An Effective Alarming Model for Danger and Activity Monitering Using Wearable Sensors for Children

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Abstract—**This paper presents a child activity recognition approach using a single 3-axis accelerometer and a ultra-sonic sensor which is belted around the waist of the baby so as to prevent him from dangers and getting injured. The accelerometer data is collected and monitored in a computer using IEEE 802.15.4 protocol. In addition to the activity recognisation child body temperature can also be monitored at regular time intervals. A fire sensor is also embedded in the proposal so as prevent the baby from fire accidents and a SMS using GSM will be sent to their parents if they are going to be involved in any fire accidents. Child activities are classified into 8 daily activities according to our consideration which are moving left, right, front, back, standing still, climbing up, climbing down, and stopping. The accuracy obtained for every activity is around 90% in any situation using single MEMS ADC sensor and ULTRA-SONIC sensor.**

Index Terms—**Accelerometer, activity classification, activity recognition, baby care, child care.**

I. INTRODUCTION

AT PRESENT BABIES are getting into some accidents due to lack of personal monitoring in this busy world, usually child start walking between 9 and 16 months, there will be chance of falling from higher heights or stairs. As the child learns to climb, they will be at risk of falling from stairs, chairs and beds. Children frequent come across injury due to these accidents unknowingly. Medical research show that these accidents are one of the most common cause of injuries that require medical care, and in some situations non fatal injuries also leads to hospitalization. The main areas these accidents occur are at homes because of lack of parental care. Thus, a new effective alarming model for danger and activity monitoring using triaxial accelerometer for children is required to prevent child from accidents at homes. These accidents have great effect on growth and development of the child. Accident prevention measures are to be taken effectively. The challenging thing is the classification activities in terms of safety and damage occurring to the child. There are many proposals for the recognisation of activity but the challenging task lies with the accurately recognisation of activity the child

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A smart sensor network is used in this proposal for rescuing the baby from injuries and some small cracks on the body. Multi sensor link has been provided for elderly people and children at home. This approach will give the activity data in a simple and recognizable manner. According to the proposal the human activity is recognized by fusing two highly accurate sensors one which is attached to one of the foot and another sensor to the waist of a baby subject, respectively. Due to the use of multiple sensors robustness of the classification systems has been improved drastically and increases the partialness of high-level decision making. On the other hand, the ultra-sonic sensor could fail to detect the activities involved in the activates like head motion, body tilt, and hand motion. In addition to that and for the purpose of minimizing the number of sensors worn, it is important to know the capability of a certain position to classify a set of activities. Recently, Attalla *et al.* Investigated the effects of sensor position and feature selection on activity classification tasks using accelerometers. Accelerometers are the most broadly used sensors to recognize ambulation activities such as walking and running the advantage of the accelerometer is inexpensive, require relatively low power, and are greatest applications in most of mobile phones. The study of the optimal sensor concluded that positions depend on the activities being performed by the subject and these activity recognisation can be made optimized using accelerometers. The dominant role in the designing the system is that it must be designed in a small space and low weight which can be bearable by the baby. As we are optimizing the sensor activity so we have to compromise in the accuracy. It is difficult to configure an optimal system. It depends on mainly on two important factors one is sensor activity and the positions of the baby. In our study, to decrease the incomfertness the waist belt is kept diaper for the children below three years of age, during physical activity and to measure body motions such as moving left, right forward backward, climbing up and climbing down. In our proposal mainly we have designed a wearable sensor device and a monitoring application to collect information about the activities and to recognize baby activities baby is doing. We classified baby activities into 8 daily activities which are moving left, right, front, back, standing still, climbing up, climbing down, and stopping. As multiple sensors are embedded in a wearable device which are more accurate for collecting different types of sensing information but would be very inconvenient for users.

TABLE I
SENSOR AND TYPES OF THE COMPONANTS USED

TYPE	SENSOR	VALUE	FEATURE
Space	RFID	Room identification	Location (kitchen, dining room, bed)
Object	RFID	ID	Object Name (electric socket)
Activity	3-axis accelerometer	[-2g, +2g]	Activity (moving left, right)
Height	Ultra-sonic sensor	[30kPa,129kPa]	Height from the ground
Temperature	LM35	[20◦C,100◦C]	Ambient temperature
Fire	Fire sensor	-	Detection of fire near the baby
SMS	GSM	-	Alarming the baby is in danger

For this reason, we present only one single unit of sensor nodes, which collects multiple types of information. The nature of information interaction involved in sensor fusion can be classified as competitive, complementary, and cooperative fusion. In competitive fusion, each sensor provides equivalent information about the process being monitored. In complementary fusion, sensors do not depend on each other directly, as each sensor captures different aspects of the physical process. The measured information is merged to form a more complete picture of the phenomenon. Cooperative fusion of the two sensors enables recognition of the activity that could not be detected by each single sensor. Due to the compounding effect, the accuracy and reliability of cooperative fusion is sensitive to inaccuracies in all simple sensor components used. In this paper, we select the cooperative fusion model to combine information from sensors to capture data with improved reliability, precision, fault tolerance, and reasoning power to a degree that is beyond the capacity of each sensor. The main contributions of this paper over the earlier previous work are

1) To extend the method to work with arbitrary every day activities not just walking by improving the feature selection and recognition procedure.
2) To perform evaluation on a large (50 h) dataset recorded from real life activities.
3) To have studied ten divers subjects: 16, 17, 20, 25, 27 months-old baby boys and 21, 23, 24, 26, 29 months-old girls.
4) To employ a barometric pressure sensor for improving upon the previous algorithms.

The proposed method classified daily physical activity of children by a diaper worn device consisting of a single triaxial accelerometer and a ultra-sonic sensor. We demonstrate our improvements in comparison to the accuracy results of only a single-wearable device and multiple feature sets to find an optimized classification method.

II. METHODS

A. Sensor Device

In order to recognize daily activities, we adopt multiple sensors, as shown in Table I, as follows:
1) A 3-axis accelerometer measures the movement;
2) An absolute ultra-sonic sensor measures absolute pressure enabling a measurement of a distance between the ground and the wearable sensor device;
3) A radio-frequency identification (RFID) (Skye Module M1-mini) is selected to read/write tags and smart labels, which has compatibility with most industry standard 13.56 MHz's.

We used the MEMS ADC that is a 3-axis accelerometer for applications requiring high performance with low power consumption. It consists of three signal-processing channels where it is low-pass filtered and communicates with the processing layer based on SPI bus that is a full duplex synchronous 4-wire serial interface. We also used the as a ultra-sonic sensor that measures absolute distance to measure distance between the ground and the sensor. The distance and temperature output data are calibrated and compensated internally. The sensor Communicates with the processing layer through an SPI bus. The Skye Module M1-mini has a read/write distance that is typically greater than or equal to two inches for an ISO15693 RFID inlay. The sensor allows us to recognize objects and space that may cause dangerous situations. Finally, we developed the prototype wearable sensor device (size of 65mm × 25 mm) including the dual-core processor and sensors as shown in Fig. 1.

III. BLOCK DIAGRAM

In the baby side we will be having LPC2148, LM35, Fire sensor, RFID reader, MEMS sensor and Ultra-sonic sensor a 3-axis accelerometer measures the movement. An absolute ultra-sonic sensor measures absolute pressure enabling a measurement of a distance between the ground and the wearable sensor device. An absolute ultra-sonic sensor measures absolute pressure enabling a measurement of a distance between the ground and the wearable sensor device. We also used the as a ultra-sonic sensor that measures absolute distance to measure distance between the ground and the sensor. The temperature sensor which measure the body temperature at regular intervals of time. The fire sensor which helps baby to be involved in any fire accidents. When the baby was in danger a sms will sent to their parents so they can come for his rescue. These all devices can be embedded on single chip and they can be attached on a belt so that it will not be uncomfortable to the baby.

MEMS ADC that is a 3-axis accelerometer for applications requiring high performance with low power consumption. The MEMS used in this proposal is mainly intended to increase the accuracy of the baby activity recognisation. The ultrasonic sensor is mainly useful to find the distance of the baby from the ground so we can calculate the position of the baby by their respective heights for their corresponding activity.both these two sensors must work efficiently to make the system perfect.

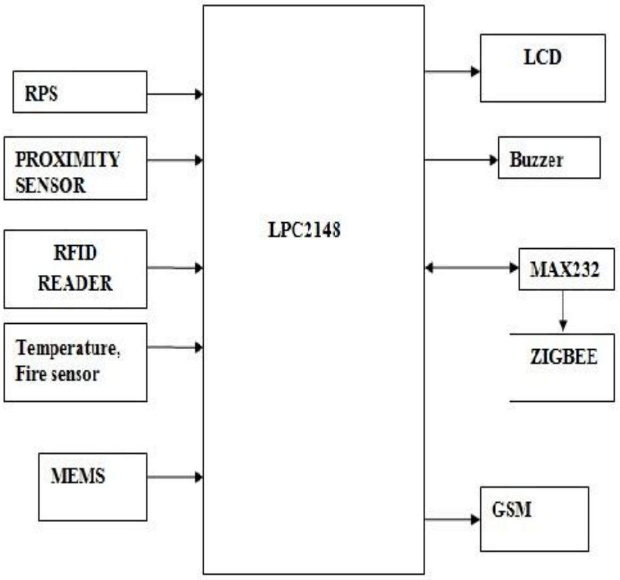

Fig.1. Prototype of the wearable sensor device and the RFID reader.

At the receiver section for monitoring purpose we will be having a computer attached with a zigbee module so as soon as the data is transmitted from the baby that will be displayed in the hyper terminal. For every change in the activity the corresponding activity name will be displayed on the screen.

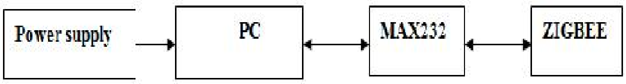

Fig.2. Prototype of the receiver end for monitoring.

Here in this proposal RFID tags are provided for each room and any dangerous objects like power sockets e.t.c, so when the active cards are detected by the RFID reader in the baby unit then an alarming message will be displayed on the computer hyper terminal so after seeing this a man can go and avoid the baby from that danger preventing injuries and some fedial injuries on the body. A message will also be sent to the chosen person by using the gsm module present with the baby. Here in this proposal we are giving a RFID tag to each and every room in the house so as to monitor the baby position in the house which makes it easy for the person to go for the rescue.

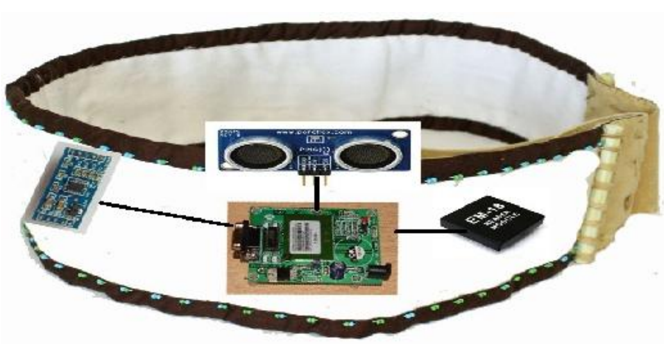

Fig.3. Prototype of the waist belt

The above figure shows the prototype of the waist belt we are using in the proposal, this belt is properly placed on to the baby so that it will not be uncomfortable for the baby.

D. Activity Recognition

After the preparation of the all the mechanical possibilities are ready and all the circuitry is complete then we will proceed to the working of accelerometer and ultra-sonic sensor to recognize the activities. A classification procedure separates the child’s activities from all other primitive features. The activity recognition algorithm should be able to recognize the accelerometer signal pattern corresponding to every activity.

***Standing still**:* If the baby is standing still the position of the the plane of the mems sensor will be perpendicular to x-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has no task to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

***Moving left**:* If the baby is moving let the position of the the plane of the mems sensor will be perpendicular to negative y-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has no task to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

***Moving right**:* If the baby is moving right the position of the the plane of the mems sensor will be perpendicular to y-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has no task to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

***Moving forward**:* If the baby is moving forward the position of the the plane of the mems sensor will be perpendicular to negative z-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has no task to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

***Moving backward**:* If the baby is moving backward the position of the the plane of the mems sensor will be perpendicular to z-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has no task to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

Climbing up: If the baby is climbing up the position of the the plane of the mems sensor will be perpendicular to x-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has task to perform. The ultra-sonic sensor will move up for a fixed distance indicating that the baby is climbing up. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

Climbing down: If the baby is climbing down the position of the the plane of the mems sensor will be perpendicular to x-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has a task a to perform. The ultra-sonic sensor will move up down for a fixed distance indicating that the baby is climbing down. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

Sitting down: If the baby is Sitting down the position of the the plane of the mems sensor will be perpendicular to negative x-axis respectively. The mems sensor will sense all the positions accurately. Here in this activity the ultra-sonic sensor has task a to perform. Then the data is transmitted i.e. nothing but some milli volts voltage will be generated and it is compared according to the program. Then the data will be transmitted to the receiver section and displayed in the hyper terminal for monitoring purpose with the help of zigbee modulus.

TABLE II
SENSOR POSSITION ACCOURDING TO ACTIVITIES

ACTIVITY	ACCELEROMETER POSITION	ULTRA-SONIC POSITION
Standing still	Perpendicular to x-axis	-
Moving left	Perpendicular to negative y-axis	-
Moving right	Perpendicular to y-axis	-
Moving forward	Perpendicular to negative z-axis	-
Moving backward	Perpendicular to z-axis	-
Climbing up	Perpendicular to x-axis	Will move upwards
Climbing down	Perpendicular to x-axis	Will move downwards

The above sensors data will stored at regular intervals of time so as to analyze the baby behavior. So as we can take preventive measures an avoiding those things which greatly effecting the baby. Here temperature sensor plays an important role in sensing the temperature of the baby, the abnormal condition of the temperature is programmed between 28°F to 100 °F respectively. So these are the abnormal which are taken into consideration. Here a fire sensor is provided so as rescue the baby if he is involved in any fire accident or if he is near to fire. Each and every device which is harmful to the baby in the house is given with an rfid card so as to prevent the baby from injuries. If in any situation the baby is near to these devices the alarm will be blown and baby will rescued from all the dangerous articles in the home. For smaller devices a RFID pil can be provided as to facilitate comfortable working. So from the proposal we are able to provide a secure home for the babies below 2 years of age. This system is more accurate compared with all the present existing systems in the market. This proposal has a greatest advent in present day world which makes a great sense.

III. RESULTS

A. Experimental Setup

We have volunteered two families to conduct the experiment in 40 m^2 bed room and 20 m^2 gardens. In a controlled environment setting, all data were collected from ten babies who are 16, 17, 20, 25, 27 months-old baby boys and 21, 23, 24, 26, and 29 months-old baby girls. A supporter who observed the experiments annotates raw data by clicking buttons or typing name of the activities through the monitoring application. All experiments were performed in a real home environment consisting of one wearable sensor device for the child and the monitoring application operated on a laptop computer. Baby boys wiggled more than baby girls. They squirmed more and get restless on the floor, and crawl over longer distances. While the average boy did not move around much more than the typical girl, the most active children were almost always boys, and the least active children were girls.

The following are the results of different activities of a child in different conditions.

i) This is the result when the baby is moving forward.

Fig.4. baby in forward motion

ii) This is the result when the baby is moving backward.

Fig.5. baby in backward motion

iii) This is the result when the baby is climbing down.

Fig.6. baby is climbing down

iv) This is the result when the baby is climbing up.

Fig.7. baby is climbing up.

v) This is the result when the baby is moving right.

Fig.8. baby is moving right

vi) This is the result when the baby is moving left.

Fig.9. baby is moving left

vii) This is the result when the baby is baby is danger, sms will be sent to the parents.

Fig.10. sms alert to the parents

viii) This is the result at the receiver section

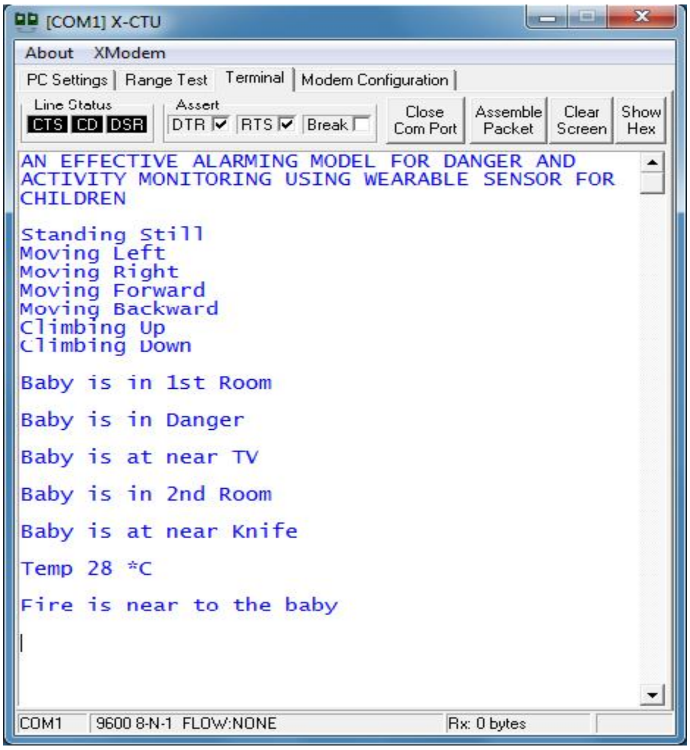

Fig.11. Result at the receiver section

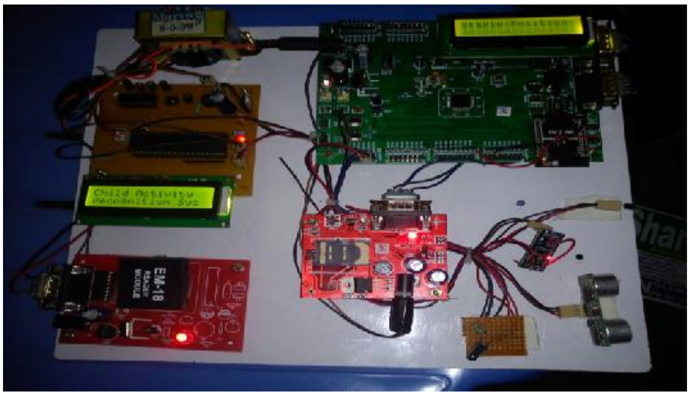

Fig12: Practical implementation of the idea.

IV. CONCLUSION

This paper has presented the activity recognition method for Children using only a triaxial accelerometer and an ultra sonic sensor. Results showed that using an ultra-sonic sensor could reduce the incidence of false alarms. The early warning system will give the parents enough time to save their babies, and, thus, minimize any instances of falling accidents or sudden infant death syndrome.

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