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Child Activity Recognition Using Accelerometer and RFID Reader

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Abstract—This paper presents a child activity recognition using a accelerometer and RFID reader. Usually children start walking between 8 months to 16 months and they are more dangerous during this age. So we place accelerometer and RFID on the body of child to prevent child accidents such as falling or any injuries at home. In this paper we determine the activity of child such as sitting down, standing still, walking, toddling, crawling, rolling, and wiggling. The accelerometer and RFID are placed on waist of babies which gives every movement of child. That determine whether the child is falling or in safe mode. The accuracy of each child activity recognition was 98% using accelerometer and RFID reader. The temperature at home and fire at home can be determined by smoke sensor and temperature sensor for safety of child. To recognize daily activities, mean, standard deviation, and slope of time-domain features are calculated over sliding windows.
Index Terms— Accelerometer, RFID reader, child activity, activity recognition.

I. INTRODUCTION

The child activity recognition using sensor such as accelerometer and RFID reader can be used in Varity of application. The activity recognition can be adopted in real time. As children usually start walking between 8 months and 16 months, at this age they are more risk of falling from window and staircase. Falls are a frequent cause of injury in children. At this age they go near dangerous material such as refrigerator, electric socket, wet room, kitchen etc. Accident and emergency departments systems show that falls are one of the most common mechanisms of injuries that require medical care, and the most common nonfatal injury that at times needs hospitalisation. In children younger than four years of age, most fall-related injuries occur at home. Thus, a new safety management method for children is required to prevent child home accidents. In order to overcome problem we are implementing child activity recognition using accelerometer and RFID reader. One of most challenging issue in this context is to monitor daily activity of children and prevent child from high temperature using temperature senor and determine fire at home using smoke sensor. Recently, Atallah *et al.* investigated the effects of sensor position and feature selection on activity classification tasks using accelerometers. Accelerometers are not only the most broadly used sensors to recognize ambulation activities such as walking and running, but also inexpensive, require relatively low power, and are embedded in most of cellular phones. Their study concluded that optimal sensor positions depend on the activities being performed by the subject. Other important factors to consider, especially if the system is designed for long and continuous use, are how comfortable it is to wear and how easy it is to put on. Frequently, accuracy must be compromised for ease of use and comfort, due to a reduction in number of sensors. The optimal system configuration is, therefore, difficult to evaluate. It depends not only on the accuracy of the system but also on other practical aspects. In our study, for children under three years of age, the waist-worn sensor is put in a diaper to minimize uncomfortableness during physical activity.

We have developed a wearable sensor device and a monitoring application to collect information and to recognize baby activities

TABLE I
SENSOR TYPES OF THE WEARABLE SENSOR DEVICE

Type	Sensor	value	Feature
Space	RFID	ID	Location(e.g. living room, dining room)
Object	RFID	ID	Object name(e.g. electric socket)
Activity	3-axis accelerometer	[-2g, +2g]	Activity(e.g. toddling, standing)
Smoke	Smoke sensor	2.5v	Smoke
Temperature	Temperature sensor	[40◦C,125◦C]	Ambient temperature

II. DATA COLLECTION

Data from accelerometer has the following attributes: time, accelerometer along x axis, accelerometer along y axis, accelerometer along z axis. We use a accelerometer ADXL335 which is capable of sensing accelerations up to 4G with tolerance within 2%. The accelerometer is mounded on body of child as shown in figure 1. The data generated by accelerometer was transmitted to Renasas microcontroller which is heart of our project then it is transmitted to parents through GSM.

We collect data for 7 activities

- Sitting down
- Standing still
- Walking
- Toddling
- Crawling,
- Rolling
- Wiggling

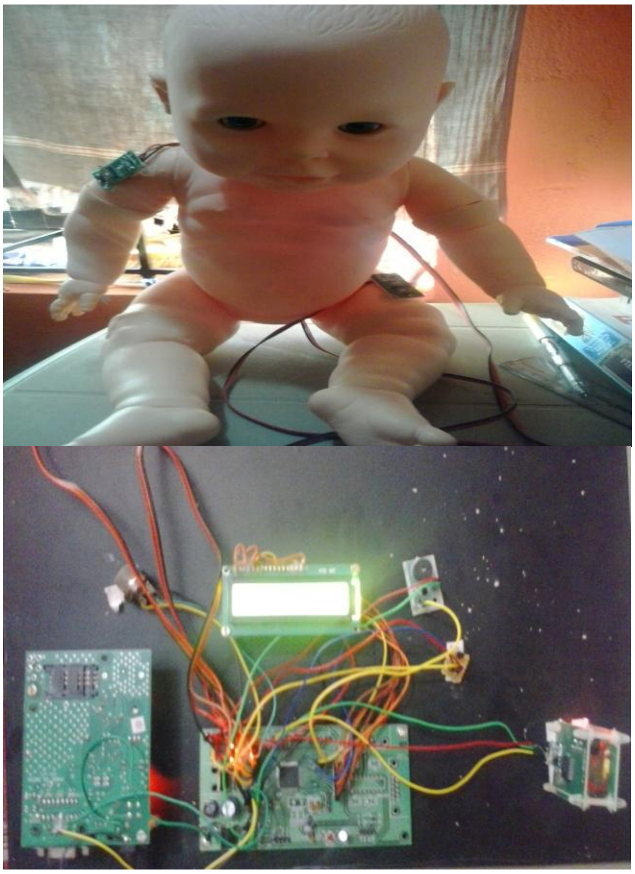

Figure 1: accelerometer placed on body

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. 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 is sensitive to inaccuracies in all simple sensor components used. In this paper, we select Renasas microcontroller to store 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) Accelerometer measures the movement: We used the ADXL335 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.

2) A radio-frequency identification (RFID):is selected to read/write tags and smart labels, which has compatibility with most industry standard 13.56 MHz.
3) Temperature sensor: We also used LM35 as temperature sensor to record the temperature at home to prevent the child.
4) Smoke sensor: we use MQ-2 as a smoke sensor to detect fire or any smoke in home for security of child to prevent child.

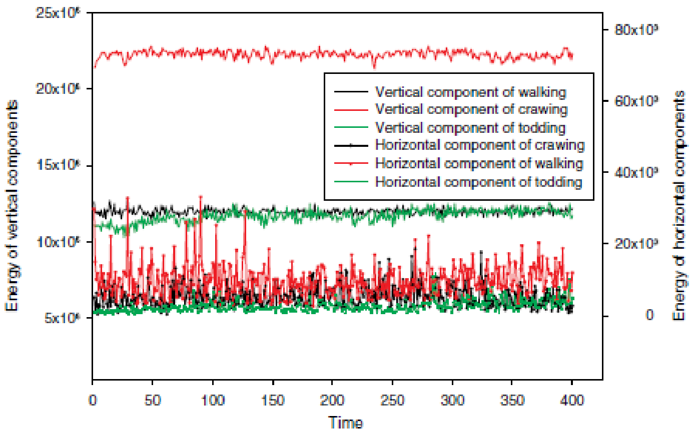

Figure 2: Energy of vertical and horizontal components for crawling, walking and toddling

III. METHODOLOGIES

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
2) a radio-frequency identification (RFID) (SkyeModule M1-mini)is selected to read/write tags and smart labels.
3) Temperature sensor
4) Smoke sensor

Based on SPI bus that is a full duplex synchronous 4-wire serial interface. The sensor communicates with the processing layer through an SPI bus. The SkyeModule 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.

B. System Architecture

The proposed system consists of eight main components:
1. Renasas Micro Controller
2. ALCD
3. GSM.
4. Buzzer
5. Temperature Sensor
6. Smoke Sensor
7. RFID
8. Accelerometer
1. Micro Controller: we used Renasas R5F100LEA microcontroller which is heart of our project
2. ALCD: LCD is thin flat display used to display text and image
3. GSM: GSM is global system for mobile communication used to send message.
4. Buzzer: Buzzer is an audio signaling device, which may be mechanical, electromechanical or piezoelectric.
5. Temperature Sensor: The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature.6. Smoke Sensor: It is used to detect smoke in home ee used MQ-2 as smoke sensor
7. RFID Reader and Card: Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags
8. Accelerometer: It is mainly used for determination of x, y and z direction

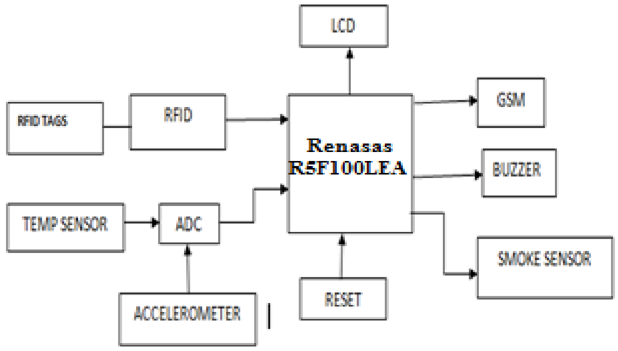

Figure 3: system Architecture

- This project is designed to monitor the physical activities of child which are generally disabled/ injured with some body parts (example hand , leg etc) ,where baby try to avoid to make movement of injured part, which will results in retard growth of tissue of that body part and may lead to totally damage to that part.
- So to overcome all these problems we need to monitor the activities of child whole day which is impossible for doctor.
- At this time we make use of our system which will help us to monitor & give us whole day activity log of child with graphical representation on Android/dot net system.
- For demo point of view we place three accelerometers on baby toy's body parts such as Hand, legs & back.
- Here we observe the different voltage values of accelerometers form only X axis of hand, X axis of leg & both X & Y axis of back.
- Generally those output voltage values ranges from 1.32 to 1.98 approximately w.r.t. axis.
- We manually set different position of child toy by making movement of different parts, Example for demo like walk, crawling, standing still etc.
- As programmer technical point of view the accelerometers will give different scale of voltage ranges for walking crawling etc.
- Last we lastly compare all the position levels of different parts and come to conclusions that baby toy is standing still, walking, crawling etc. Example if hand position = 1 && leg position =1 && back position=1, then baby is standing still.
- Whenever different position are attained these position will be sent to android/dot net system where they plot a pie chart graph of activities of child on hit rates of position from main system on child i.e. a complete day log, But for demo we plot around 10 minutes log graph.

C. Feature Extraction

Let X, Y, and Z denote the infinite data stream of measured Acceleration values of the three space dimensions

X = (x1, x2 . . .), Y= (y1, y2 . . .), Z= (z1, z2 . . .).(1)

The corresponding data stream *M* of the magnitude is defined as

M = (*m*1, *m*2 . . .)

$$\text{where } m_i = \sqrt{x_i^2 + y_i^2 + z_i^2}. \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Features were extracted from accelerometer data using window size of 256 with 128 samples overlapping between consecutive windows. Feature extracted on window with 50% overlap has demonstrated success in previous work. At sampling frequency of 50Hz each window represent data for 5.12 second.

Two features were extracted from each of the three of accelerometer are

- Mean
- Std deviation

Table II

Feature subsets and recognition accuracy

Feature Set	NB	BN	SVM
Mean	24.2%	62.3%	28.7%
Std	41%	49.9%	26.6%
Mean & std	40.3%	68.6	49.6%

IV. RESULTS

A. Testing

Ten families were volunteered to conduct the experiment in Kitchen. In a controlled laboratory setting, all data were collected from ten babies who are 8, 9, 10, 12 months-old baby.. 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. And record each activity of child in android mobile using GSM.

B. Experimental Results

Figure 4: ALCD display of main activity

Figure 5: ALCD display to punch card

Figure 6: ALCD display to system start.

Figure 7: ALCD display of sitting down

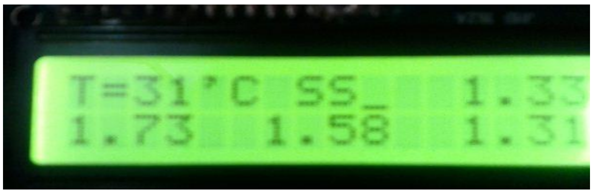

Figure 8: ALCD display of standing still

Figure 9: ALCD display of walking

Figure 10: ALCD display of toddling

Figure 11: ALCD display of wiggling

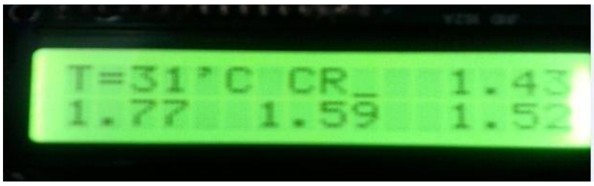

Figure 12: ALCD display of crawling

Figure 13: ALCD display of rolling

Figure 14: ALCD display of hard material

Figure 15: ALCD display of refrigerator

Figure 16: ALCD display of kitchen

Figure 17: ALCD display of electric socket

Figure 18: ALCD display of high temperature

Figure 19: ALCD display of smoke sensor

V. CONCLUSION AND FUTURE WORK

Child activity recognition using accelerometer and RFID reader presented the activity recognition method for children using only accelerometer and RFID reader. Time-domain and frequency-domain features are extracted for categorizing body postures such as standing still, sitting down ,walking, rotating and wiggling as well as locomotion such as toddling and crawling. To improve the performance of the child activity recognition method, six features including magnitude, mean, standard deviation, slope, energy, and correlation are extracted from the preprocessed signals. Multiple feature sets are compared to find an optimized classification method, and showed how well they performed on a body.

One of the most challenging issues in this context is to classify daily activities of children into safe and dangerous activities. Although numerous approaches have proposed various activity recognition methods, human activity recognition is one of the challenging issues in terms of accurate recognition. In general, a pervasive safety management system aims to reduce risk factors of injuries to prevent accidents by using smart sensors. Multi sensor fusion has been applied to daily life monitoring for elderly people and children at home.

The use of multiple sensors has been shown to improve the robustness of the classification systems and enhance the reliability of the high-level decision making. On the other hand, a waist worn sensor could fail to detect activities involving 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.

Even though the overall objectives of the project are met still there is lots of scope for further enhancement to improve upon.

- Wireless communication technologies: There are various wireless communication technologies that are available in the market, we can use them and improve range of communication. However step by step improvements could move towards that goal.
- Night vision camera: Usage of the night vision camera with an inbuilt microphone helps us to collect A/V data during night also.
- Satellite phones: There are many satellite phones are available to provide continuous network to overcome problems of network breakdown.
- Security system: There is various security systems for homes we can integrate into the same project to make project very useful.
- Camera and microphone: Usage of camera and microphone at home to record the activity of child and to get video information to the parents.

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