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Design and Development of Infant Monitoring using Smart Wearable System

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***Abstract* - This paper proposes a productive infant monitoring framework utilizing wearable sensors with wireless communication medium. A few million life births in the world was overshadowed by a large number of infant deaths for various reasons like apparently life threatening events (ALTE) or sudden infant's death syndrome (SIDS). A prototype is designed and developed which gives a solid and viable framework that can assume an imperative part in infant care. The developed system monitors fundamental parameters like body temperature, pulse rate, growth of an infant, moisture content and CO2 sensors to recognize the low oxygen level present around the infant's crib. By utilizing GSM and RF433 modules in this framework will enable the system to communicates the sensors output to their parent's lookout and make them to initiate the possible control activities. The proposed framework utilizes a new simpler design which comprise of relevant sensors attached to microcontroller and it is safely fasten with infant. Moreover, the extracted fundamental parameters will be evaluated with a set of thresholds and the outputs are communicated to the parents through wireless communication modules that will make the system more compatible and user-friendly.**

Keywords* - *Smart Wearables, Infant Monitoring, Wearable sensors, RF433 module, GSM

I. INTRODUCTION

In recent years, infant care has become a great challenge in daily life. In many families, both the parents need to work, so it has become a great difficulty in monitoring their infants. If a system is developed to constantly monitor the infant, it will become easier for the female parent who has to manage lot of workload both in the working place and in their house. The system can constantly monitor the infant with the help of sensors placed on the infant and if any sensor crosses the threshold, the indication can be sent through communication modules. Usually, when a young infant cries, the cause is one of the following reasons i.e. high body temperature, high moisture level or low oxygen level present around the crib. So in this paper, we have developed a system, which can monitor the activities of the infants as well as their condition and give this necessary information to their parents. The prototype of the entire system placed on the infant should be made compact, so that it wont cause any sort of discomfort to child.

Various kinds of wearable sensors have emerged for different purposes with the development of sensing technologies [1]. Other systems [2, 5] were developed in such a way that it can be easily wearable by the infants. We have developed the prototypes on the same line as shown in Fig 1, but it solves most of the issues faced by the infant and parents will get updated information on a real-time basis by extending the use of wireless communication technologies.

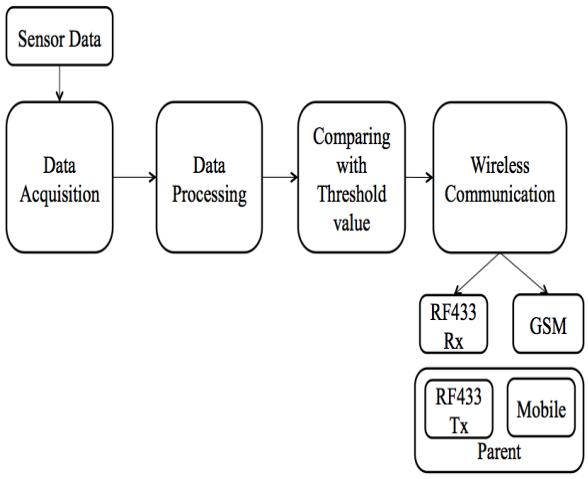

Fig 1. Infant Monitoring Framework

In the present scenario for prosperous living in the fast-moving world, both parents should do some job to lead a happy life. But this adds a threat to the personal life, i.e, lack of monitoring of their infants. This will always be disturbing on their mind and even it will affect their day-to-day work. There is great need of a new system which has to monitor the infants and this will bring some sort of relief to the parents. They will get continuous messages based on the information collected from the sensors attached to the crib of the infant through an attached wireless module.

Fig 1 is the proposed framework of the infant monitoring system. First, the data collected from the sensors will be processed and analysed based on fixed thresholds. Any sensor value which crosses the threshold, the information will be

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communicated through wireless media. This will be an effective solution for monitoring the infants.

II. RELATED WORKS

Numerous home-based frameworks [3, 4] are uncommonly intended for the matured individuals and patients. These frameworks can screen their well being status, consequently convey crisis flags, and have different capacities. In any case, these systems will not be useful for adapting to babies. Kids and grown-ups require distinctive kind of care since they are needy and manage on their own and require help from other person only for certain works. Babies can't give any input about their distress or well being grumblings. Generally, understanding Infant's problem is too tedious and they will show their distress distress by crying. Henceforth, a home-based IoT framework exceptionally intended for new born children which would considerably help parents to understand the infant's problem.

The prerequisite numerous exploration papers and licenses for social insurance application are considered with the aim of conceivable answers to deal with the baby. Creator had built up a framework which depends on fixing GSM with infant [5]. Remote subsystem with GSM module gets information which is then send to a server by a USB port. Information are put away on the server and remotely showed in a site. In another work [6], author's applied SMS based tele-medicine framework, patient's temperature estimated by Infrared temperature sensor MLX 90614 and ECG signals obtained with anodes interfaced with the microcontroller PIC16F877. A wearable equipment device is created which catches the organic status of the infant [7,8], for example, movement, temperature and heart rate sensors (both optical and weight) which are controlled by the microcontroller and associated with the Bluetooth module to give remote communication. In addition to this, in this paper, we would like to measure some indispensable parameters like body temperature estimation utilizing LM35, Heart rate utilizing IR Transmitter and Beneficiary, respiratory rate by utilizing Piezo film sensor situated on Patient's Chest and pulse are detected, enhanced with variable pick up, sifted and given to microcontroller.

III. SYSTEM OVERVIEW

The proposed system consists of various nano sensors and communication modules used in effective monitoring of the infant. The framework, sensors used in this system and its functionalities are described below.

A. Infant Monitoring Prototype:

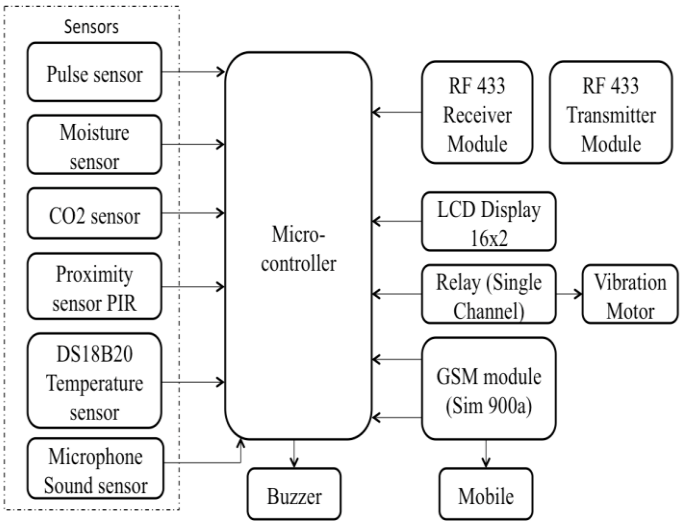

Fig 2. System Design

Fig 2 shows the system design of the Infant Monitoring System. In this setup, various nano-sensors are connected to a microcontroller and made in to a wearable system. The sensor readings will be collected from the infant's body and will be processed. This system will help the parents to be indicated about the infants health and necessary details. The sensors connected to the setup are Pulse rate, CO2, Moisture, Temperature, Sound and PIR sensor. The setup also consists of communication modules such as GSM and RF433 modules. The GSM module is used to send messages to the parents when the sensors cross the threshold value and the RF433 modules are used to send a digital signal to turn on the vibration motor.

B. Sensors:

1. Pulse Rate Sensor

The MAX30100 [9] is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals.

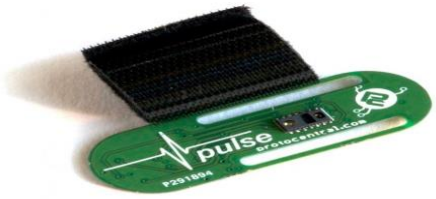

Fig 3. Pulse Oximeter

In the proposed system, the pulse sensor is used to measure the heart rate of the infant constantly and if any abnormal readings the indication will be sent to their parent's through GSM module.

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2. CO2 Sensor

A carbon dioxide sensor or CO2 sensor is an instrument for the estimation of carbon dioxide gas. The most widely recognized standards for CO2 sensors are infrared gas sensors (NDIR) and substance gas sensors. Estimating carbon dioxide is imperative in monitoring indoor air quality, the capacity of the lungs as a capnograph device, and numerous modern procedures.

In this setup, the CO2 sensor is used to indicate the CO2 level present around the infant's crib. By this, if the value is above the threshold, the low oxygen level can be indicated using communication modules.

3. Sound Sensor Module – Microphone

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. Its accuracy can be easily adjusted for the convenience of its usage. It uses a microphone which provides the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage which is sent to a microcontroller and then performs necessary processing.

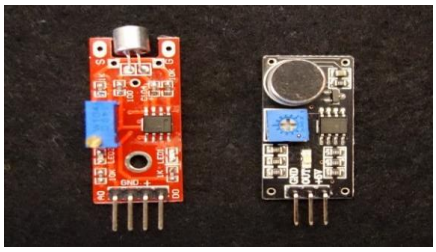

Fig 4. Microphone module

Sensitivity can be referred by the following: When less sensitive, it takes more sound to trigger the device. When more sensitive, it takes less sound to trigger the device. With the help of this sensor, the baby crying sound can be identified and depending on the sensitivity level, the messages can be triggered accordingly.

4. DS18B20 Sensor - Temperature:

The DS18B20 advanced thermometer gives 9-bit to 12-bit Celsius temperature estimations with non-volatile client programmable upper and lower trigger focuses. The DS18B20 conveys over a 1-Wire transport by a single information line (and ground) for correspondence with a focal microchip. Moreover, the DS18B20 can get control straightforwardly from the information line, disposing of the requirement for an outside power supply. Each DS18B20 has a one of a kind 64-bit serial code, which permits numerous DS18B20s to work on a similar 1-Wire transport. Consequently, it is easy to utilize one chip to control numerous DS18B20s dispersed over an expansive region. Applications that can profit by this component incorporate HVAC ecological controls, temperature checking frameworks inside structures, gear, or apparatus, and process observing and control frameworks.

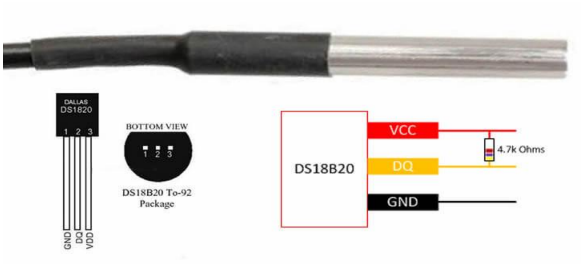

Fig 5. Temperature sensor

It reduces component count with integrated temperature sensor and EPROM. It has a capacity to measure temperatures from 55°C to +125°C (-67°F to +257°F). The accuracy of the readings will be ±0.5°C from -10°C to +85°C. The parasitic power mode requires only 2 pins for operation (DQ and GND). It simplifies distributed temperature-sensing applications with multidrop capability. Each device has a unique 64-Bit serial code stored in on-board ROM.

This sensor is placed on the infant's body to constantly monitor the body temperature and if the temperature rises beyond a certain limit, it will be easier to inform the parents immediately.

5. Moisture sensor

The Moisture Sensor is used to measure the volumetric water content present on infant's body. If the moisture content present on the infant body is higher, it can be indicated to the parents immediately.

6. PIR Proximity Sensor :

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are frequently utilized as a part of PIR-based movement indicators. A PIR-based motion detector is used to sense movement of the infant or other objects. They are commonly called PIR or PID(passive infrared detector).

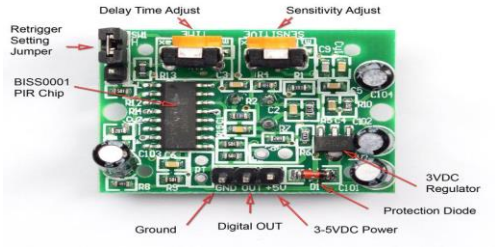

Fig 6. Proximity sensor

A PIR sensor identifies changes in the measure of infrared radiation affecting upon it, which fluctuates relying upon the temperature and surface qualities of the articles before the sensor. In this situation, it will identify the baby's development, the temperature by then in the sensor's field of view will rise from room temperature to body temperature, and after that it back once more. The sensor changes over the subsequent change in approaching infrared radiation into an adjustment in the yield voltage, and this triggers the recognition.

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C. Flow of Events:

Fig 7 shows the flow of events from the wireless communication modules [10]. If the sensors connected to the micro-controller crosses certain threshold value, the messages will be triggered from the GSM module connected to the infant system to the parent's mobile. The message will be triggered for the sample conditions mentioned in Fig 7.

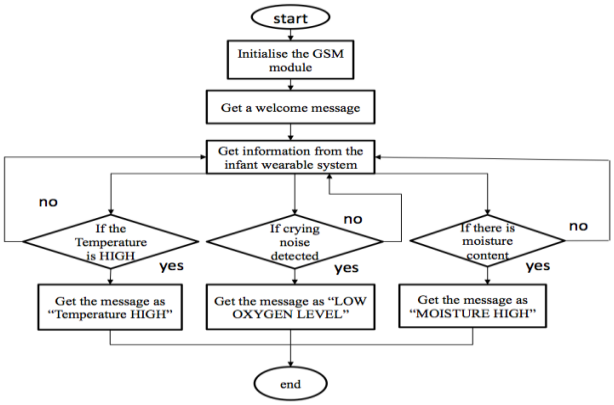

Fig 7. Flow of events

IV. SOLUTION ARCHITECTURE

Fig 8 shows the overview of the design of infant monitoring system. This system consists of various sensors to wirelessly monitor the health and other aspects of the infant and updating the necessary information to the parents. In this model, the CO2 sensor is used to detect the amount of CO2 present around the crib and if the threshold it reached, it will indicate that the oxygen level present around the crib is low. The pulse oximeter, temperature and moisture sensor are used to detect the pulse rate, body temperature and the moisture content on the infant's body respectively. The microphone sound sensor module is used to detect the sound of the crying baby and according to the sensitivity level, the message will be sent through GSM module to the parents mobile. The threshold level for the sensors where fixed based on the average value of the readings collected from the sensors.

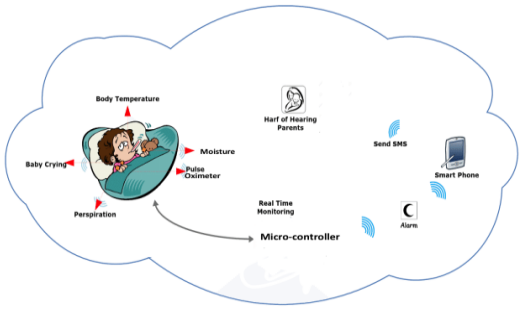

Fig 8. Design

In this system design, the RF433 module consist of transmitter and receiver modules which aids for proper communication. The receiver module will be placed near the infants crib and the parent will be having the transmitter module. This RF module [10] will help the parent to send digital signals wirelessly and switch on the vibration motor.

Fig 9. LCD Output

The body temperature, pulse rate of the infant will be shown in the LCD display (Fig 9). It will also display whether the oxygen level present near the infant's crib is normal or high.

V. RESULTS AND DISCUSSIONS

This Infant Monitoring System circuitry consists of various sensors, a microcontroller and communication modules. The sensors are interfaced with the micro-controller and the sensor data is mapped with the threshold value and if it exceeds certain value, the message will be triggered from the GSM module to the parents mobile.

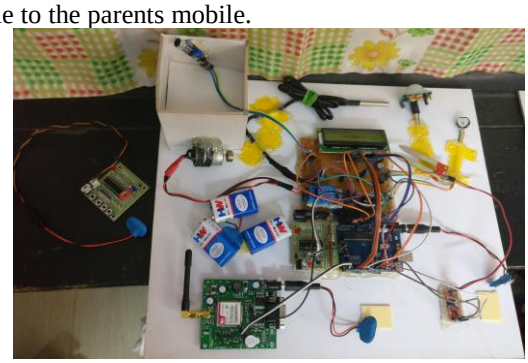

Fig 10. Prototype

Fig 10 shows the final prototype of the Infant Monitoring System with all the sensors connected to the micro-controller. This system will be an efficient way for monitoring the infant in the absence of the parent. So, it will also monitor the health condition of the infant and constantly indicate the parents through messages. This might bring some sort of relief to the parents and they don't have to keep an eye on their infant always.

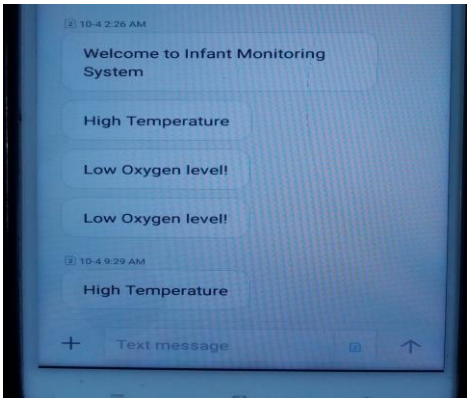

Fig 11. Messages sent from GSM module

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Fig 11 shows the messages received on the parents mobile through GSM module. These messages will be triggered only when the sensor value reaches the threshold level.

VI. CONCLUSION AND FURTHER WORK

The paper focuses on remotely monitoring the infant's health as well as the other aspects and the necessary information will be sent to the parents using wireless communication modules. In the developing country like India, it is necessary for both the parents to work and this type of system will help them have some relief and concentrate on their work. In this setup, camera can also be connected if necessary to monitor the activities of the infant wirelessly on a monitor.

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