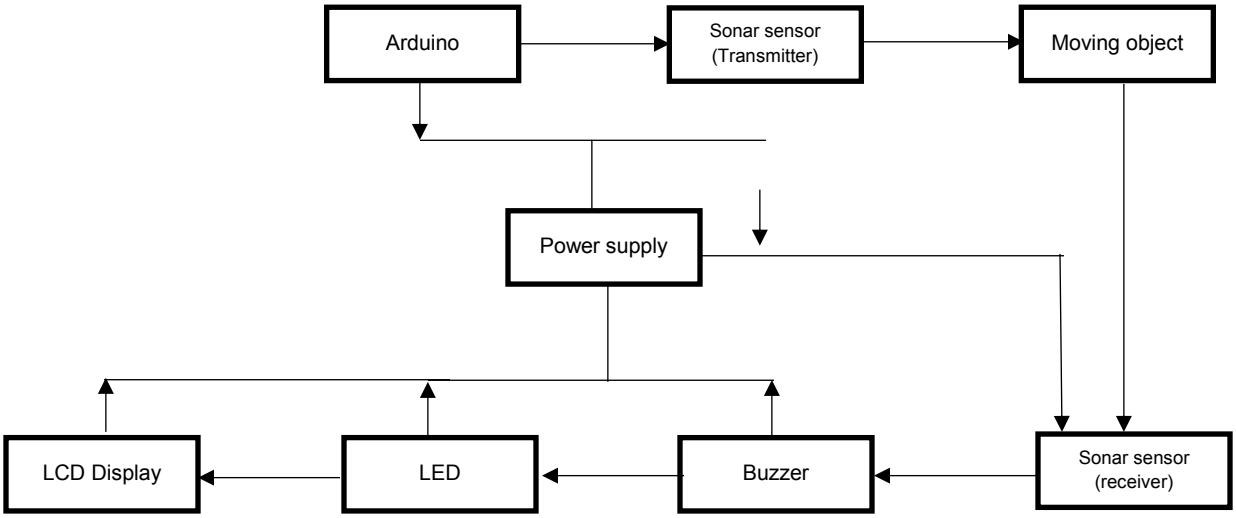


Figure 1: block diagram of Baby Safety Device

Figure 1 show a block diagram of our proposed model. Our proposed model of Baby Safety Device is consisting of an Arduino, sonar senor, a LCD display, three pairs of LEDs and a buzzer. The transmission will be done by the 2 modules, the signal processed in Arduino codes and the output will be shown in the LCD display, in LEDs and by buzzer. The device will have 2 modules at the front for catching the signal and the display, buzzer and LEDs will be at the top of the device to show the output while the Arduino will process the signal.

5 Hardware implementation of proposed model:

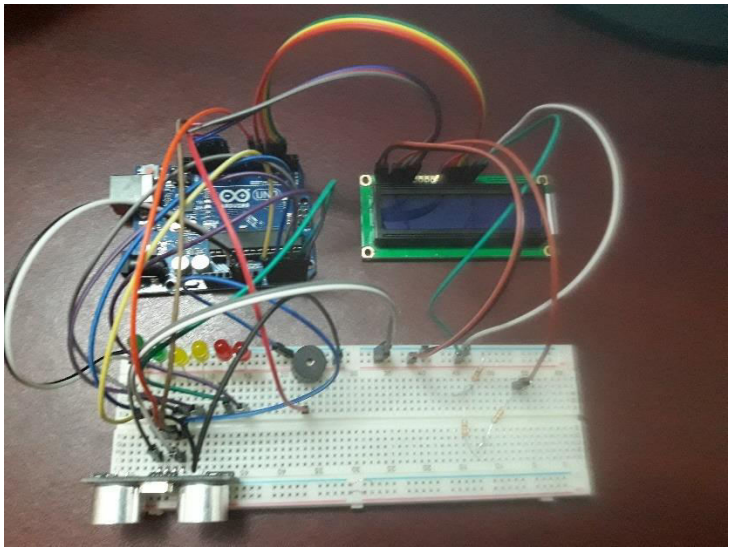


Figure 2: Hardware implementation of proposed model

We can see from Figure 2 that we have implemented our proposed model for Baby safety device physically. All components will be described next which were used for hardware implementation.

6 Components

1. Arduino Uno R3
2. Sonar sensor
3. Bread board
4. Power bank (Used as power source)
5. Male to Male jumpers
6. 6 LED Lights (1 pair of red, 1 pair of green, 1 pair of yellow)
7. Buzzer
8. 16x02 LCD Display

6.1 Sonar Sensor

Sonar sensors detect any kind of object or entity on its path by using a distance measurement procedure. This distance measurement has a vast usage in many modern devices. Sensors run this measurement by using ultrasonic transmitter and receiver units [2]. The ultrasonic sensors measure distance in a versatile way. Measuring distance by transmitting ultrasound makes such sensors function fast in many common applications [1].

Figure 3: Sonar Sensor HCSR04

6.2 Arduino Uno

Figure 4: Arduino Uno R3

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. [8]

Table 1: Specifications of Arduino Uno R3

1	Microcontroller	ATmega328
2	Operating Voltage	5V
3	Input Voltage(recommended)	7-12V
4	Input Voltage (limits)	6-20V
5	Digital I/O Pins	14 (of which 6 provide PWM output)
6	Analog Input Pins	6
7	DC Current per I/O Pin	40 mA
8	DC Current for 3.3V Pin	50 mA
9	Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
10	SRAM	2 KB (ATmega328)
11	EEPROM	1 KB (ATmega328)
12	Clock Speed	16 MHz

6.3 Buzzer

An electrical device, similar to a bell, that makes a buzzing noise and is used for signaling.

Figure 5: Arduino Uno R3

6.4 LEDS

A light-emitting diode (LED) is a two-lead semiconductor light source. A device that emits visible light when an electric current passes through it. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength.

Figure 6: LEDs

6.5 LCD 16x2 Display

This is a basic 5V 16 character by 2-line OLED display with green text on a blue background. OLEDs (Organic Light Emitting Diode) differ from LCDs in that they can produce their own light instead of requiring a backlight, this provides you with an advantage of lower power consumption and better viewing in the light. [6]

Figure 7: LCD 16 x02

7 Experimentation

7.1 Setup

Already we have mentioned that we used Arduino Uno R3, Sonar HC SR04 and LCD 16x02 display, LEDs, buzzer. The connection of these elements are given in a chart for better presentation in following tables,

Table 2: Arduino to Sonar HC SR 04

Sonar	Arduino
trigPin	D13
echoPin	D6
VCC	VCC
GND	GND

Table 3**:** Arduino to LCD display

LCD	Arduino
Vss	GND
Vdd	Power(Vcc)
Vo	GND
Vr	GND
Rs	D12
E	D10
D4	D5
D5	D4
D6	D3
D7	D2
A	Vcc

Table 4**:** Arduino to buzzer

Buzzer	Arduino
Buzzer	D11

Table 5**:** Arduino to LEDs

LEDs	Arduino
LED Green 1	A0
LED Green 2	A1
LED Yellow 1	A2
LED Yellow 2	A3
LED Red 1	A4
LED Red 2	A5

8 Working Principle

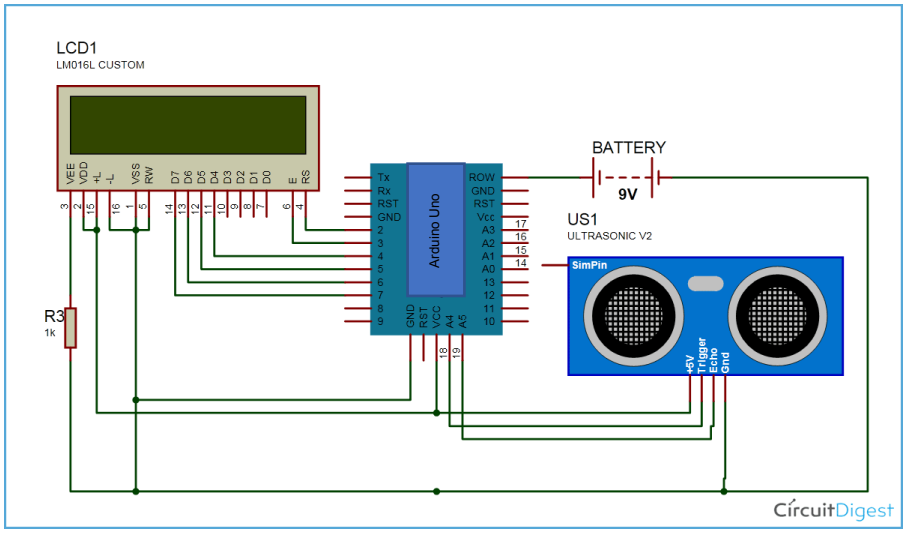


Figure 8: Working Principle

Figure 7 shows the working principle of our proposed model. The echo of a sound generated by a source could be used to measure the height of the water in a well. The same principal of echo is used by ultrasonic sensors. We know remember the range of sound people can perceive so we cannot hear above 20,000dB. Ultrasonic sounds work at much higher range meaning it is safe for us to work with. In same procedure, we will detect the distance covered by the baby from his safe zone.

8.1 Algorithm

1. Sonar sensor will check if there is some obstacle found front of it or not

2. It will detect if there is something in 50cm range.

3. If detects something mostly close, the green LEDs will turn on and the buzzer will sound low and the LCD screen will display the type of danger

4. If detects further distance than before then yellow LEDs will be turned on and the buzzer will sound a bit louder and the LCD screen will display the type of danger

5. If detects more distance than before then red LEDs will be turned on and the buzzer will create an even louder sound and more and the LCD screen will show presence of high danger.

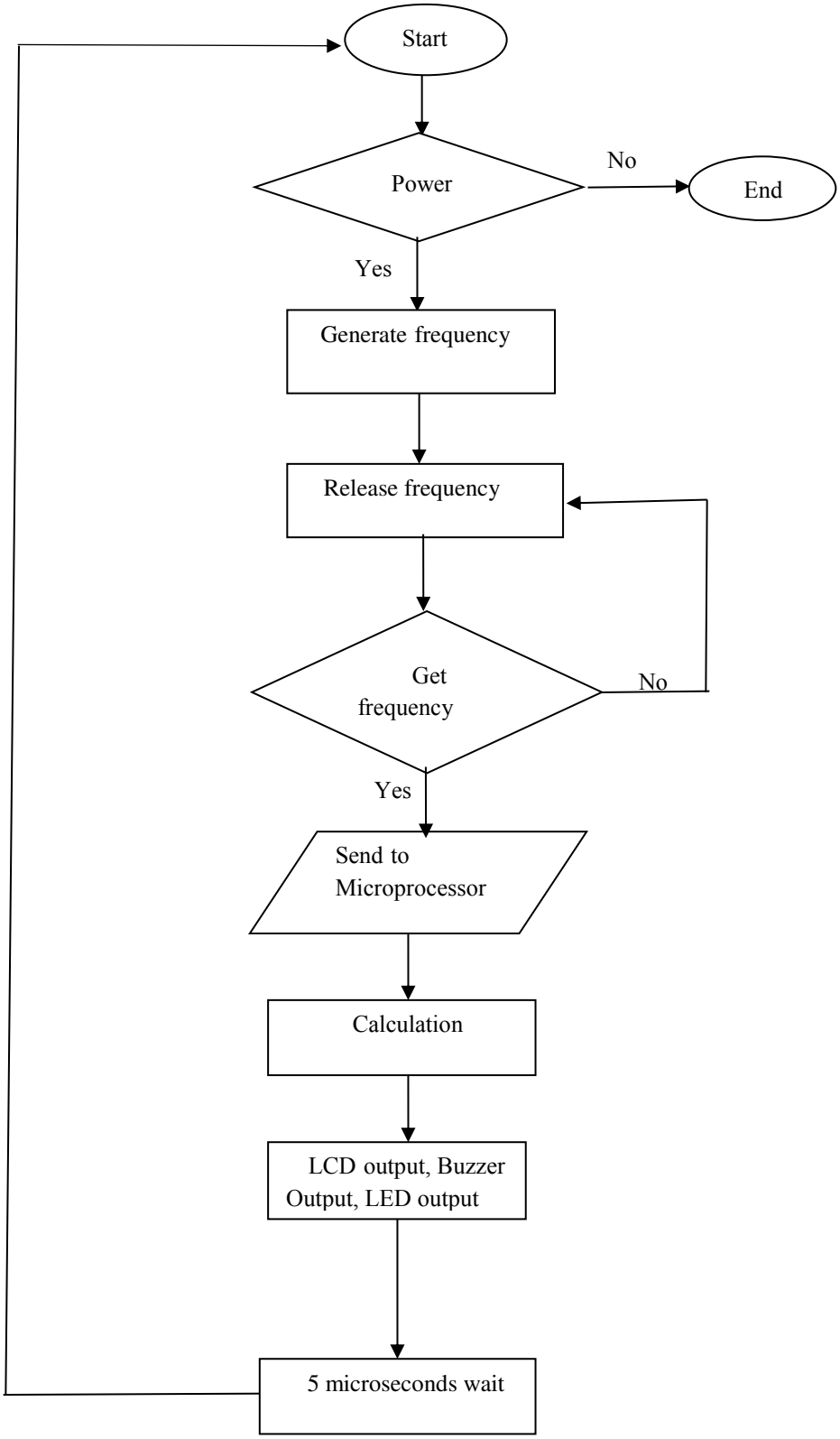
6. If the object is extremely close to the device, then all LEDs will turn on and off simultaneously and the beeping noise by the buzzer will also turn on and off continuously.

8.2 Problems

The device created by us is not fully perfect. It can be improved in mainly three ways. They are:

1. The LCD screen present can be used to display the distance covered by the baby from his safety position.
2. Also, a CC camera can be used to see whether the warning call given by the buzzer is wanted or not. For example, if a ball appears, the buzzer might cause a sound. But the CC camera is going to ensure the parent that the baby is all right and the warning was a wrong one.
3. Also, GSM module can be used by a parent when the child is at home, while the parent is outside. The parent can use the GSM module to turn on the device by calling from a mobile phone to check the welfare of the infant.

8.3 Flow Chart



9 Result

When baby is more than 50cm from the gate where the device is attached, in LCD display's screen it will be shown "Baby is safe" and no LED will be turned on and buzzer won't produce any noise. Now, the time the baby come near at least distance from the device is less than 50cm but more than 40cm the LCD display's screen will show "Baby at door" and then one green LED will turn on and buzzer will make sound of 50Hz. After that, at the time the distance from device of baby is less than 40cm but more than 30cm, then the LCD display's screen will show "Danger Alert 1", 2 green LEDs will turn on and the buzzer will make sound of 100Hz. Then if the distance decreases more and becomes less than 30cm but more than 20cm, LCD display's screen will show "Danger Alert 2", 2 green LEDs and 1 Yellow LED will turn on as well as the buzzer will make noise of 120Hz. Sequentially, if the distance becomes less than 20cm but more than 15cm the LCD display's screen will show "Danger alert 3", 2 green LEDs, 2 yellow LEDs and 1 red LED will turn on and the buzzer will make sound of 170Hz. In the same procedure, if the distance between baby and the device becomes less than 15 cm but more than 10 cm the LCD display's screen will show "Danger alert 4", 2 green LEDs, 2 yellow LEDs, 2 red LEDs will turn on and the buzzer will make sound of 200Hz. Finally, if the baby comes extremely close like even less than 10cm of the device that means extremely close of the gate of room as the device is attached with the gate, the buzzer will once make sound of 255Hz and once will turn off, which will sound like "beep beep" and all the LEDs will once turn on and once turn off simultaneously with the buzzer. The LCD display's screen will show "HIGH DANGER".

Table 6: Result

No	Distance	LCD Display Zone	LED	Buzzer
1	More than 50 cm	Safe	None	No sound
2	Less than 50 cm but more than 40 cm	At Door	1 LED Green	50Hz
3	Less than 40 cm but more than 30 cm	Danger Alert 1	2 LEDs Green	100Hz
4	Less than 30 cm but more than 20 cm	Danger Alert 2	2 LEDs Green And 1 LED Yellow	120Hz
5	Less than 20 cm but more than 15 cm	Danger alert 3	2 LEDs Green And 2 LEDs Yellow And 1 LED Red	170Hz
6	Less than 15 cm but more than 10 cm	Danger alert 4	2 LEDs Green And 2 LEDs Yellow And 2 LEDs Red	200Hz
7	Less than 10 cm	HIGH DANGER	All LEDs turn on and off simultaneously	255Hz and 0Hz (Beep Beep)

9 Performance Analysis

We are purchasing our components for this project from BD Speedy Tech. The list of components and its current market value are given below.

Table 7: Cost of hardware and others

No	Description (Code)	Quantity	Unit Price	Subtotal
1	Bread Board	1.00	140.00	140.00
2	M2M WiRf	1.00	70.00	70.00
3	Arduino Uno R3	1.00	480.00	480.00
4	Buzzer	1.00	15.00	15.00
5	Resistor	1.00	5.00	5.00
6	LED	6.00	1.00	6.00
7	LCD	1.00	120.00	120.00
8	Sonar Sensor	1.00	130.00	130.00
			Total Amount (BDT)	**966.00**
Nine hundred sixty-six taka and zero paisa only				

Following table 5, it is clear that it is cost efficient, in fact a lot cost efficient compare to the traditional baby safety device [9] [10]

As we connect sonar to Arduino in our device, it can measure distance of an object accurately within 3cm to 4m. Nevertheless, if the body gets too close to the sensor, it fails to catch the echo and measure the time differential. Other key specs are, it needs 15mA of current, has a resolution of 1cm etc. But when looking for Ultrasonic sensor, pay special attention to the Trigger Pulse Width and angle of sight i.e. the area of line of sight of the sensor. [11] So we should concern about that we cannot measure any calculation or distance if it is 3cm or less than it.

Conclusion

In the end, we developed a device which is going to ensure the safety and wellbeing of any baby and his mother in a more simplistic way. This device, with the help of a Microprocessor, LEDs and Buzzer, is going to inform an infant's mother about the distance of her child from the safety zone. Furthermore, the mother does not even need to be in the same room to ensure her child's security all due to this device. If the baby moves away a bit too far away from its safe zone, the buzzer present in the device is going to make noise and the LEDs will light up to ensure the mother so that she can come to the baby's room to put it in a safer location. So, we hope this technology is going to help a lot of mothers to take care of their babies without keeping an eye on

them whole time. The infants' mothers can be free to do other things at home without any tension or panic, while also ensuring their children's security. Hence, with the help of our device, a lot of stress is expected to be removed from the shoulders of all mothers, while at the same time the welfare of their infants can also be taken care of properly.

Acknowledgement:

We would like to thank Dr. Jia Uddin, assistant professor, for supporting us in this work.

References

1. J.David and N.Cheeke, "Fundamentals of Ultrasonic Waves", CRC press, Florida,USA, 2002, ISBN 0-8439-0130-0.
2. A.K Shrivastava, A. Verma and S.P Singh, "Distance Measurement of an Object or Obstacle by Ultrasound Sensors using P89C51RD2", International Journal of Computer Theory and Engineering, Vol-2, Feb-2010.
3. Complete guide for Ultrasonic sensor HC-SR04 Tutorials: http://randomnerdtutorials.com/complete-guide-forultrasonic-ssensor-hc-sr04/
4. Arduino Distance Detector With a Buzzer and LED's: http://www.instructables.com/id/Arduino-Distance-Detector-with-a-Buzzer-and-LEDs/
5. Arduino Based Distance Measurement using Ultrasonic Sensor: https://circuitdigest.com/microcontroller-projects/arduino-ultrasonic-sensor-based-distance-measurement
6. LCD (https://www.sparkfun.com/products/11987)
7. Implementation of a Wearable Sensor Vest for the Safety and Well-being of Children (https://core.ac.uk/download/pdf/82700091.pdf)
8. KiMS: Kids' Health Monitoring System at day-care centers using wearable sensors and vocabulary-based acoustic signal processing (http://ieeexplore.ieee.org/document/6026744/)
9. iBaby Wall Mount for the M6/M6T/M6S Baby Monitors (https://www.amazon.com/gp/product/B0111M5WLW/ref=s9_acsd_top_hd_bw_bBIAVn_c_x_w?pf_rd_m=ATVPDKIKX0DER&pf_rd_s=merchandised-search-3&pf_rd_r=4WC8AJ9KYQ6FHG2QSAE8&pf_rd_t=101&pf_rd_p=6ee806f4-a719-5f80-843e-5464afc8121b&pf_rd_i=166870011)
10. Video Baby Monitor, with 7.0" Large LCD Screen, Video Recording, Infrared Night Vision Camera and Two-Way Audio System - Corner Shelf Included (https://www.amazon.com/gp/product/B071DGKDMB/ref=s9_acsd_top_hd_bw_bBIAVn_c_x_w?pf_rd_m=ATVPDKIKX0DER&pf_rd_s=merchandised-search-3&pf_rd_r=4WC8AJ9KYQ6FHG2QSAE8&pf_rd_t=101&pf_rd_p=6ee806f4-a719-5f80-843e-5464afc8121b&pf_rd_i=166870011)
11. Arduino Official website (https://www.arduino.cc)