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Android Based Embedded Baby Monitoring and Controlling System by using Raspberry Pi

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Abstract:

This project presents a design of a Baby Monitoring and Controlling System over a GSM network. A prototype is developed for this system, which is reliable, efficient and that can play a vital role in providing better infant care when the baby's parents are absent. This system monitors vital parameters such as body temperature, moisture conditions, and movement of an infant. When the baby is crying it is recognized by a microphone and automatically music is played from an SD card through a loudspeaker. Any movements in the room near to baby can be measured by IR sensor and that object and baby distance is measured by Ultrasonic sensor. Under emergency situations, the parents are alerted with the help of a buzzer to initiate proper action. The system consists of a temperature sensor, a humidity sensor and a microphone for monitoring vital parameters. A touch screen (TFT LCD Monitor), a GSM interface and a buzzer are used in the monitor and control system. These monitoring and controlling is done by a single Raspberry pi.

Key terms:

Raspberry pi, TFT LCD Monitor, GSM module, microphone, Loudspeaker and Sensors.

Introduction:

Introduction to Embedded Systems:

Embedded systems are electronic devices that incorporate microprocessors with in There implementations. The main purposes of the microprocessors are to simplify the system design and provide flexibility.

Having a microprocessor in the device means that removing the bugs, making modifications, or adding new features are only matters of rewriting the software that controls the device. Or in other words embedded computer systems are electronic systems that include a microcomputer to perform a specific dedicated application. The computer is hidden inside these products. Embedded systems are ubiquitous. Every week millions of tiny computer chips come pouring out of factories finding their way into our everyday products. Embedded systems are self-contained programs that are embedded within a piece of hardware. Whereas a regular computer has many different applications and software that can be applied to various tasks, embedded systems are usually set to a specific task that cannot be altered without physically manipulating the circuitry. Another way to think of an embedded system is as a computer system that is created with optimal efficiency, thereby allowing it to complete specific functions as quickly as possible.

Introduction to Project:

In the past few decades, female participation in the labour force in the industrialized nations has greatly increased. Subsequently, infant care has become a challenge to many families in their daily life. Mother always worries about the well being of her baby. As we see in India both the parents need to work and look after their babies/infants, so they experience more stress, especially the female counterparts. If a system is developed which continuously gives updates about their infants during illness and also during normal conditions then it will be of great help to such people as they can work in a stress less environment giving fruitful outputs.

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Also emergency situations can be identified and attended to quickly. Usually, when a, baby cries, the cause is one of the following things, they are hungry, tired, not feeling well or need their diaper changed. So we developed a prototype which can monitor the activities of the baby and/or infant along with finding one of the above causes and give this information to their parents. This proposed system gives a peace of mind to parents when they are away from their infant as they can get an updated status of their wellbeing. Communication is done by GSM interface through Short Messaging Service (SMS). A wrist band which is worn by the baby measures the vital parameters such as body temperature and humidity using DHT11 sensor. Movement of the baby is identified using PIR sensor and when the baby cries it is recorded by a microphone. Any movements near to the baby can be measured by IR sensor. These all are interfaced to the Raspberry pi. Raspberry Pi system receives that sensors information and displays it on a Touch Screen. If the baby is crying soothing music comes from Loudspeaker though SD card of Raspberry Pi, this information is send to parent using GSM network.

Many home-care systems are available but majority of this system are specially designed for the aged people and patients. These systems can monitor their health status, automatically send out emergency signals, and have other functions. However, the caring methods for infants are not the same. Children and adults require different type of care because they are totally dependent for their normal functions on someone else. Infants cannot give any feedback about their discomfort or health complaints. Infants cannot express themselves like old people, e. g when an infant has a fever, he/she can only express his/her discomfort by crying. Hence, a home-care system specially designed for infants is today's need which would substantially lighten parents' especially mother's burden. In support of this requirement many research papers and patents for healthcare application are studied with the intention of possible solutions to take care of the infant. This system is based on commercial GSM network.

Vital parameters such as body temperature and dry/wet conditions measurement using DHT11. Remote subsystem with GSM module receives data which is then send to a server by a USB port. Data are stored on the server and a message is sent to their parents. Baby's temperature and humidity are measured by DHT11 and interfaced with the Raspberry Pi. A wearable hardware gadget is developed which captures the biological status of the baby such as motion, temperature and humidity. There is a module having three sensors attached to the diaper. The baby unit includes a microphone and can transmit sounds to the parent unit. However, in order for the parent to detect a problem with the child, the parent must constantly monitor the sounds being transmitted from the baby unit. It includes an infant's sleep blanket/garment which is offered as either a sleep sack or a sleep shirt, depending on the age of the infant. The sack with no arm holes for newborns and with arm holes and sleeves for older infants

BLOCK DIAGRAM:

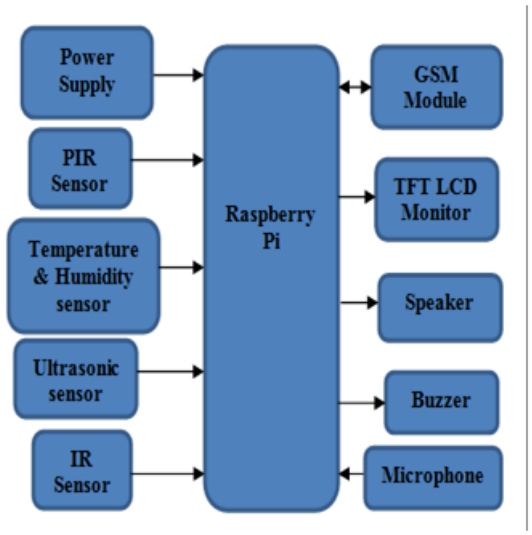

Figure 1: Block Diagram of Embedded Baby Monitoring and Controlling System

TOUCH SCREEN:

TFTs are Active-Matrix LCDs that have tiny switching transistors and capacitors.

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These tiny transistors control each pixel on the display and require very little energy to actively change the orientation of the liquid crystal in the display. This allows for faster control of each Red, Green and Blue sub-pixel cell thus producing clear fast-moving color graphics. The transistors in the TFT are arranged in a matrix on the glass substrate. Each pixel on the display remains off until addressed by applying a charge to the transistor. Unlike conventional Passive-Matrix displays, in order to activate a specific pixel, the corresponding row is turned on and a charge is sent down the proper column. This is where only the capacitor at the designated pixel receives a charge and is held until the next refresh cycle. Essentially, each transistor acts as an active switch. By incorporating an active switch, this limits the number of scan lines and eliminates cross-talk issues. This provide smooth operation and allows "drag and drop" or "signature capture".

- Hantouch driver software allows the user to decide which side is "UP" on the Screen, the software will adjust.
- Hantouch controller and driver software allow several levels of calibration to meet sensitivity requirements.

Figure 2: TFT LCD Monitor

RASPBERRY PI:

The Raspberry Pi is a credit-card sized computer is capable of many of the things that your desktop PC does, like spreadsheets, word-processing and games. It also plays high-definition video. It can run several flavors of Linux and is being used to teach kids all over the world how to program.

The Raspberry Pi 2 delivers 6 times the processing capacity of previous models. This second generation Raspberry Pi has an upgraded Broadcom BCM2836 processor, which is a powerful ARM Cortex-A7 based quad-core processor that runs at 900MHz. The board also features an increase in memory capacity to 1Gbyte.

Figure 3: Raspberry Pi 2 Model B

The GPU provides Open GL ES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high-profile decodes and is capable of 1Gpixel/s, 1.5Gtexel/s or 24 GFLOPs of general purpose compute. What's that all mean? It means that if you plug the Raspberry Pi into your HDTV. The Model B also has a 10/100 Ethernet port so you can surf the web (or serve web pages) from right there on the Pi. The pin diagram of Raspberry Pi including description as show in below figure 4.

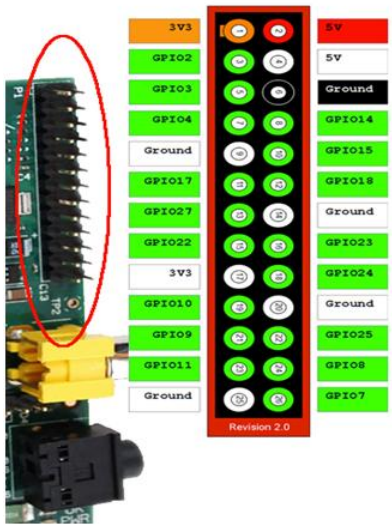

Figure 4: Raspberry Pi Pin diagram

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GSM

GSM (Global System for Mobile communication) is a digital mobile telephone system that is widely used in Europe and other parts of the world for transmitting mobile voice and data services. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band. GSM was first introduced in 1991. As of the end of 1997, GSM service was available in more than 100 countries and has become the de facto standard in Europe and Asia. GSM supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (Short Message Service).

GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. The 850MHz band is also used for GSM and 3G in Australia, Canada and many South American countries. By having harmonized spectrum across most of the globe, GSM's international roaming capability allows users to access the same services when travelling abroad as at home. This gives consumers seamless and same number connectivity in more than 218 countries. Terrestrial GSM networks now cover more than 80% of the world's population. GSM satellite roaming has also extended service access to areas where terrestrial coverage is not available.

GSM Frequencies

GSM networks operate in a number of different frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G). Most 2G GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including Canada and the United States) use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated. Most 3G GSM networks in Europe operate in the 2100 MHz frequency band.

The rarer 400 and 450 MHz frequency bands are assigned in some countries where these frequencies were previously used for first-generation systems. GSM-900 uses 890–915 MHz to send information from the mobile station to the base station (uplink) and 935–960 MHz for the other direction (downlink), providing 124 RF channels (channel numbers 1 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used. In some countries the GSM-900 band has been extended to cover a larger frequency range. This 'extended GSM', E-GSM, uses 880–915 MHz (uplink) and 925–960 MHz (downlink), adding 50 channels (channel numbers 975 to 1023 and 0) to the original GSM-900 band.

Figure 5: SIM900A

Time division multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots (giving eight burst periods) grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate for all 8 channels is 270.833 Kbit/s, and the frame duration is 4.615 ms. The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.3.4 GSM

ARCHITECTURE

The GSM network consists mainly of the following functional parts:

MSC

The mobile service switching centre (MSC) is the core switching entity in the network.

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The MSC is connected to the radio access network (RAN); the RAN is formed by the BSCs and BTSs within the Public Land Mobile Network (PLMN). Users of the GSM network are registered with an MSC; all calls to and from the user are controlled by the MSC. A GSM network has one or more MSCs, geographically distributed.

Digital Humidity and Temperature Sensor (DHT11):

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin. It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds.

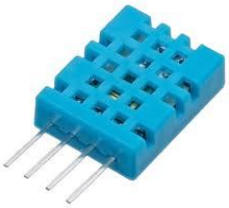

Figure 6: DHT11

This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. The temperature sensor actual readings are listed in below table 1

Table 1: Temperature reading of a baby

S.No	Actual Temperature(^{0}C)	Practical Temperature(^{0}C)
1	32	33
2	34.2	35
3	31	31.5
4	36	37.7

Data format:

The 8bit humidity integer data + 8bit the Humidity decimal data +8 bit temperature integer data +8bit fractional temperature data +8 bit parity bit.

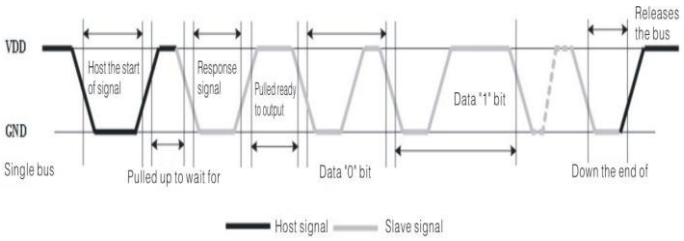

Figure 7: DHT11 Data flow

PIR Motion Sensor:

The active elements of the PIR sensor are exposed to a change in the surrounding temperature field, electrical charges is separated within the sensor elements. The voltage across the sensors controls a J-FET source follower impedance converter and thus modulates the output current of the PIR detector. The spectral sensitivity of the sensor is controlled by the optical transfer characteristics of the window in the case and has been optimized to pick up radiation of the human body.

Figure 8: PIR Sensor

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PIR sensors are more complicated than many of the other sensors explained in these tutorials (like photocells, FSRs and tilt switches) because there are multiple variables that affect the sensors input and output. To begin explaining how a basic sensor works The PIR sensor itself has two slots in it; each slot is made of a special material that is sensitive to IR. When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves.

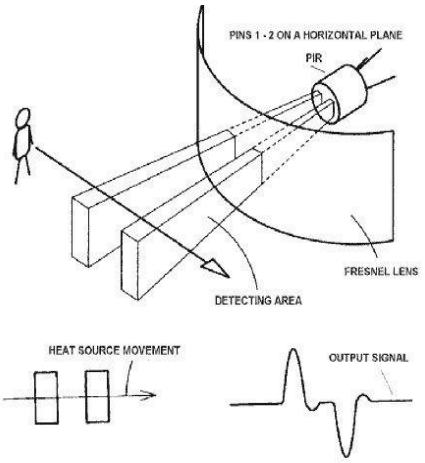

Figure 9 : PIR Sensor working Process

Ultrasonic Sensor:

HC-SR04 is a commonly used module for non contact distance measurement for distances from 2cmto 400cm. It uses sonar (like bats and dolphins) to measure distance with high accuracy and stable readings. It consists of an ultrasonic transmitter, receiver and control circuit. The transmitter transmits short bursts which gets regulated by target and are picked up by the receiver. The time difference between transmission and reception of ultrasonic signals is calculated. Using the speed of sound in the baby room and the distance between the source and baby can be calculated using following equation:

Speed = Distance/Time

Figure 10: Ultrasonic Sensor

The Timing diagram is sh**o**wn below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal.

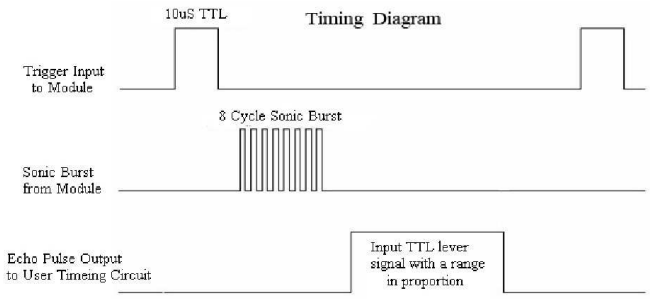

Figure 11: HC-SR04 timing diagram

Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.

IR SENSOR:

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes that can be detected by an infrared sensor.

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The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and these output voltages, change in proportion to the magnitude of the IR light received.IR light is represent any movement in the baby. It can be send that information to parent using GSM Network

Figure 12: IR Sensor

Although there are many ways in which LDR's or photo resistors can be manufactured, ther are naturally a few more common methods that are seen. Essentially the LDR or photo resistor consists of a resistive material sensitive to light that is exposed to light. The photo resistive element comprises section of material with contacts at either end. Although many of the material used for light dependent resistors are semiconductors, when used as photo resistors, they are used only as a resistive element and there are no p-n junctions. Accordingly the devices purely passive.

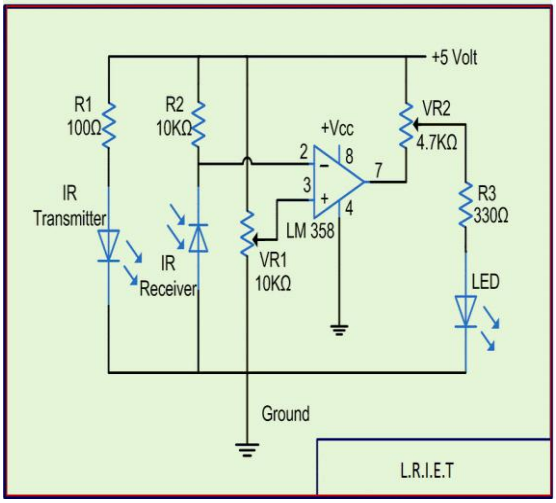

Figure 13: IR sensor internal circuit

In this project, the transmitter section includes an IR sensor, which transmits continuous IR rays to be received by an IR receiver module. An IR output terminal of the receiver varies depending upon its receiving of IR rays. Since this variation cannot be analyzed as such, therefore this output can be fed to a comparator circuit. Here anoperational amplifier (op-amp) of LM 339 is used as comparator circuit. When the IR receiver does not receive a signal, the potential at the inverting input goes higher than that non-inverting input of the comparator IC (LM339). Thus the output of the comparator goes low, but the LED does not glow. When the IR receiver module receives signal to the potential at the inverting input goes low.

Thus the output of the comparator (LM 339) goes high and the LED starts glowing. Resistor R1 (100), R2 (10k) and R3 (330) are used to ensure that minimum 10 mA current passes through the IR LED Devices like Photodiode and normal LEDs respectively. Resistor VR2 (preset=5k) is used to adjust the output terminals. Resistor VR1 (preset=10k) is used to set the sensitivity of the circuit Diagram. Read more about IR sensors. A typical structure for a Light Dependent Resistor uses an active semiconductor layer that is deposited on an insulating substrate. The semiconductor is normally lightly doped to enable it to have the required level of conductivity.

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Contacts then placed either side of the exposed area. In many instances the area between the contacts is in the form of zig zag, or inter digital pattern. This maximizes the exposed area and by keeping the distance between the contacts small it enhances the gain. It also possible to use a poly crystalline semiconductor that is deposited onto a substrate such as ceramic. This makes for a very low cost light dependent resistor.

BUZZER:

Piezoelectric buzzer is an electronic device commonly used to produce sound. Light weight, simple construction and low price make it usable in various applications like car/truck reversing indicator, computers, call bells etc. When subjected to an alternating electric field they stretch or compress, in accordance with the frequency of the signal thereby producing sound.

- When a piezo is struck, it “rings” like a bell. But instead of sound, it outputs voltage

Figure 14: Piezoelectric buzzer

SPEAKER, MICROPHONE AND POWER SUPPLY:

In this project, Microphone is connected to raspberry Pi audio port. It receives the baby crying send that information to the raspberry Pi. Speaker is connected to GPIO pins of Raspberry Pi. When the Raspberry Pi receives the information from the microphone, that frequency is check and if the frequency is matched to baby crying frequency then automatically song played from Raspberry Pi though the speakers to control baby crying .

In this project, Raspberry Pi requires 5V and 1A power adapter is used and TFT LCD Monitor requires 230V and 12A switch board used for power supply.

SOFTWARE:

Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make your Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages; pre-compiled software bundled in a nice format for easy installation on your Raspberry Pi. The initial build of over 35,000 Raspbian packages, optimized for best performance on the Raspberry Pi. However, Raspbian is still under active development with an emphasis on improving the stability and performance of as many Debian packages as possible. The new Raspberry Pi configuration allows you to enable and disable interfaces, tweak performance and configure internationalization options, such as time zone and keyboard. It also allows some more control over boot options than was available in the past. With the option to automatically login in as the”pi” user available when booting to both CLI and desktop.

Figure 15: Rasbian Software install and Raspberry pi window

RESULTS:

The system was tested carefully on an infant, the results found to be same as the one's measured by standard instrument. While testing this system on an infant baby's concern was considered. During the execution of the system snapshots of the display were taken. The system being a complete hardware design and the data available on cell phone and TFT LCD

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monitor display have been captured. Test results of the system are given below, shows successful implementation of the system. Fig.5 and Fig.6 shows hardware module and the actual implemented system.Fig.7,8,9 shows a sample readings of infant onto the LCD attached to the module on an infant's side. The reading were matched to the readings taken by standard instrument and found to be same.Fig.10 and Fig.11 shows message received on parent's cell phone when some abnormal condition exists. Message shows temperature is high and moisture condition exists.

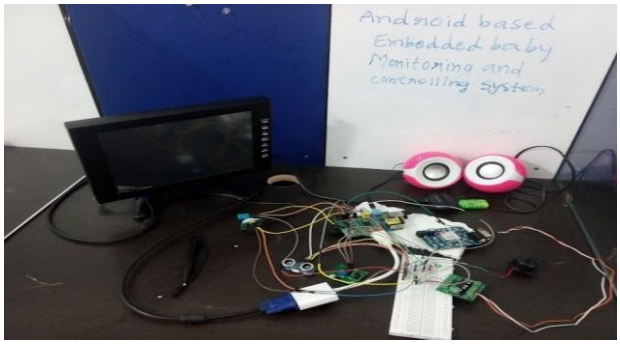

Figure 16: Hardware kit of Baby Monitoring and Controlling System

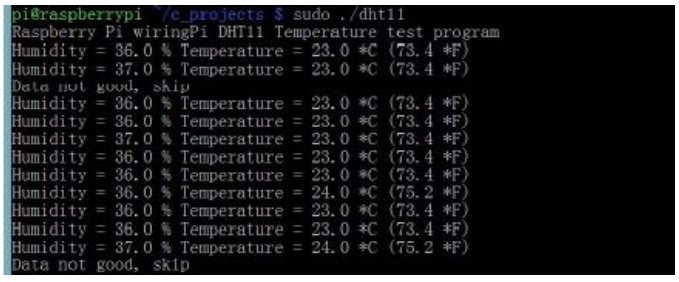

Figure 17: Humidity and Temperature reading of DHT11

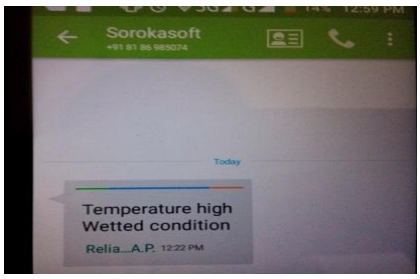

Figure 18: Temperature and humidity condition of baby

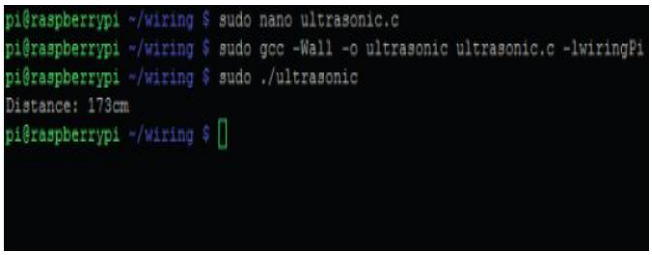

Figure 19: Measure the distance of any sound near to baby

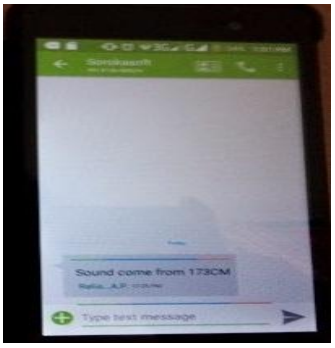

Figure 20: Sound from outside world to baby surroundings

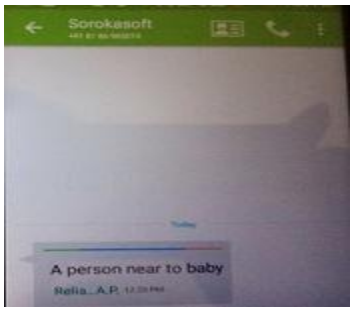

Figure 21: Detect any person near come near to baby

FUTURE SCOPE:

If you use intelligent smart mat to the every baby in baby care centers. This intelligent smart mat used to measure the all conditions of baby like temperature, humidity, movement and send this information to these project, Raspberry Pi is monitor and control of all conditions of baby and send that information send to their parents using GSM network.

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Figure 22: Intelligent smart mat and sensible watch

If you add the thermal to this project, we can use this project below all applications with more efficient and reliable usage purpose. It works by hitting a passenger with IR radiation as they stand between two box detectors. The image is produced on a nearby computer and can reveal weapons and explosives hiding under clothing or stowed away inside a person's health conditions.

APPLICATIONS:

- Baby care centers
- Hospitals
- Transport places
- Industries
- Shopping mall

CONCLUSION:

This system is inexpensive and simple to use, which can improve the quality of parenting. It gives parents a feeling of assurance. The constant recording of multiple biological parameters of a baby and analysis of overall health helps a mother to understand the overall health condition of the baby, and can take actions for improvement, if necessary. Baby room temperature and any new entry person movements can be recognized by IR Sensor. When the baby cries, that received by microphone and distance measure by ultrasonic sensor, he/she can be soothed by the music from the SD card, and the system intimates the situation to parents. As GSM technology is used, communication can happen over longer distances.This is an efficient system for monitoring the baby's health condition from any distance. We can also use the same system for monitoring a patient's health conditions and send information to a doctor.

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