A Smart Wearable System for Sudden Infant Death Syndrome Monitoring

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***Abstract*—Sudden Infant Death Syndrome (SIDS) is one of the major causes of death among infants during their sleep. To increase the safety of the infants, we matched different emergent research fields for the development of Baby Night Watch. This Smart Wearable System (SWS), developed under the context of the European Texas Instruments Innovation Challenge (TIIC) 2015, is composed by the following elements: a Wearable IoT Device, a Gateway and the H Medical Interface. The Wearable IoT 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 and body position. After a minimal data processing, this set of information is sent to the Gateway, via ZigBee technology, and it is accessible to the user through the H Medical Interface. If a critical event occurs, the device will trigger an alarm, visible and audible in the proximity, and sends a distress message to a mobile application. The Baby Night Watch is an important tool for medical studies, since it allows the visualization of previous physiological data and export it to different types of datasets. Experimental tests have proven that the SWS has the potential to identify situations that could be potentially life-threatening for an infant.**

Keywords*—*E-textile; Internet of Things; Smart Textiles; Smart Wearable System; Sudden Infant Death Syndrome

I. INTRODUCTION

Sudden Infant Death Syndrome (SIDS) is one of the major causes of death among infants, and it was the main motivator to design a Smart Wearable System (SWS) capable of increasing the safety of the infant.

The "Baby Night Watch" project is a combination of emergent technologies, such as: wearable devices; smart textiles; embedded systems; wireless communications; web-interfaces; and mobile applications, aiming to monitor the infants during their sleep. This SWS is composed by a Wearable IoT device, a Gateway, and an H Medical Interface. The Wearable IoT 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 [1].

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 [2]. 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. For the newborns the typically breathing rate is between 30 to 60 breaths per minute, 40 breaths per minute for infants, and it decreases to 24 to 30 breaths per minute after the first year [3]. 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. For the infants the normal heart rate is above 100 beats per minute [4]. For the body temperature monitoring we use a small contactless infrared temperature sensor.

The main goal of the Baby Night Watch is to reduce the response time in a SIDS scenario. This SWS is able to send different types of alarms (sound, light and, distress messages to smartphones), increasing the reliability of the system. Along with the metrics reliability and latency, the system has to operate continuously for long periods of time (over 8 hours), making the energy efficiency an important metric of the system. Like WSN and WBSN, in SWS main cause of energy consumption are the wireless communications, corresponding to > 60% of the total of energy consumption [5]. Therefore, to improve the lifetime of the battery some features of the wireless transceiver were explored, these techniques are described in [6].

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, such as: health

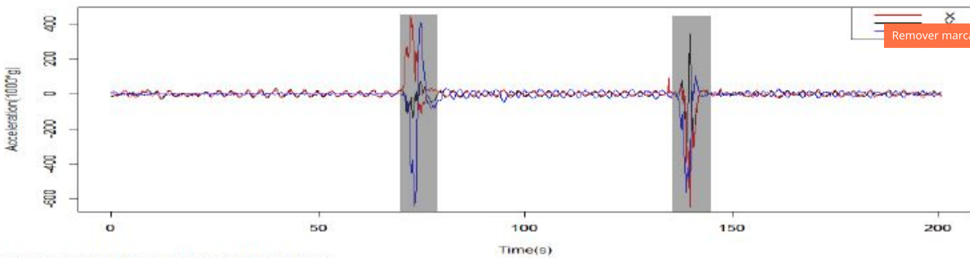

Fig. 11. Breathing waveform during position's changes.

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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