Infant Monitoring System & Theft Alert

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Abstract— Nowadays its highly impossible to find the proof for the fact that natural phenomena of giving birth to a child and growing up. Let it be, with the development of the advanced technology in medicine with specialization of the monitoring it has been a gradual development especially in case of new born babies and infants. So monitoring needs sensing units to show the parameters required to analyse the condition of infants, so it is proposed that wearable sensing units with 24*7 monitoring will be the responsible development in the field of monitoring. A lucid technology is provided for the efficient and accurate calculation of heart beat, temperature and may be the breathing level of the infants to be monitored. A legal authorization should be provided for the systems introduced in the field of hospitality which has embedded based technology as a working media.

Key words: Smart Wearable System; Sudden Infant Death Syndrome

I. INTRODUCTION

Sudden Infant Death Syndrome (SIDS), the name which if familiar threat with the infants born without proper birth by their parents. It can be prevented but the only requirement is monitoring that too frequently.

This project is a combination of emergent technologies, such as: wearable devices; smart textiles; embedded systems; wireless communications and mobile applications, aiming to monitor the infants during their sleep. This SWS is composed by a Wearable device, a Gateway, and an H Medical Interface. The Wearable Device is the sensing unit, in the form of a Chest Belt, and is responsible for monitoring the body temperature, the heart and breathing rates and the body position. This set of parameters is vital for the identification of SIDS scenarios and for the evaluation of the quality of the sleep.

During sleep, doctors state that the infants should sleep on their back and they must not sleep on their stomach, as the infants are particularly vulnerable to SIDS due the risk of asphyxiation. Thus, we have developed an algorithm for the continuous monitoring of the position of the infant during the sleep. This algorithm is based on the data retrieved from an accelerometer and it is able to identify all four possible positions of the infant during the sleep: lying on his back; lying on his side; lying on his stomach. Moreover, the two of the major signs that SIDS may be about to happen is abnormal breathing pattern and heart rate. The heart beat rate for a new born babies is 30 to 60 beats per minute, for the infants after the first year their heart beats is between 24 to 30 breaths per minute. For the detection of the breathing rate, we used the same 3D accelerometer, and we have developed a low complexity algorithm with low overhead. Through the use of textile electrodes, knitted in the chest belt and with dedicated electronic, the heart rate is measured by our system. The textiles revealed to be an excellent interface for bio-signal sensing, as they are flexible, stretchable and conform to the body (increasing the physical comfort of the infant), rendering them an interesting solution for ubiquitous, continuous health monitoring. This is for the infants whose normal heart rate is above 100 beats per minute. For the body temperature monitoring we use a small contactless infrared temperature sensor.

The main objective of the project is to reduce the response time of the SIDS, so the wearable system is made to work over 8 hours with the optimum consumption of energy may be >60% which will the better rate at which the monitoring is done efficiently. The alarms will be provided to indicate the critical conditions and light indications to show the levels of the data that is obtained by monitoring.

In the last decade, the research community and the industry have been taking special attention to wearable systems. These are designed for a vast range of applications, Monitoring sleep that means calculating breathing level and oxygen consumption evaluation athletes' performance assessment. It is common to find SWS that are able to monitor multiple vital signs and access if the user is in an emergency situation. Some of the parameters that can be monitored by a SWS are: electrocardiogram signals (ECG); electroencephalogram (EEG); electromyogram (EMG); heart rate; activity of the user; fall; breathing rate; blood pressure; blood glucose; blood oxygen; perspiration (sweating) or skin conductivity; and body or skin temperature . Several design approaches have been tested to make the SWS more intrusive, like wristwatches , shirts , jackets , gloves , socks , chest bands, But the use of intrusive technologies, like cables, cuffs, and devices with big dimensions, make those SWS not truly wearable and in some cases uncomfortable for the user . The use of smart textiles like textile electrodes or printed sensors allows the user to have more freedom of movements and comfort in its use, but some of those technologies are still a prototype. Several types of wireless communications technologies are used in SWS for off-body communications with the Base Station, Smartphones and/or Graphic User Interface. Although multiple technologies have been already created to prevent SIDS, they do not seem to be comfortable or they do not have the capacity to measure all the required parameters. Also, alongside with the prevention, Baby Night Watch tries to be a continuous tool to study what may cause this Syndrome. Storing the information of any variation of patterns may be helpful to understand this syndrome.

II. LITERATURE SURVEY

[1] Smart Wearable Systems (SWS), is composed by the following elements: a wearable device is a wireless sensor node integrated in a chest belt, and it has the capacity to monitor the following parameters: body temperature, heart and breathing rates, body position. After a minimal data processing, this set of information is sent, and it is accessible to the user.

[3] The adverse prone effect of prone sleeping position was 6 times stronger among the infants sleeping on titre or kapok mattress than among infants sleeping on other types of mattress. The prone position was a strong risk factor is heated then unheated rooms

[4] it is used to measure the maternal heart rate of the infants using photo plethysmo graph sensor. The infant offer suffer from pain, distress and discomfort and these are measured using memo which is placed under the pillow

III. SYSTEM DESIGN AND ARCHITECTURE

In this section we will discuss the architecture and the design methodologies that were chosen for the development of the Baby Night Watch.

A. System Overview

The Fig. 1 illustrates the architecture of the Baby Night Watch, where the different components and communication technologies used are depicted. The Wearable IoT Device collects different types of physiological data and send those parameters to the Gateway, which is inside of the communication range of the wearable Device. This off-body communication is made using the IEEE 802.15.4-compilant wireless transceiver radio, CC2530, over the 2.4 GHz Industrial Scientific and Medical (ISM) band.

The main operative part is communication and transfer of data. Let us think that something suspicious or deviation happens in the programmed data and the limit programmed in the system as soon as the system provides buzzing sound and transfers the data to cloud computing database and also to the hospitalized database even to the doctors in personal.

1) Heart Rate Sensor

The acquisition of the full ECG is a very resource consuming task. As it requires many computational resources, which are usually not available on wearable systems due to the power and size constraints, or a big power source for the data transmission. Thus, considering the requirements and constraints of the Wearable Device, we will only acquire the heart rate information.

For the chest belt a two-electrode sensor configuration was chosen, these textile electrodes were made based on the patent. The electrodes were knitted by the base-fabric, using a silver coated textured polyamide elastic yarn from Elitex, with low electrical resistance. The wearable chest belt, composed by textile electrodes and conductive leads (to connect these elements to the analog front-end) were knitted by a MERZ MBS seamless knitting machine. For the electrode area, a particularly voluminous structure was developed, making the electrode area stand out of the rest of the fabric, and thus, improving the contact between skin and textile electrode. To ensure the correct positioning of sensors and signal acquisition hardware, the optimal electrode and sensor arrangements were studied. Regarding the electrodes for the heart rate acquisition, measurements with the electrodes at different positions in the chest area were carried out and compared. It was concluded that the best position is below the pectoral muscles, where the electrodes are closer to the ribs, avoiding electromyography interference.

To implement the heart rate measurement conditioning circuitry, an AD8232 was used and the heart rate monitor was designed to measure small bio potential signals in noisy conditions. The Instrumentation Amplifier has a gain of 100 V/V. Regarding the cut off frequencies, the implemented block of the two-pole high-pass filter eliminates motion artifacts and drift caused by varying electrode-skin polarization and contact noise whilst the additional two-pole low-pass, using a Sallen-Key configuration, attenuates the line noise and other interference.

To compute the heart rate value, a CC2530 microcontroller was used in combination with the AD8232. Using its ultralow-power internal analog comparator, it is possible to compare the filtered ECG wave with an external voltage level. The analog comparator solution compares the voltage reference with the level of the ECG signal and the output changes when the ECG signal drops below the voltage divider value (voltage reference set to 300 mV). To calculate the infant's heart rate, a timer of the CC2530 is used to measure the time between two heart rate pulses.

2) Infants Posture

To detect the position of the infants during the sleep, the LSM330DLC inertial sensor from STMicroelectronics was used. In this project we did not use the built-in gyroscope. The LSM330DLC has 3 independent acceleration channels, a dynamically user-selectable full-scale range and, a SPI/I2C serial interface.

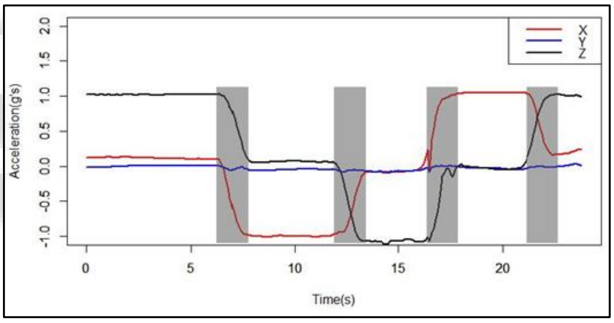


Fig. 1: Acceleration variation on each axis over positions changes.

±9.81m/s^2) applies to each axis. Fig. 2 also shows that the gravity force on the YY's axis is almost zero for all of the four possible positions and therefore, YY is not used to determine the infant's position. In scenario C the infant is lying on his stomach and in in the XX's ~0g. Also we have developed an algorithm for position recognition. Based on the information depicted, we have developed an algorithm for position recognition. To minimize the small fluctuations that can occur between accelerometer readings, a threshold value was defined that allows to control the tilt angle in which a position is defined. So, the working principle of the proposed algorithm is: if the accelerometer reading in one axis is higher than the threshold value and the reading of the other axis is lower than the defined threshold, the position is set according to the values read. To prevent unnecessary energy consumption, the position updates will only be send to the Gateway when a valid position change is detected.

3) Breathing Rate sensor

The sampling rate for the 3D accelerometer was set to 10 Hz, since it acquires the data at least ten times higher than the maximum frequency of the signal (60 breaths per minute). Fig. 4 illustrates the data acquired in one of the accelerometer axis over a period of one minute. Due to the huge variations of the original signal between each sample (represented by the red line), a smoothing algorithm based on the sliding window technique was employed, with a window of 10 samples or 1 second.

Since each breathing cycle has different amplitude and the techniques for peak detection require too much computational resources and, therefore have a huge energy consumption, a state machine with three possible states (Middle, High and Low) was used for obtaining the breathing rate, in order to minimize power consumption. For the correct recognition and validation of a breathing cycle, the signal must follow this sequence: start on the Middle state; High state; Middle state; Low state and; Middle state again. The Middle state is defined by a threshold interval that sets the maximum and minimum breathing signal values. The selection of the threshold range is one of the key factors for the correct performance of the breathing rate sensor because, if this interval is too narrow the algorithm is likely to miss the transition between the Middle state, and if the interval is too large it is likely that the state machine never reach the Low or High state. Since the amplitude of the signal can be very small (0.219 g to 0.25 g), the selection of the threshold interval is very difficult due to the proximity of the values. So, the original signal was amplified on an order of a thousand times to make the selection of the threshold interval simpler. As it can also be seen in Fig. 4 the mean value of the breathing waveform can vary over the time. In order to prevent that this fluctuation might cause inaccuracies due to a static threshold interval, an average value of the signal over a limited period of time was used, then this value was subtracted to the current smoothed value. With the implementation of this technique the system removes the continuous component of our signal and the resulting signal is the breathing pattern. Besides this, the system can use a static threshold interval, which means that it does not need to periodically compute the thresholds limits. This results in a reduction of the computation resources required and, consequently, on a more energy efficient algorithm. The resulting signal is depicted after the implementation of all the techniques described above, these techniques were applied for the three axis, during the same sampling period. show the resulting signals over the three axis and during a period of 60 seconds, when the infant is lying on his back and when he is lying on his side, respectively.

When he is lying on his side, respectively. It is possible to observe that although some of the breathing cycles are below or slightly above of zero. This will means that the algorithm will be unable to recognize those cycles and this will lead to errors on the estimation of the number of breaths per minute. So, with a careful selection of the threshold limits the algorithm is able to achieve a good performance.

4) *Body Temperature*

For the measuring the body temperature of the infant an infrared thermopile sensor (TMP007) was used.

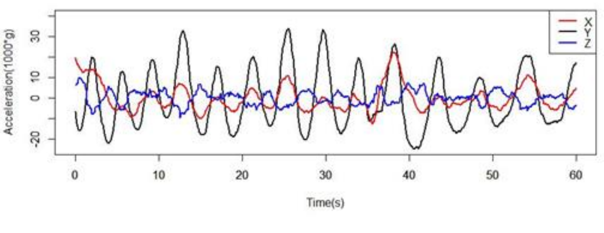


Fig. 2: Body temperature of the infant

The biggest advantage of the TMP007 is that it allows to measure the infant's body temperature without any contact with the skin of the infant. This makes our system less intrusive, more comfortable and, we have not to deal with problem of insufficient contact between the skin and the sensor. This sensor provides a digital interface (I2C/SMBus) and is low power. The I2C interface was used and so an API using the bit banging technique was developed and added to the Z-stack API. For a correct operation of the TMP007, namely the IR thermopile sensor, it must be thermally isolated from the PCB and other heat sources such as other components or, air currents.

B. *Gateway*

A Beagle Bone Black, with a Debian Wheezy image installed, acts as a Gateway. A light server with PHP 5.1 was installed on it to provide the network services. A shield, to the Beagle Bone Black, with a buzzer, RGB led, push-button and a CC2530 was designed and implemented (Fig. 3). For the communication between the CC2530 and the Beagle Bone a Serial Port communication protocol was used. The RGB led and the Buzzer are used to notify the user every time an emergency situation is detected. Different colours are used to notify the users which event occurred. The wireless USB adapter TL-WN725N is used to connect the Gateway to the router. The Beagle Bone stores the data received into the database. Unless some risk event occurs, the information received will only be store at regular intervals.

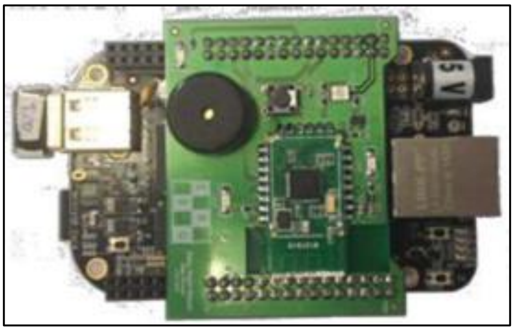
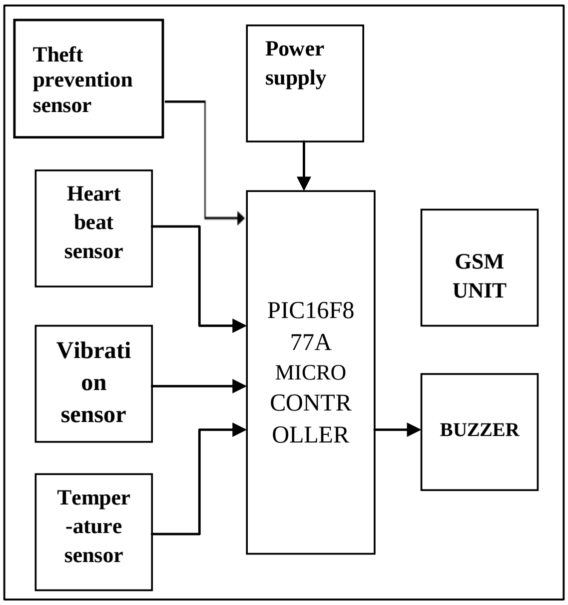


Fig. 3: Gateway: shield placement on the BeagleBone Black.

IV. WORKING



The working of the systems starts with the sensing of the heart beat temperature and miscellaneous vibrations that are expected if there is critical condition and also necessary parameters for monitoring the infants. PIC Microcontroller have the programs responsible for the automated function of the system, whenever there is increment or decrement of values calculated by sensing units, there develops a running sequence of subroutine programmed to operate the interfaced units such as alarms and GSM to communicate with databases.

This is timed and effectively initiated for the indication of abnormal situation around infants including theft of it. Theft prevention sensor is the sensing unit with IR technology which if there is change is the reflection of the signals which indicates the movement of infant it sends the signal to the microcontroller as soon as the indication and complaint is sent to the respective database. The overall working is based on the microcontroller which is developed on the basis of embedded based working medium.

V. CONCLUSIONS AND FUTURE WORK

The Baby Night Watch is capable of detecting unexpected events and registering several physiological parameters, making it a powerful medical tool to understand SIDS, and a reliable real-time monitor of infants. The project proved that with a small amount of hardware a huge number of parameters can be measured, improving the users experience and safety of the infant. The data rate produced by the Wearable IoT Device is in the order of 35 bytes per minute, easily supported by ZigBee.

In the future some changes must be made to improve this SWS: placing the Cloud Storage Center into a webserver, allowing the users to retrieve information without having to be connected to the Gateway; implement some functionalities of the H Medical Web Interface in Python to improve stability and speed; use a more accurate thermophile sensor for the acquisition of the body temperature; improve the connection between the textile electrodes and the sensor node; and use a commercial breathing rate sensor to compare the results of our system during longer periods.

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