CHILD MOVEMENT DETECTION BASED ON MEMS AND PULSE SENSOR

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Abstract: This paper presents a child activity recognition approach using a single 3-axis accelerometer and a barometric pressure sensor worn on a waist of the body to prevent child accidents such as unintentional injuries at home. Labeled accelerometer data are collected from children of both sexes up to the age of 16 to 29 months. To recognize daily activities, mean, standard deviation, and slope of time-domain features are calculated over sliding windows. In addition, the FFT analysis is adopted to extract frequency-domain features of the aggregated data, and then energy and correlation of acceleration data are calculated. Child activities are classified into 11 daily activities which are wiggling, rolling, standing still, standing up, sitting down, walking, toddler, crawling, climbing up, climbing down, and stopping. The overall accuracy of activity recognition was 98.43% using only a single wearable triaxial accelerometer sensor and a barometric pressure sensor with a support vector machine.

Keywords: Microcontroller, MEMS, Temperature, Pulse Sensors, Xbee, RFID Reader.

I. INTRODUCTION

As babies usually start walking between 9 and 16 months, they are at risk of falling from furniture or stairs. As toddlers learn to climb, they are at risk of falling from windows and beds. Falls are a frequent cause of injury in children. Accident and emergency departments and outpatient surveillance 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 hospitalization. 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. Since the major causes of fall-related injuries change as a child grows and develops, fall prevention needs to be addressed. One of the most challenging issues in this context is to classify daily activities of children into safe and dangerous activities.

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.

Recently, Atallah et al. [7] 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 uncomfortable ness during physical activity and to measure body motions such as climbing up and climbing down than head, hand, and leg motions.

We have developed a wearable sensor device and a monitoring application to collect information and to recognize baby activities. We classified baby activities into 11 daily activities which are wiggling, rolling, standing still, standing up, sitting down, walking, toddling, crawling, climbing up, climbing down, and stopping. Multiple sensors embedded in a wearable device are more accurate for collecting different types of sensing information [8], but would be very inconvenient for users. 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 [9]–[11]. 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 everyday 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 diverse subjects: 16, 17, 20, 25, 27 months-old baby boys and 21, 23, 24, 26, 29 months-old girls; and 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 barometric air pressure 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. HARDWARE SYSTEM

**Micro controller:** This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

**ARM7TDMI:** ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

**Liquid-crystal display (LCD)** is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

III. METHODOLOGY

**Temperature Sensor:**
A thermistor is a type of resistor whose resistance is dependent on temperature. Thermistors are widely used as inrush current limiter, temperature sensors (NTC type typically), self-resetting over current protectors, and self-regulating heating elements. The TMP103 is a digital output temperature sensor in a four-ball wafer chip-scale package (WCSP). The TMP103 is capable of reading temperatures to a resolution of 1°C.
MEMS:
Micro electro mechanical systems (MEMS) are small integrated devices or systems that combine electrical and mechanical components. Their size range from the sub micrometer (or sub micron) level to the millimeter level and there can be any number, from a few to millions, in a particular system. MEMS extend the fabrication techniques developed for the integrated circuit industry to add mechanical elements such as beams, gears, diaphragms, and springs to devices.
Examples of MEMS device applications include inkjet-printer cartridges, accelerometers, miniature robots, micro engines, locks, inertial sensors, micro transmissions, micro mirrors, micro actuators, optical scanners, fluid pumps, transducers and chemical, pressure and flow sensors. Many new applications are emerging as the existing technology is applied to the miniaturization and integration of conventional devices. These systems can sense, control and activate mechanical processes on the micro scale and function individually or in arrays to generate effects on the macro scale. The micro fabrication technology enables fabrication of large arrays of devices, which individually perform simple tasks, but in combination can accomplish complicated functions.
MEMS are not about any one application or device, or they are not defined by a single fabrication process or limited to a few materials. They are a fabrication approach that conveys the advantages of miniaturization, multiple components and microelectronics to the design and construction of integrated electromechanical systems. MEMS are not only about miniaturization of mechanical systems but they are also a new pattern for designing mechanical devices and systems.

Pulse Sensor:
Blood glucose monitoring is a way of testing the concentration of glucose in the blood (glycemia). Particularly important in the care of diabetes mellitus, a blood glucose test is performed by piercing the skin (typically, on the finger tip) to draw blood, then placing the blood on a chemically active disposable strip which indicates the result either by changing color, or changing an electrical characteristic, the latter being measured by an electronic meter.

Zigbee:
Zigbee modules feature a UART interface, which allows any microcontroller or microprocessor to immediately use the services of the Zigbee protocol. All a Zigbee hardware designer has to do in this case is ensure that the host’s serial port logic levels are compatible with the XBees’ 2.8- to 3.4-V logic levels. The logic level conversion can be performed using either a standard RS-232 IC or logic level translators such as the 74LVTH125 when the host is directly connected to the XBee UART. The below table gives the pin description of transceiver. Data is presented to the X-Bee module through its DIN pin, and it must be in the asynchronous serial format, which consists of a start bit, 8 data bits, and a stop bit. Because the input data goes directly into the input of a UART within the X-Bee module, no bit inversions are necessary within the asynchronous serial data stream. All of the required timing and parity checking is automatically taken care of by the X-Bee’s UART.
RFID:
Many types of RFID exist, but at the highest level, we can divide RFID devices into two classes: active and passive.

Active tags require a power source i.e., they are either connected to a powered infrastructure or use energy stored in an integrated battery. In the latter case, a tag’s lifetime is limited by the stored energy, balanced against the number of read operations the device must undergo. However, batteries make the cost, size, and lifetime of active tags impractical for the retail trade. Passive RFID is of interest because the tags don’t require batteries or maintenance. The tags also have an indefinite operational life and are small enough to fit into a practical adhesive label. A passive tag consists of three parts: an antenna, a semiconductor chip attached to the antenna and some form of encapsulation. The tag reader is responsible for powering and communicating with a tag. The tag antenna captures energy and transfers the tag’s ID (the tag’s chip coordinates this process). The encapsulation maintains the tag’s integrity and protects the antenna and chip from environmental conditions or reagents.

IV. CONCLUSION
This paper has presented the activity recognition method for children using only a triaxial accelerometer and a barometric pressure sensor. Time-domain and frequency-domain features are extracted for categorizing body postures such as standing still 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.

The average overall accuracies of the SVM and DT are 86.2% and 88.3%, respectively, with acceptable computational complexity using only a wearable triaxial accelerometer sensor. In addition, the average overall accuracies of the SVM and DT are 98.43% and 96.3%, respectively, with acceptable computational complexity using a wearable triaxial accelerometer and a barometric pressure sensor. Our proposed method including the pressure information demonstrated an improved performance in detecting climbing up and down activities. Results showed that using a barometric pressure 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.
V. REFERENCES


