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IOT BASED ACTIVITY MONITORING SYSTEM USING RFID AND MEMS

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Abstract: Elderly care is one of the many applications supported by real-time activity recognition systems. Traditional approaches use cameras, body sensor networks, or radio patterns from various sources for activity recognition. However, these approaches are limited due to ease-of-use, coverage, or privacy preserving issues. In this paper, we present a novel wearable Radio Frequency Identification (RFID) system aims at providing an easy-to-use solution with high detection coverage using GPRS module, simply Internet of Things (IoT) technique. Our system uses passive tags which are maintenance-free and can be embedded into the clothes to reduce the wearing and maintenance efforts. A small RFID reader and MEMS sensor is also worn on the user's body to extend the detection coverage and orientation of body as the user moves. We exploit RFID radio patterns and MEMS signal and extract both spatial and temporal features to characterize various activities. We also address the issues of false negative of tag readings and tag/antenna calibration, and design a fast online recognition system. Antenna and tag selection is done automatically to explore the minimum number of devices required to achieve target accuracy. We develop a prototype system which consists of a wearable RFID system and MEMS sensor to demonstrate the working principles, and conduct experimental studies with four subjects over two weeks. The results show that our system achieves a high recognition accuracy of 93.6% with a
latency of 5 seconds. Additionally, we show that the system only requires two antennas and four tagged body parts to achieve a high recognition accuracy of 85%.

***Keywords**: controller, RFID, GPS, MEMS, IoT, GPRS.*

INTRODUCTION

As an enabling technology, real-time human activity recognition plays a central role in many applications. One of the critical applications attracts much research interest is elderly care because of the growing number of elderly people around the world [1]. Studies show that aged persons perience steady decline in cognitive, visual and physical functions different age-related diseases [2]. New applications are under active development to provide daily support for elderlies with different types and degrees of impairments. For example,smart reminder systems [1] monitor the user's activities and reminds her when planned daily routines are not followed. Emergency response systems [3] send alarms on detecting dangerous user behaviors such as falling. Long-term health monitoring systems [4] monitor the user's activities over time for health assessment and monitoring. Building an activity recognition system for the elderly users with possible cognitive and physical impairments poses several challenges. Ease-of-use—Most systems are designed for personal usage scenarios which the user receives minimum supervision from the professionals [4].

Introduction to the Internet of Things (IoT)

The term *Internet of Things* (often abbreviated *IoT)* was coined by industry researchers but has emerged into mainstream public view only more recently. Some claim the Internet of Things will completely transform how computer networks are used for the next 10 or 100 years, while others believe IoT is simply hype that won't do much impact on the daily lives of most people. Internet of Things represents a general concept for the ability of network devices to sense and collect data from the world around us, and then share that data across the Internet where it can be processed and utilized for various interesting purposes. Some also use the term *industrial Internet* interchangeably with IoT. This refers primarily to commercial applications of IoT technology in the world of manufacturing. The Internet of Things is not limited to industrial applications, however. Some future consumer applications envisioned for IoT sound like science fiction, but some of the more practical and realistic sounding possibilities for the technology include:

- receiving warnings on your phone or wearable device when IoT networks detect some physical danger is detected nearby
- self-parking automobiles
- automatic ordering of groceries and other home supplies
- automatic tracking of exercise habits and other day-to-day personal activity including goal tracking and regular progress reports

Potential benefits of IoT in the business world include:

- location tracking for individual pieces of manufacturing inventory
- fuel savings from intelligent environmental modeling of gas-powered engines
- new and improved safety controls for people working in hazardous environments

HARDWARE SYSTEM

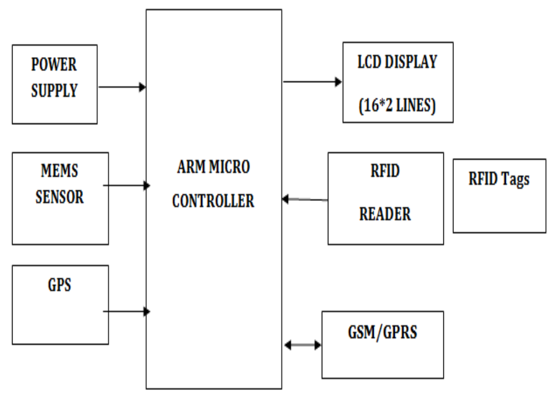

Fig 1: Block diagram

The aim at incorporating the modern ways of detecting user activities using RFID tags, MEMS sensor and GPS as well. The goal of this research is to develop a highly accurate activity recognition system to detect activities and location as well. It will recognise body parts' movements such as hands and legs along with orientation and location. For orientation special type of sensor known as 'MEMS sensor' is used for fall detection and body's orientation. In this research a prototype of an affordable and technologically advanced monitoring system is to be designed and developed. The MEMS sensor can sense the movement in body and the sensor output is given to the Microcontroller (ARM 7). Using this signals from MEMS the person's falling is detected. One tags is attached to each movable part of the body so as to detect movements using tag signals through RFID reader. The RFID reader reads the tags the sends the signal to the microcontroller. Based upon the tag readings and MEMS signal, the microcontroller will recognise the activity and the uploads it to the IoT server which makes the monitoring easy from anywhere. In case the person lost his balance and fell down then GPS will pick the coordinates and sends it to the microcontroller. Microcontroller will send a signal to GPS/GPRS module to send an SMS which contains the location data such as GPS coordinates to the predefined mobile number through GSM module and stored in the IoT server as well. This gives the scope and flexibility to monitor from anywhere. This way a complete and accurate prototype monitoring system for elder people is developed.

HARDWARE DESCRIPTION

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 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:

It 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.

MEMS:

MicroElectroMechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through microfabrication technology. While the electronics are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, Bipolar, or BICMOS processes), the micromechanical components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices. MEMS promises to revolutionize nearly every product category by bringing together silicon-based microelectronics with micromachining technology, making possible the realization of complete systems-on-a-chip. MEMS is an enabling technology allowing the development of smart products, augmenting the computational ability of microelectronics with the perception and control capabilities of micro sensors and micro actuators and expanding the space of possible designs and applications. Microelectronic integrated circuits can be thought of as the "brains" of a system and MEMS augments this decision-making capability with "eyes" and "arms", to allow micro systems to sense and control the environment. The electronics then process the information derived from the sensors and through some decision making capability direct the actuators to respond by moving, positioning, regulating, pumping, and filtering, thereby controlling the environment for some desired outcome or purpose. Because MEMS devices are manufactured using batch fabrication techniques similar to those used for integrated circuits, unprecedented levels of functionality, reliability, and sophistication can be placed on a small silicon chip at a relatively low cost.

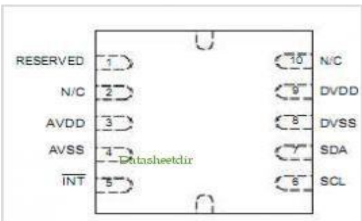

Fig 2: MEMS IC

RFID:

Radio Frequency Identification (RFID) is a silicon chip-based transponder that communicates via radio waves. Radio Frequency Identification is a technology which uses tags as a component in an integrated supply chain solution set that will evolve over the next several years. RFID tags contain a chip which holds an electronic product code (EPC) number that points to additional data detailing the contents of the package. Readers identify the EPC numbers at a distance, without line-of-sight scanning or involving physical contact. Middleware can perform initial filtering on data from the readers. Applications are evolving to comply with shipping products to automatically processing transactions based on RFID technology RFID Reader Module, are also called as interrogators. They convert radio waves returned from the RFID tag into a form that can be passed on to Controllers, which can make use of it. RFID tags and readers have to be tuned to the same frequency in order to Communicate. RFID systems use many different frequencies, but the most common and widely used & supported by our Reader is 125 KHz.

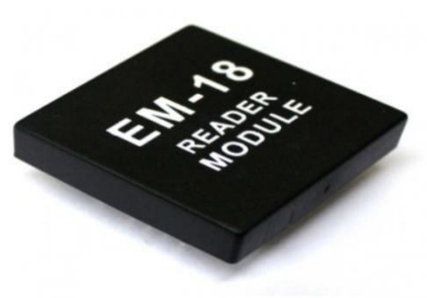

Fig: 3:RFID Reader

Tags are classified into two types based on operating power supply fed to it.

1. Active Tags
2. Passive Tags

Active Tags: These tags have integrated batteries for powering the chip. Active Tags are powered by batteries and either have to be recharged, have their batteries replaced or be disposed of when the batteries fail.

Passive Tags: Passive tags are the tags that do not have batteries and have indefinite life expectancies.

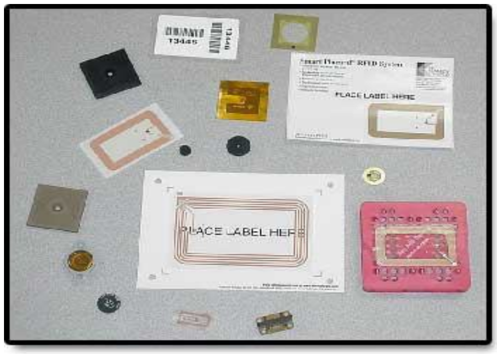

Fig:4:Different types of tags

GPRS:

GPRS (general packet radio service) is a packet-based data bearer service for wireless communication services that is delivered as a network overlay for GSM, CDMA and TDMA (ANSI-I36) networks. GPRS applies a packet radio principle to transfer user data packets in an efficient way between GSM mobile stations and external packet data networks. Packet switching is where data is split into packets that are transmitted separately and then reassembled at the receiving end. GPRS supports the world's leading packet-based Internet communication protocols, Internet protocol (IP) and X.25, a protocol that is used mainly in Europe. GPRS enables any existing IP or X.25 application to operate over a GSM cellular connection. Cellular networks with GPRS capabilities are wireless extensions of the Internet and X.25 networks.

Fig .5: GPRS module

GSM:

Global System for Mobile Communication (GSM) is a set of ETSI standards specifying the infrastructure for a digital cellular service.

The network is structured into a number of discrete sections:

- Base Station Subsystem – the base stations and their controllers explained
- Network and Switching Subsystem – the part of the network most similar to a fixed network, sometimes just called the "core network"
- GPRS Core Network – the optional part which allows packet-based Internet connections
- Operations support system (OSS) – network maintenance

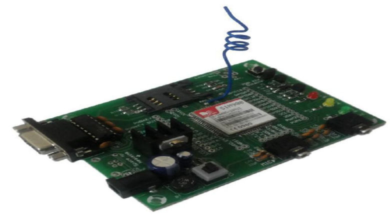

Fig .6: GSM Module

GSM was intended to be a secure wireless system. It has considered the user authentication using a pre-shared key and challenge-response, and over-the-air encryption. However, GSM is vulnerable to different class of attacks, each of them aiming a different part of the network.

GPS:

Global Positioning System (GPS) technology is changing the way we work and play. You can use GPS technology when you are driving, flying, fishing, sailing, hiking, running, biking, working, or exploring. With a GPS receiver, you have an amazing amount of information at your fingertips. Here are just a few examples of how you can use GPS technology.

GPS technology requires the following three segments.

- Space segment.
- Control segment.
- User segment

Space Segment

At least 24 GPS satellites orbit the earth twice a day in a specific pattern. They travel at approximately 7,000 miles per hour about 12,000 miles above the earth's surface. These satellites are spaced so that a GPS receiver anywhere in the world can receive signals from at least four of them.

Control Segment

The control segment is responsible for constantly monitoring satellite health, signal integrity, and orbital configuration from the ground control segment includes the following sections: Master control station, Monitor stations, and Ground antennas.

User Segment

The GPS user segment consists of your GPS receiver. Your receiver collects and processes signals from the GPS satellites that are in view and then uses that information to determine and display your location, speed, time, and so forth. Your GPS receiver does not transmit any information back to the satellites.

The following points provide a summary of the technology at work:

- The control segment constantly monitors the GPS constellation and uploads information to satellites to provide maximum user accuracy
- Your GPS receiver accounts for errors. For more information, refer to the Sources of Errors.
- Your GPS receiver determines your current location, velocity, and time.
- Your GPS receiver can calculate other information, such as bearing, track, trip distance, and distance to destination, sunrise and sunset time so forth.
- Your GPS receiver displays the applicable information on the screen.

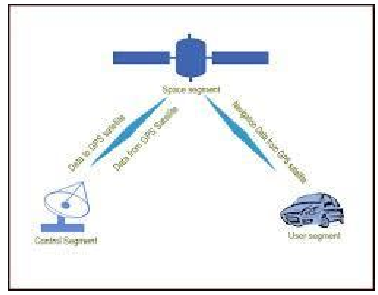

Fig .7: GPS Working

CONCLUSION

In this paper, we present a novel wearable RFID & MEMS-based system for real-time activity recognition that aims at providing an easy-to-use solution with IoT monitoring to support applications like elderly care. GPS module is used to accurately get the location details of the person which eliminates the restriction of distance coverage problem. We implement the prototype system and conduct extensive experiments using data collected in a realistic setting. The experiment results show that the proposed system can perform real-time recognition even when the delay bound is 1s, and achieve the highest recognition accuracy of 93.6% when the latency is 5s. By using the proposed antenna and tag selection algorithm, we demonstrate that a small number of properly selected antennas, tags and MEMS sensor suffice to achieve high recognition accuracy. Through comparison studies, we show that our approach achieves comparable performance with the BSN-based approach, and outperforms the smartphone-based approach.

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