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Real time Recognition and monitoring a Child Activity based on smart embedded sensor fusion and GSM technology

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----------ABSTRACT----------

HUMAN activity recognition is one of the most promising research topics for a variety of areas, including pervasive and mobile computing, surveillance-based security, context-aware computing and AAL (Ambient Assistive Living).Activity recognition means, a task which involves identifying the physical activity a user is performing. In this proposed system, we describe the method of recognition of a child activity of both sexes up to the age of 16 to 29 months by using 3-axis accelerometers on leg, hand and waist of the body to prevent child accidents such as unintentional injuries at home. Falls are a major cause of injury in children. Child activities are classified into 6 daily activities which are rolling, standing still, sitting down, walking, toddling, crawling. The proposed system consists of five main components: 1) 3-axial accelerometer to measure movement in X, Y, Z direction. 2) the wireless receiver to receive the measured data over ZiGBee wireless protocol and transmit it to PC over USB connection; 3) the activity monitor and analyzer working on the PC to aggregate the measured raw data and to analyze behavioral characteristics using features and classifiers and 4) the GSM modem to broadcast emergency message alerts to their parents or a guardian. 5) The temperature sensor measures the body temperature of child.

Keywords *- Activity recognition, 3-axis accelerometer, GSM modem, Radio Frequency Identification System, Zigbee wireless module.*

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I. INTRODUCTION

Usually the babies of the age between 9 and 16 months starts walking and they are at a risk of falling down from stairs or furniture's. As toddlers will learn jumping and climbing they are at risk of falling from windows and beds. The major causes of injury in children are falling. Accident and emergency departments and outpatient surveillance systems have declared that falls are the major common mechanism of injuries that required a medical care. In children less than 4years most fall related injuries will occur at home hence to prevent child home accidents a new safety management is required. Hence childrens falling has to be prevented. Multi-channel accelerometry with calibrated sensors are very promising methodology have many advantages. The actual posture and the pattern of motion are basically provides a frame of reference for the evaluation of many behaviors, symptoms and physiological changes. Accelerometers are embedded within wrist bands, bracelets, adhesive patches and belts. The data from sensor is sent to mobile computing device through wireless communication. The computing device analyze the received signal and recognize the user activity.

Although numerous approaches [1]–[3] 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 [4], [5]. This approach trained using manually annotated data and applied for activity recognition. Zhu et al. [6] also suggested human activity recognition by fusing two wearable inertial sensors attached to one foot and the waist of a human subject, respectively. 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.

Activity recognition is a complex process that can be roughly characterized by four basic tasks. These tasks include (1) to choose and deploy appropriate sensors to objects and environments in order to monitor and capture a user's behavior along with the state change of the environment, (2) to collect, store and process perceived information through data analysis techniques and/or knowledge representation formalisms at appropriate levels of abstraction, (3) to create computational activity models in a way that allows software systems/agents to conduct reasoning and manipulation, and finally (4) to select or develop reasoning algorithms to infer activities from sensor data. For each individual task a raft of methods, technologies and tools are available for use. It is often the case that the selection of a method used for one task is dependent on the method of another task.

II. CLASSIFICATION OF ACTIVITY RECOGNITION

Activity recognition has been classified in the following ways.

- Vision-based activity recognition.
- Sensor-based activity recognition.
- Data driven activity recognition.
- Knowledge-driven activity recognition.

2.1 Vision-based activity recognition

The first is referred to as vision-based activity recognition, which is based on the use of visual sensing facilities such as video cameras to monitor an actor's behavior and environmental changes. The generated sensor data are video sequences or digitized visual data. The approaches in this category exploit computer vision techniques, including feature extraction, structural modeling, movement segmentation, action extraction and movement tracking to analyze visual observations for pattern recognition.

2.2 Sensor-based activity recognition

The second category is referred to as sensor-based activity recognition, which is based on the use of emerging sensor network technologies for activity monitoring. The generated sensor data from sensor-based monitoring are mainly time series of state changes and/or various parameter values that are usually processed through data fusion, probabilistic or statistical analysis methods and formal knowledge technologies for activity recognition.

2.3 Data driven activity recognition

This method involves the creation of probabilistic or statistical activity models, followed by training and learning processes. As this method is driven by data, and the ensued activity inference is based on probabilistic or statistical classification, it is often referred to as data-driven or bottom-up approaches. The advantages of the data-driven approaches are the capabilities of handling uncertainty and temporal information. However, this method requires large datasets for training and learning, and suffers from the data scarcity or the "cold start" problem. It is also difficult to apply learnt activity models from one person to another. As such this method suffers from the problems of scalability and re-usability.

2.4 Knowledge-driven activity recognition

The other method for building activity models is to exploit rich prior knowledge in the domain of interest to construct activity models directly using knowledge engineering and management technologies. This usually involves knowledge acquisition, formal modeling, and representation. Activity models generated in this method are normally used for activity recognition or prediction through formal logical reasoning, e.g., deduction, induction or abduction. As such, this method is referred to as knowledge-driven or top-down approach. Knowledge-driven approaches have the advantages of being semantically clear, logically elegant and easy to get started.

III. SYSTEM DESIGN

3.1 Sensor Device

In order to recognize daily activities, we adopt multiple sensors, as shown in Table 1, as follows: 1) a 3-axis accelerometer measures the movement; 2) a temperature sensor measures the body temperature of child; 3) a radio-frequency identification (RFID) is selected to read/write tags and smart labels.

Table 1. Sensor type of Wearable sensor device

Type	Sensor	Value	Feature
Object	RFID	ID	Object Name(e.g. Electric socket)
Activity	3-axis accelerometer	[-3g, +3g]	Activity(e.g. toddling, standing)
Temperature	Temperature sensor	[-40 C, 125 C]	Body Temperature

We used the ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. We also use LM35 as temperature sensor. The EM-18 RFID Reader module operating at 125 KHz is an inexpensive solution for your RFID based application. The Reader module comes with an on-chip antenna and can be powered up with a 5V power supply. We describe the method of recognition of a child activity of both sexes up to the age of 16 to 29 months by using 3-axis accelerometers on leg, hand and waist of the body to prevent child accidents such as unintentional injuries at home. Falls are a major cause of injury in children. Child activities are classified into 6 daily activities which are rolling, standing still, sitting down, walking, toddling crawling.

3.2 Proposed System

The proposed system consists of five main components: 1) 3-axis accelerometer to measure movement in X, Y, Z direction. 2) the wireless receiver to receive the measured data over ZiGBee wireless protocol and transmit it to PC over USB connection; 3) the activity monitor and analyzer working on the PC to aggregate the measured raw data and to analyze behavioral characteristics using features and classifiers and 4) the temperature sensor to measure the temperature of child; 5) the GSM modem to broadcast emergency message alerts to their parents or a guardian. The proposed activity recognition method using a 3-axis accelerometer and a temperature sensor comprises the following three steps: 1) collecting and preprocessing the sensor data from an accelerometer; 2) extracting features; and 3) training and classification.

3.2.1 Block diagram of Transmitter

ARM7 (LPC2148) is the heart of the system which controls all the blocks of the system shown in the fig.1. To observe the child and to show all the activities of the child in home, accelerometer and RFID card (NFC Cards) are attached. Where accelerometer detects child present and falling stages through its axis and RFID card will be read by RFID reader. Which will acts as near field communication RFID card is attached to table or bulky items. ZIGBEE is used for sending wireless data to receiver side.

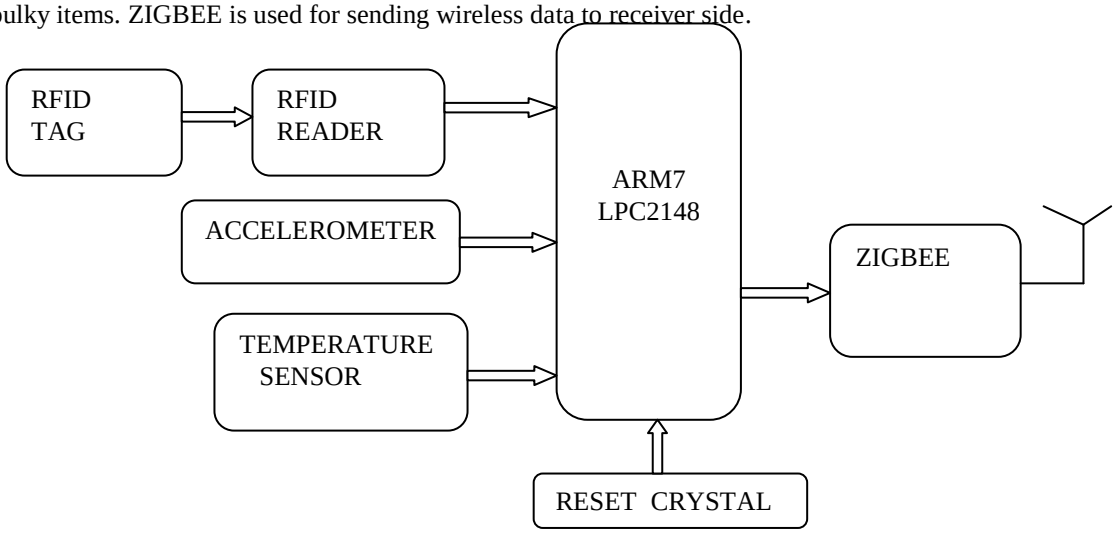

Fig. 1 Block diagram of Transmitter.

3.2.2 Block diagram of Receiver

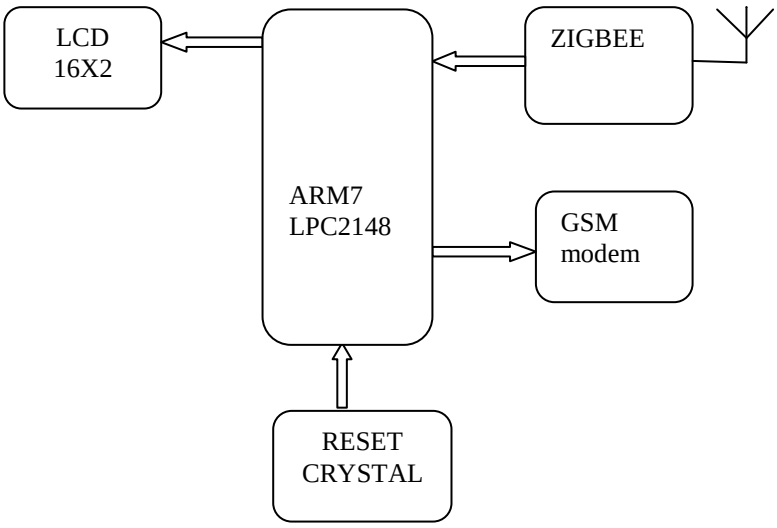

Fig. 2 Block diagram of Receiver.

The above fig.2 shows block diagram of receiver of proposed system. Global System for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM has established in 1982 is the name of a standardization group to create a common European mobile telephone standard. AT Commands are used to get information in SIM card. GSM in receiver used to send message alerts to their parents or guardian. LCD shows output message.

IV RESULT

4.1 Experimental Setup

In this proposed system, coding is written for GSM and RFID, measuring body temperature, fall detection of children of which is interfaced with ARM7 board at the transmitter end. As per the code embedded in the controller, the interfaced modules generate appropriate output at the receiving end. We use keilμvision4 for writing embedded c programs. Fig.3 shows the prototype for transmitter section. RFID reader detects the RFID tag which is attached to any objects. Transmit the signal to the ARM7 controller, which sends data to receiver through wireless zigbee module.

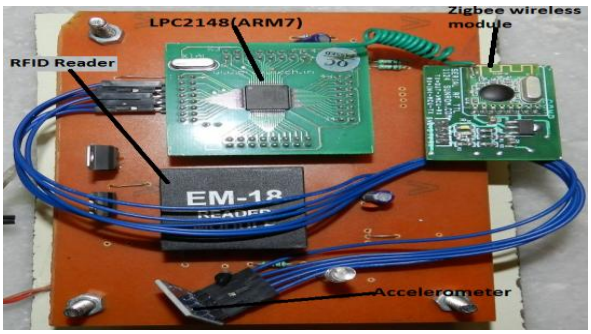

Fig. 3 Prototype of wearable sensor device of Transmitter side

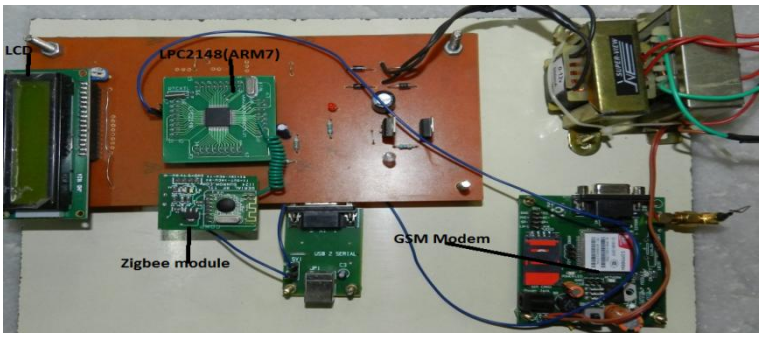

Fig. 4 Prototype of wearable sensor device of Receiver side

The above fig.4 shows receiver prototype of proposed system. The GSM Modem is connected to the Tx/Rx pins of the microcontroller. The obtained ADC values are compared with reference values. If the obtained values are less than reference value then activity of child will be recognized. The activity of child can be extracted by swiping the RFID tag. When RFID is swiped the unique ID is sent to the controller. By processing the ID, the activity of child is displayed on LCD and also the records are sent to their parents via GSM.

The temperature sensing is performed by using a LM35 IC. Human body needs special type of sensors for reliable Readings which led to the choice of using the LM35 Temperature Sensors in our prototype. It operates at 3 to 5 V and can measure temperature in the range of -40 C to +125 C which is sufficient for the targeted body temperature range. The sensor's output is an analog DC voltage signal which is read by the microcontroller using an analog pin linked to an ADC. The ADC used has a resolution of 10-bits, 1024 levels, with a sample rate of 9600 Hz input voltage range depending on the ground and Vcc. The temperature monitoring system main objective is to continuously measure body temperature. The system shall always check for three hazardous conditions which are maximum temperature, minimum temperature, and maximum temperature change over a specific period of time. The below Table 2 measure the values of voltages of simulated graph. Depending on the values child activity will be recognized and displayed on PC.

Table 2 Voltage values of sensor

Position	Leg	Hand	Back x	Back y
Sitting down	1.39V	1.26V	1.20V	1.47V
Standing still	1.21V	1.24V	1.20V	1.51V
Walking	1.29V	1.31V	1.20V	1.51V
Toddling	1.47V	1.61V	1.21V	1.52V
Crawling	1.32V	1.33V	1.45V	1.48V
Rolling	1.55V	1.38V	1.51V	1.80V

4.2 Experimental Result

This prototype consists of ARM controller, temperature sensor, voice play back device, accident detector, and GSM module. The temperature sensor senses the temperature value in Celsius and sends SMS in case of high temperature (60 degree). The accident detection sensor will detect the three levels that is low, middle and high level and when the low level is detected the alert message will be send to an ambulance as well as parents number. The below fig.5 shows the magnitude of acceleration is plotted, which classifies the different activity based on voltage values of accelerometer.

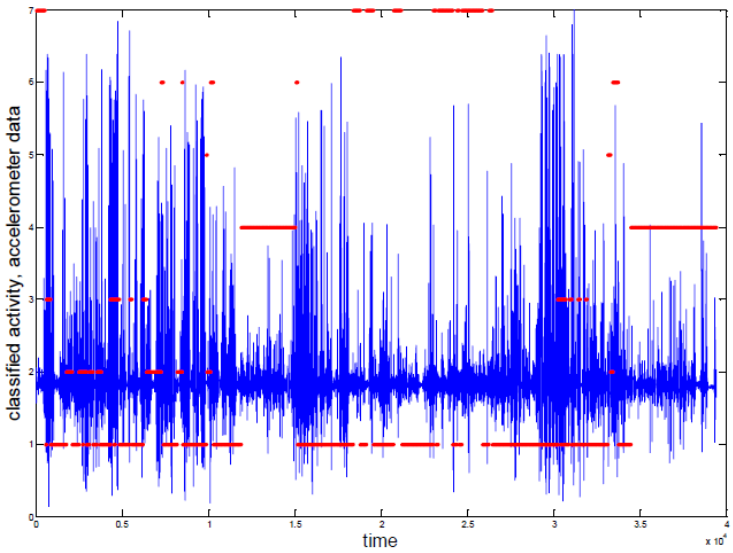

Fig.5. Magnitude of acceleration is plotted.

The experiment was conducted during a normal activity of a 2-year old child in an indoor setting. As shown in fig.3 the wireless sensor device was placed in the back pocket of the trouser. The sensor signals were sampled with a frequency of 50 Hz. Seven types of activities have been considered during the experiment. Approximately 30 minutes of sensor data has been recorded with a synchronized video material for ground-truth creation. The sensor device contains a tri-axial accelerometer with maximum acceleration of 3g. From the acquired data, train and test sets were obtained by randomly splitting the data segments into training and test sets. A 3-fold validation was employed to obtain mean classification performance numbers including 95% confidence intervals. However the design system resulted in a good performance of 97.8%±0.2%. This result shows clearly the benefit of using a multi-sensor approach.

V. CONCLUSION

Activity recognition has become the determinant to the success of the new wave of context-aware personalized applications in a number of emerging computing areas, e.g., pervasive computing and smart environments. We present a survey of the state-of-the-art research on sensor-based activity recognition.

The proposed system has presented the activity recognition method for children using only a tri-axial accelerometer and a temperature sensor. The output voltage level shown in table for standing still and wiggling as well as locomotion such as toddling and crawling. To prevent accident of child use RFID system to detect the position of child if child is founding danger situation and alert massage send to be parents. The temperature sensor give the body temperature of child and temperature value will be display on pc.

Using Multi-sensors and GSM communication monitoring children activity at home. Multi sensors are used to monitor daily life children at home. This approach is trained using manually annotated data and applied for activity recognition. A waist- worn sensor could fail to detect activities involving head motion, body tilt, and hand motion. Multiple sensors are used to improve the robustness of the systems and increase the reliability of the high-level decision making. Using RFID prevents children to go danger areas like electrical socket, RFID is used to trace the movement and existence of goods. RFID can provide a direct and continuing recognition, including the identification, position, and trace of children. Implementation of vision-based activity recognition, which is based on the use of visual sensing facilities such as video cameras to monitor an actor's behavior and environmental changes.

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