Infant monitoring using wearable computing

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Abstract— **First-time parents find the infant's behavior very unfathomable. Some parents lose out on their sleep trying to keep their baby safe, sound and healthy. A new technological advancement that allows parents to manage their babies much more easily with the help of a smart wearable device and a user-friendly Android application is proposed in this paper. The wearable device can monitor the infant's pulse, temperature and baby position and it generates an alert in case of an irregularity on the Android app.**

***Index Terms*—Distributed database, Android application, Arduino device, sensors, SIDS, wearable device.**

I. Introduction

Parenting infants is a difficult task in the initial stages. It becomes difficult for parents to understand the language of their infants but baby monitors help to try and understand their infants by providing them with vitals so the parents can understand the cause of uneasiness experienced by the baby.

As infants are at the highest risk for SIDS during sleep, it is sometimes referred to as cot death or crib death. Typically the infant is found dead after having been put to bed, and exhibits no signs of having suffered [5]. SIDS was the third leading cause of death of infant mortality in the U.S. in 2011. According to the Centers for Disease Control and Prevention, SIDS deaths have been declining since 1988 [6].

Recent advances in sensor technologies and wireless communication technologies enable the creation of a new generation of healthcare monitoring systems with wearable electronics and photonics [7] [8]. Smart textiles have already been integrated into a garment for electrocardiogram (ECG) and respiration monitoring with wireless transmission. [9] [10] Reflectance pulse oximeters attached on the forehead have been developed.[11] Embedding optical fiber into textiles for patient health monitoring are being developed [12]. A biosensor belt is described for monitoring the heart rate, breathing frequency, body movements and temperature of new born baby with embedded sensors Improvements on sensors, signal processing and integration are required for obtaining sufficiently reliable signals, combating movement artifacts, developing sensors with higher sensitivity, and optimizing the design and integration. All these embedded devices provide infant monitoring to a great scale but they are all wired and pose some threats to the baby because of the materials used.

Many new parents lose out on their sleep trying to understand the baby's sleep patterns, food and pooping habits. It becomes difficult for them to keep track of their baby's habits using various data points and collection of records. Tired moms and dads with no mathematical background aren't about to write down hundreds of data points, and might not know how to analyze that information anyway.

In the imminent future, though, any curious parent with a smartphone will have access to helpful analytics, thanks to the rise of wearable gadgets for babies. Following the success of self-trackers for grown-ups, like Jawbone and Fitbit, companies like Sproutling, Owlet, and Mimo want to quantify the infants. These devices connect to a baby via boot, anklet, or onesie, and record his or her heart rate, breathing patterns, temperature, body position, as well as the ambient conditions of the room. They aim to replace baby monitors, which give an incomplete picture of a sleeping child. There's also the nascent "smart diaper" market, led by Pixie Scientific, which scans dirty diapers for signs of infection. [3]

In addition to alerting parents of any concerning findings, these companies encourage a big-data approach to parenting. By gathering information on the infant's sleep, and eating schedules, the idea goes, to engineer a happier, healthier baby. [3]

In this paper, we propose to develop a wearable device prototype which monitors the temperature, pulse and position of the infant using a small Arduino UNO board with a Wi-Fi shield, LM35 as a temperature sensor, pulse sensor amped for measuring the pulse and LSM303D for measuring the infant's position in the bed. Alerts are generated on a user-friendly Android application if anything goes abnormal. This wearable device allows the parents to monitor the baby at home itself and helps to increase the bonding between the infant and the parent by letting the parents keep their baby close to

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themselves. This new approach intends to ease the parents' lives by easy monitoring of the infant.

II. Motivation

A survey of existing wearables that have already taken a high opinion in the market is mentioned here. These existing systems do not solve the problem of SIDS but help monitor the risk factors involved for the occurrence of SIDS.

Sproutling Baby Monitor: A wearable band for the baby; this system monitors the baby's heart rate, breathing, the position in which the baby is sleeping and the noise levels in the baby's environment. Additionally, it predicts baby's sleep pattern and optimal sleep condition.

MonBaby Baby Button : MonBaby is a smart wearable button that can be attached to the baby's clothing. MonBaby monitors the baby's breathing and sleeping position. It uses pulse oxymeter to monitor the breathing.

Owlet Baby Monitor : Another wearable device which can be worn as a Sock. Owlet provides base station along with the wearable device. It monitors the heart rate and oxygen levels of the baby. It also detects sleep disturbances and analyzes the breathing pattern.

Withings Baby Monitor : Withings, unlike the other systems, is not a wearable device but a stand up camera that can be attached to the baby's crib. Unlike other systems, it provides live feed from the baby's crib. It monitors the room temperature, provides alerts regarding the ideal environment for the baby. It provides talk back to baby through a speaker. It plays lullabies and has a smart light to fascinate the baby if the baby gets scared.

In the IMS, we try to combine the features from these systems and add some more for an exclusive and helpful system. The IMS, along with temperature, heart rate and position sensors, will also include a Vaccination schedule for parents to refer and provide a centralized database of the abnormal records of their infant.

III. Methodology

IMS aims to provide continuous monitoring of vital functions when the wearable device is attached to the infant.

The first step towards IMS is the design of a wearable device that:

1) Contains the integration of sensors for monitoring necessary vitals
2) Forms a platform for future research for vaccination schedules and doctor appointments in case of emergencies.
3) Obtains a sense of trust by parents.

The prototype of the proposed device prototype will consist of the following hardware:

- Arduino UNO microcontroller Wi-Fi Shield CC33000
- Temperature sensor LM35
- Pulse sensor amped
- Accelerometer LSM303D

With consideration of both user aspects and technical functions, the full design of the wearable device should meet the following requirements: [1]

- support the vital health monitoring functions be safe to use
- be scalable to include more monitoring functions support continuous monitoring
- The android app must look appealing and user-friendly The accuracy of alerts generated must be optimum
- There should be minimum power consumption

IV. Prototype and Architecture

The prototype consists of an Arduino UNO micro-controller that is attached with a Wi-Fi shield CC3000. The 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.

The micro-controller is attached with a temperature sensor (LM35), an accelerometer (LSM303D) and a pulse sensor (Pulse sensor Amped).

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in 0 C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 C temperature rise in still air. The operating temperature range is from -55 C to 150 C.

The LSM303D is a system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor. The LSM303D includes an I^2C serial bus interface that supports standard and fast mode (100 kHz and 400 kHz) and SPI serial standard interface. The system can be configured to generate an interrupt signal for free-fall, motion detection and magnetic field detection. Thresholds and timing of interrupt generators are programmable by the end user.

The Pulse Sensor Amped is a plug-and-play heart-rate sensor for Arduino. It can be used to easily incorporate live heart-rate data into projects. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable

pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications.
The entire hardware is embedded as one single piece of wearable that can be attached to the infant's leg to measure the vitals.

This wearable device will be constantly connected to the infant's body.

Fig.1. Arduino board with Wi-Fi shield CC3000

Fig. 2. Temperature sensor (LM35)

Fig. 3. Accelerometer (LSM303D)

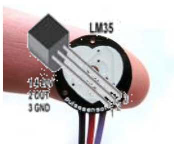

Fig. 4. Pulse sensor A

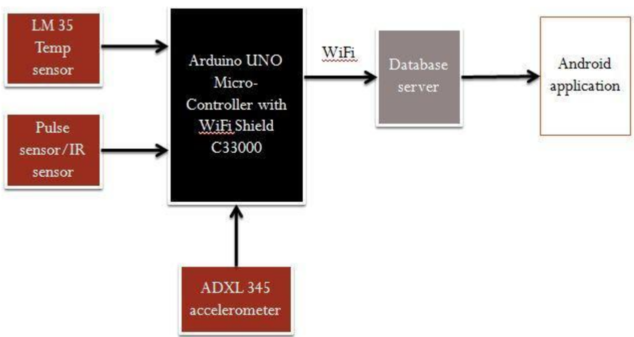

Fig. 5. Architecture of IMS

The wearable device can be charged as and when required.

The wearable device will send the infant's vitals to a database in fixed intervals of time using the Wi-Fi shield. These values are then checked with the threshold values, that is, the actual values considered normal. If the values generated are within the normal range, the values are ignored and stored in the database in the history of values otherwise an alert is generated in the parent's android phone indicating the abnormality and the need to check the infant. This avoids overwhelming the parent with the enormous amount of data that is been tracked by the wearable device and helps them know just the necessary status of the baby.
The device does not provide a numerical value of the heartrate or the breathing rate, it provides the information whether the baby's vitals are normal or not which makes it easier for the parent to understand rather than them trying to interpret the difference in heartrate if it becomes 130 from 120.

V. LIMITATIONS

Although the wearable allows the parent to know more about the baby by constant monitoring and it helps to ease the parents' lifestyle it poses security issues like hacking. Many hackers would get access to information stored on the distributed database. However, security encryptions are done to avoid such mishaps and the ease the wearable provides outweighs the risk factors it poses.

VI. FUTURE SCOPE

The device prototype can be made more powerful by using a powerful controller Atmega2560. The high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller combines 256KB ISP flash memory, 8KB SRAM, 4KB EEPROM, 86 general purpose input output lines, 32 general purpose working registers, real time counter, six flexible timer/counters with compare modes, PWM, 4 USARTs, byte oriented 2-wire serial interface, 16-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The device achieves a throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts.

Introducing artificial intelligence along with monitoring which allows the monitor to predict moodswings of the baby and the sleep patterns so the parents can adjust their schedules accordingly is the next target.

Allowing the wearable device to be able to find out the reason the baby is crying is another challenging task which is also being considered. Many researches have been carried out in this field by monitoring the baby's movements before and after crying to predict the actual cause of crying. This research may also be considered while introducing AI in the wearable device

Allowing the wearable to charge wirelessly thus helping to increase the uptime of the device. Integrating vaccination schedules and the family doctor's schedule in the app which helps parents to easily schedule their appointments with their doctor is also an advancement under consideration.

VII. Conclusion

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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