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Track My Health: An IoT Approach for Data Acquisition and Activity Recognition

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Abstract. Human Activity Recognition (HAR) is an arisen research topic because of its usage of self-care and prevention issues. In our days, the advances of technology (smart-phones, smart-watches, tablets, wristbands) and achievements of Machine Learning provide great opportunities for in-depth research on HAR. Technological gadgets include many sensors that gather various, which in turn are input to machine learning techniques to derive useful information and results about human activities and health conditions. Activity Recognition is mainly based physical sensors attached to the human body, with wearable devices coming with built-in sensors such as the accelerometer, gyroscope. This work presents a system based on the Internet of Things (IoT), that monitoring essential vital signals. A mobile application has designed and developed to collect data from a wearable device with built-in sensors (accelerometer and gyroscope) for different human activities and store them for use in a database. The purpose of this work is to present the module of the system that is responsible for the data acquisition, processing and storage of signals that will feed then the Machine Learning module to identify the human health status.

Keywords. Human activity recognition, IoT, data acquisition, sensors, m-health

Introduction

The study of Human Activity Recognition (HAR) is a discipline research area of medical and computer science community. The increase of the cost of health care on one hand and the continuously increasing number of elderly people on the hand, has led to investigate new and more efficient health services [1]. The availability and broaden usage of smartphones with integrated sensors, many functionalities and high computational power is driven the interest of mobile health research. Smartphones include various sensors able to provide essential information for monitoring the behavior and activity of their users and their location (behavioral data), but usually they do not include sensors that provide immediate data on their physical conditions.

The development and design of wearables have addressed this need, that in conjunction with the use of smartphones they provide advances capabilities for tracking human activity and behavior. These wearable devices incorporate different types of

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sensors and can have computing capabilities. Wearables are worn to different parts of the body depending on the desired measurement data [2]. Furthermore, they gather health related data (e.g. heart rate, body temperature, blood pressure, etc.) and continuously monitor (individual, behavioral) human activities, without interrupting or limiting his activity (e.g. to block its movement) [3].

Internet of Things (IoT) technology has widely used to connect all sensing devices to internet and to provide remote and constant access to various services [4]. IoT technology has evolved rapidly and is providing many applications in healthcare in both electronic-Health (e-health) and mobile-Health (m-health) [5]. Actually, a new segment "Wearable IoT (WIoT)" has been created by the IoT technology and is based on the ability of wearables to detect, calculate and communicate [6].

In our case, we are proposing a WIoT system that is consisted of wearable devices, an application for smartphones, and a back-end server for the database and the processing module [7]. This IoT system obtains data of different human activities (sitting, standing, walking, downstairs, and upstairs) and the wearable device is set on the wrist. Data is collected using a 3-axial accelerometer and 3-axial gyroscope sensors, which are built into the wearable device. Accelerometers and gyroscopes are popular choices since they are small, affordable and easily built-in wearable devices [8]. These sensors can be used alone or combined to record data generated from human activities [9].

The proposed system is consisted of a developed mobile application for android smartphones to collect data from the wearable device via Bluetooth. The architecture of the system is described in Figure 1, where the smartphone acts as a bridge in order to transfer the data from the wearable device to the back-end server in which operates a data storage environment built-in MongoDB. For data transfer, the Retrofit technology is used, which is a library for accessing the Representational state transfer (REST) Web APIs [10].

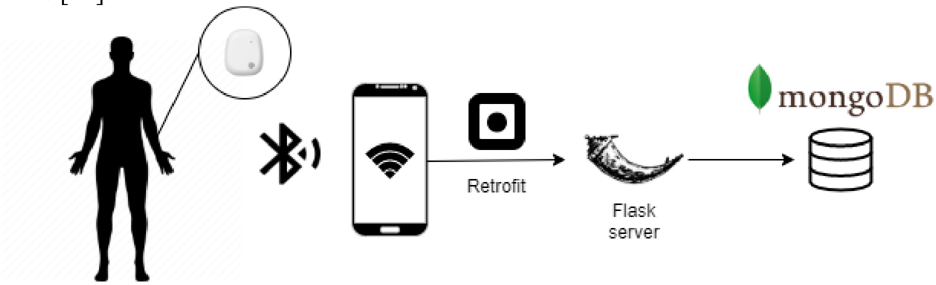

Figure 1. IoT architecture of the system. The data collected by the device is transferred via Bluetooth to the smartphone and sent via Retrofit to the server, in which we have built the database.

Here, in this paper we present an accurate data acquisition system based on an IoT technology. The system is based on a wearable device with built-in sensors and a smartphone with purpose the accurate data collection for different human activities. Accurate identification of human activities combined with a machine learning model could help to provide a better patient recovery training guidance, or an early alarm of emergency that may happen to older people, such as stroke, falls, etc. [11]. The machine learning module of the system is presented at the second paper [7], where it is explained how the collected data from the device is inserted and processed into a machine learning model and the achieved accuracy for activity prediction reaches 99% [7].

1. System Description

1.1. Hardware Components

We have investigate various wearable devices but we have choice devices based on four essential features:

- **Sensor Features:** Refers to the characteristics such as range, resolution, and sampling rate of the 6-axis Inertial Measurement Unit (IMU). IMUs are composed of a 3-axis accelerometer and 3-axis gyroscope sensors providing accurate data recording.
- **Device Features:** Refers to characteristics such as Bluetooth, battery, and memory for both data and recording time.
- **User-Friendliness:** Refers to characteristics such as size, weight, and location on the body where the wearable device will be placed so that to be comfortable and to facilitate human movement.
- **Application Programming Interface (API):** This feature refers to flexibility for developers to create their applications in various programming languages.

In this work, we are using an open-source developer kit MetaMotionR (MMR) of Ambient Lab™ (Figure 2) [12], which consists of a built-in 6-axis IMU sensors. It includes sensor fusion that combines the measurements of the two aforementioned sensors [13]. Also, the MMR has the ability to be connected wirelessly with mobile software and is small in size so that it is worn on human body without any discomfort. MMR provides continuous real-time monitoring of motion and environmental sensor data.

Figure 2. MetaMotionR device with rubber watch band.

The MMR is coming as a small rectangular form factor and a wrist strap. On the board, there is an LED that informs about the operation of the device (sleep, standby, and action mode), a button for resetting the device, and a flash memory in which all the data is saved when it performs measurements. When the MMR is connected via Bluetooth Low Energy to another device, it is able to transfer all the collected data from its multiple sensors (accelerometer, gyroscope, magnetometer, barometer, light, and temperature). Table 1 presents a summary with the key characteristic of the MMR device.

Table 1. MetaMotionR specifications

Parameter	Value
Accelerometer range	±2g, ±4g, ±8 g, ±16 g
Gyroscope range	±125°/s, ±250°/s, ±500°/s, ±1000°/s, ±2000°/s
Battery type	Rechargeable Lithium-ion
Battery capacity	70-100 mAh
Memory	8Mb

1.2. Software Components

There are two main software components of the gathering and storing data system. The first one is the designed and developed smartphone application, which is used to communicate with the wearable device, to collect the data and send them to the database, which is developed for Android devices. The other one is a database system to gather the data and providing it for further processing (Figure 1).

1.2.1. Smartphone Application

The design and development of the application took place on the Android Studio platform [14] with Java programming language, and it is compatible with Android 5.1 (API level 22) or higher. The application collects the data from the MMR and it sends them to the database. The developed application operates the following main functions:

- Connection via Bluetooth with the wearable device.
- Selection the sampling rate of the respective sensors (accelerometer and gyroscope).
- Selection of the kind of human activity.
- Save data locally using Room persistence library of Android [15] in case that the connection with the server is lost
- Sending data to the database via Retrofit.

1.2.2. Database

For the data storage environment, we selected the MongoDB, which is a NoSQL database management system that includes four main characteristics: flexibility, power, speed, and ease of use [16]. The database is built and running on a server using the flask framework. Flask is a lightweight web framework written in Python [17]. It provides simplicity and flexibility and a set of powerful libraries for handling the most common web development tasks such as HTTP request parsing and flexible response handling. Flask has a lot of extension tools and libraries, and one of these is PyMongo that allows the handling of MongoDB. The developed database has the following main functions:

- Insert a user with a specific id.
- Insert a document to a collection by id. The document is the data obtained from the application in the form of a JavaScript Object Notation (JSON) file, and MongoDB stores them to collections in BSON (Binary JSON) format. Collections are analogous to tables in relational databases.
- Export data from DB. This function allows data to be extracted in JSON or Comma Separated Values (CSV) file format for further processing.

2. The Overall System for Monitoring Health

IoT applications in healthcare have successfully applied to monitor, evaluate and so enhance well-being related to health and fitness. A lot of wearable devices have been developed in order to monitor the human physical and health status [18]. The health condition of a person is associated with his regular physical activity and there are many studies in order to monitor and recognize it. Solid evidence shows that regular monitoring and recognition of physical activity could be associated with health condition and so to contribute to manage and reduce the risk of various health problems such as obesity, cardiovascular and diabetes [19]. Mobile healthcare applications are used for monitoring patients, elder people and lone workers. The proposed IoT system provides an unceasing record of data on human activity that can be used either for human wellness or to warn about dangerous health conditions. The system could be used for elderly fall monitoring, by sending warnings to a health care center or other family members of the monitoring person (Figure 3).

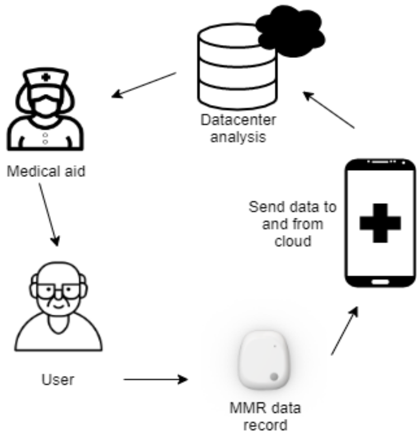

Figure 3. Application of IoT in healthcare with MMR device.

3. Conclusions and Future Work

This work presents a useful and accurate approach that is used to recognize human activity and so identify the health status of an individual by evaluating basic vital signals. The wearable device MMR is used for collecting human activity data based on accelerometer and gyroscope sensors working on high frequency and we designed and developed a smartphone application that facilitates communication and interaction based on an open-source API.

In future work will exploit all the sensors, that are embedded in the MMR device so that to provide better and broaden human activity recognition and we will develop further m-health applications for the collection of clinical data. Another point that deserves to be adequately and further assessed is related to the wearer's privacy, although inertial sensors are less invade the wearer privacy compared to other sensors like the cameras.

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