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Training Monitoring System for Cyclist Based on Android Application Development

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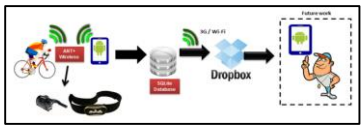
Graphical abstract



Abstract

Recently, technological advance in Android application has grown rapidly especially in health care application along with the development of smartphone. The utilization of wireless sensor networks with the mobile wireless health devices has provided us with an alternative solution in health monitoring instead of using the traditional approach with higher cost. Therefore, the objective of this project is to develop and implement a training monitoring system for cyclist based on android application. In this system, wireless sensor nodes are assigned to collect the required data such as cyclist's heart rate and cadence. All the data are then sent to the mobile device used by cyclist via wireless communication. The data collected are first stored in device's internal memory before they are transferred to the server. This project involved programming of hardware using specific software such as Eclipse Juno Android SDK and SQLite database. The system also includes the graphical user interface (GUI) design using Java language for application on smartphone. In addition, the simple Dropbox command is used to design the server for data storage. All the stages of implementations are integrated in one whole system and can be run as an application by cyclist. The developed system is proven to be cost effective and reliable as well as easy for customization.

Keywords: Android; training monitoring system; health application

Abstrak

Baru-baru ini, kemajuan teknologi dalam pembangunan aplikasi Android telah mengalami pertumbuhan yang pesat terutama dalam pembangunan penjagaan kesihatan seiring dengan pembangunan telefon pintar. Penggunaan rangkaian pengesan wayarles bersama peranti kesihatan mudah alih telah memberikan penyelesaian alternatif kepada kita dalam memantau kesihatan berbanding dengan penggunaan kaedah tradisional yang memakan kos yang tinggi. Oleh itu, objektif projek ini adalah untuk membangunkan dan melaksanakan sistem pemantauan latihan bagi pelumba basikal berdasarkan aplikasi android. Dalam sistem ini, nod pengesan wayarles berfungsi untuk mengutip data yang diperlukan seperti kadar degupan jantung pelumba basikal dan juga kadar putaran pedal. Kesemua data kemudiannya dihantar ke peranti mudah alih yang digunakan oleh pelumba basikal melalui komunikasi wayarles. Data yang dikumpulkan akan disimpan di dalam memori dalaman peranti sebelum dipindahkan ke dalam pelayan. Projek ini melibatkan kerja-kerja pengaturcaraan peralatan menggunakan perisian tertentu seperti Eclipse Android SD dan SQLite pengkalan data. Sistem ini juga merangkumi penciptaan antaramuka bergrafik pengguna menggunakan bahasa Java untuk aplikasi telefon pintar. Tambahan juga, arahan mudah Dropbox digunakan untuk tujuan penyimpanan data di dalam pelayan. Di akhir projek ini, semua peringkat pelaksanaan diintegrasikan dalam sistem yang sama dan boleh digunakan sebagai suatu aplikasi oleh pelumba basikal. Sistem yang dilaksanakan ini telah dibuktikan efektif dari segi kos dan mudah untuk disesuaikan untuk aplikasi lain.

Kata kunci: Android; sistem pemantauan latihan; aplikasi kesihatan

1.0 INTRODUCTION

Nowadays, healthcare development using smart phone application has become one of the popular topics among researchers and programmers because of the advanced in new technology especially in wireless health devices. This paper presents a development and implementation of a training monitoring system for cyclist based on Android application which includes data collection in the server and memory card. There are several parameters that are measured for the purpose of monitoring which are bike speed and cadence, heart rate and Global Positioning System (GPS) distance. This application helps the users to monitor their health condition in a cheap and efficient way by using their tablet or mobile phones. In addition, training monitoring can help the cyclists in optimizing their performance while preventing overtraining and injuries. The developed training monitoring system can be used during training activities without causing any harm since it is lightweight and easy to be carried around. In addition, the mobile device can be attached to the bike using an attachment that is available on the market.

2.0 RELATED WORK

The use of training monitoring system using wireless communication is becoming more popular among athletes in optimizing their performance and at the same time avoiding overtraining that can lead to injuries. Overtraining is an extreme state of fatigue and if occurs, it can force the athletes to rest for several weeks and not being able to continue their training [1]. Moreover, it can give negative impact on their performance, health and daily life. Therefore, by implementing a sensible training monitoring program together with careful training planning, such problem can be prevented.

The application of mobile devices for pervasive healthcare monitoring and information management is not relatively new and has been proposed and presented in the literature before [2] – [5]. The authors in [2] have reported a design and implementation of android Electrocardiogram (ECG) application that can work together with VS100, a wearable sensor Vitalsens Bluetooth ECG monitoring device. In this work, the ECG data signals from sensors were sent to the smartphone and laptop via Bluetooth communication. Nevertheless, the use of Bluetooth connections between sensors and smartphone as well as between sensors and laptop require high energy consumption and this leads to rapid loss of battery power. Hence, this application is not efficient to be used in outdoor application such as cycling where the smartphone battery can only be recharged at certain duration of time. In addition, there is no analysis of the results that were obtained from the system development and the results were not verified to be correct.

A mobile healthcare system for monitoring of ECG data of a patient is proposed in [3]. The work used the shimmer sensor to sense ECG heart rate from patient and the data is sent via wireless connection to the smartphone. The data is stored in the server before it is distributed to the doctors for patient monitoring. However, the size of the sensor utilized in this work is quite big and hence, it is not suitable to be carried around while doing activities.

The paper in [4] presents a study to determine the validity of an Android-based software program to detect and capture heart rate measurements as a proof of concept for its use. The system was developed and tested on a Motorola Droid running Android OS 2.2. Heart rate measurements derived from this application were compared to those acquired using a four-lead ECG, as well as a pulse oximeter. This work nonetheless requires further testing for fast moving activities in order for the software to detect accurate heart rate signals. Therefore, activities such as slow walking and/or stationary bicycling are more feasible conditions for using the proposed system.

A personal health application for smartphone that is capable of automatically monitoring a user's overall wellbeing is proposed in [5]. In this paper, the authors discussed the design, implementation and evaluation of BeWell, which is a real-time, continuous sensing application that provides easily digested feedback that pro- motes healthier lifestyle decisions. Feedback from BeWell can help users better understand the wellbeing impact of their day to day social interaction, physical activity and sleep patterns. Our work on the other hand focuses on the application development for cyclist training monitoring. Next section will discuss on the system architecture of our proposed system. Results and discussion will be presented in Section 4.0 while Section 5.0 will conclude the paper.

3.0 SYSTEM ARCHITECTURE

The purpose of this project is to develop and implement a training monitoring system for cyclist based on Android application development. The data collected during the monitoring duration are stored in the memory card before they are transferred to the server using cloud computing. Several parameters are used for the purpose of monitoring which are speed of bike, heart rate and GPS distance. The use of heart rate sensor is to monitor heart conditions in real time without any delays. Meanwhile, GPS sensor is used to measure the distance for cyclist and the speed sensor is to measure the speed of bike in real time so that perspective measures can be taken. Figure 1 illustrates the full diagram of the developed training monitoring system.

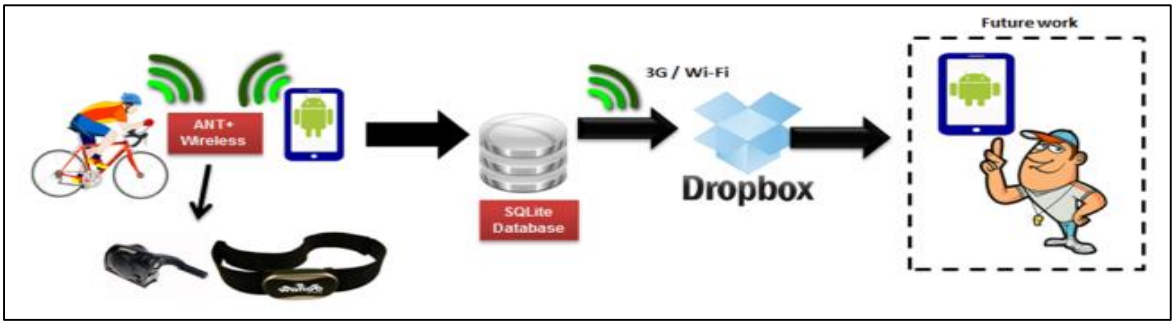


Figure 1 Full diagram of training monitoring system

The overall project flow is depicted in Figure 2. Initially, an interface for the specific application to monitor heart rate, bike speed and cadence must be developed in the smartphone. This is done by using Eclipse Juno Android Software Development Kit (SDK). Eclipse is a multi-language integrated development environment (IDE) comprising a base workspace and extensible plug-in system for customizing the environment. Besides, Eclipse is free and developed by open source software community. Eclipse used Java as a main programming language and can be operated for cross platform such as Linux, Mac OS X, Solaris and Windows. Meanwhile, Android is referred as the first open source mobile application development platform [6] and Android operating system (OS) has increased its popularity since it was first released back in November 2007. It was developed by Google in cooperation with Open Handset Alliance such as Bouygues Telecom, Alcatel mobile phones, Ándago Ingeniería S.L. and etc. companies. Android was chosen as the OS in this system since it offers simple interface and user friendly to user with powerful SDK that can be used for development in multi-purpose environment. Android application for this project was written in Java programming language. The language is then compiled into byte codes which are then converted into a Dex (Dalvik executable) file using the dx converter. The file is compiled into Android package file (apk file) before it is installed on the Android device. Figure 3 shows the flowchart of the Android development for this project. The smartphone used for this project is Sony Xperia S Smartphone. All the equipment used in this project are shown in Figure 4.

The type of sensors used in this project is ANT+ sensor, which is a wireless sensor network technology featuring a wireless communication protocol that operates at 2.4 GHz ISM Band (Industrial, Scientific and Medical) that allows users to monitor their psychological and health by using android or iPhone devices. ANT+ sensors utilize ANT wireless protocol that was developed in 2003 by Dynastream Innovations Inc., and became a wholly owned subsidiary of Garmin Ltd. in December 2006 [7]. ANT+ sensor used low power consumption and it can give high efficiency performance with low computational overhead.

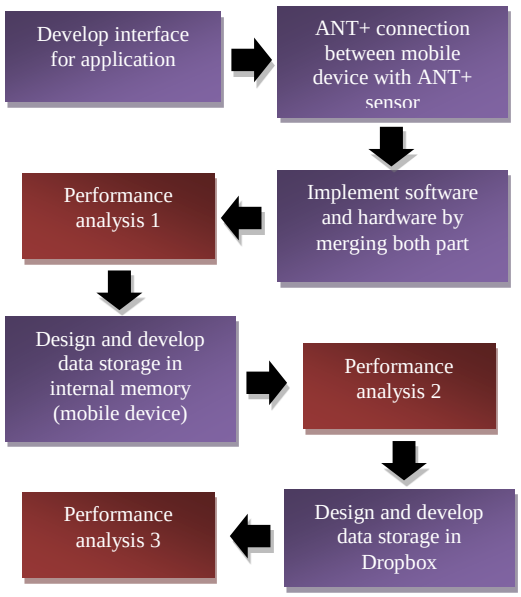


Figure 2 Overview of project flow

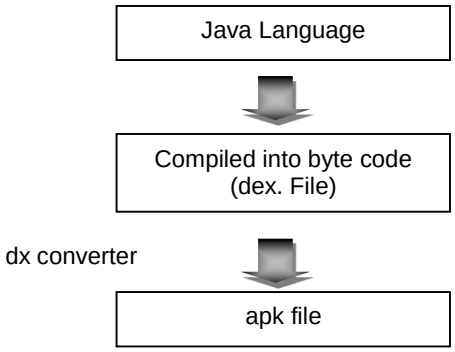


Figure 3 Flowchart of Android development

Figure 4 Smartphone and sensors used in the system

Upon the completion of Android interface, the communication link between ANT+ sensors and smartphone is developed via ANT wireless protocol. In order to make the mobile device to recognize ANT+ sensor, the programming must be made using Eclipse Juno. Figure 5 shows the connection process between ANT+ sensor and mobile device.

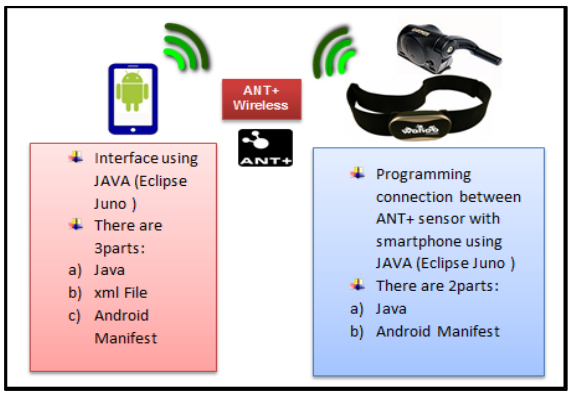


Figure 5 Connection process between smartphone and sensors

Once the connection between sensors and smartphone has been tested and established, the final step is to save the received data in the internal memory and server. For this purpose, we use cloud storage such as Dropbox. Cloud storage is a storage that stores data virtually, anywhere and at any time when it connects to the server. It can store data by using mobile device, computer or tablet as long as the device is connected to the server. Cloud

storage service can be accessed through a web service application programming interface (API) or web based user interface. Dropbox is one type of the cloud storage in which it is a file hosting service that allows users to create a special folder on their computers or mobile devices in Dropbox, and can be synchronized with folders inside the computer or mobile devices. In this project, the data are first stored in the internal memory of a smartphone by using Eclipse Juno software before they are transferred to the server using the 3G connection. Finally, the whole system is run and tested several times to verify the correctness of the data and for performance evaluation.

4.0 RESULTS AND DISCUSSIONS

The Android interface and data storage developed for this project are shown in Figure 6 and Figure 7, respectively. There are three displays for the interface which are heart rate, GPS distance, bike speed and cadence. Meanwhile for storage, there are two types of data storage which are internal memory of the smartphone and the server (Dropbox).

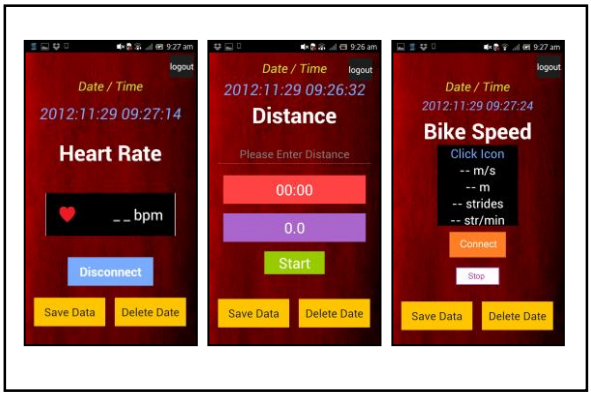


Figure 6 Interface for training monitoring system

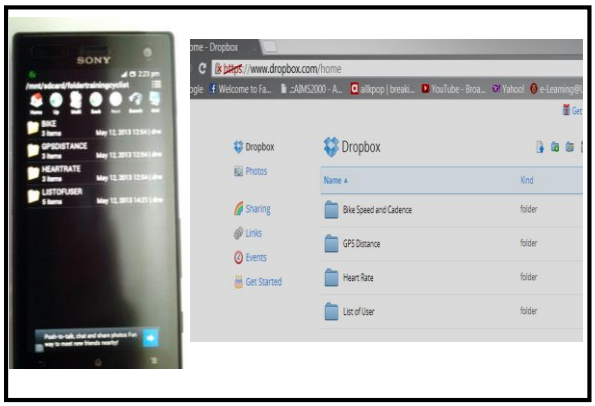


Figure 7 Data storage for training monitoring system

To make the application user friendly, the interface as shown in Figure 8 is designed so that the user can easily choose the specific application that he/she intends to use. There are several steps before a user can use the training monitoring application. First of all, a user needs to open the application on mobile device. The first page of the application is shown in the first figure on the left in Figure 8. Then, the user can choose either to view the information related to the system or start the application. If the user clicks to start the application, he/she needs to login to the system before he/she can start to run the sensor by selecting any three applications from the menu.

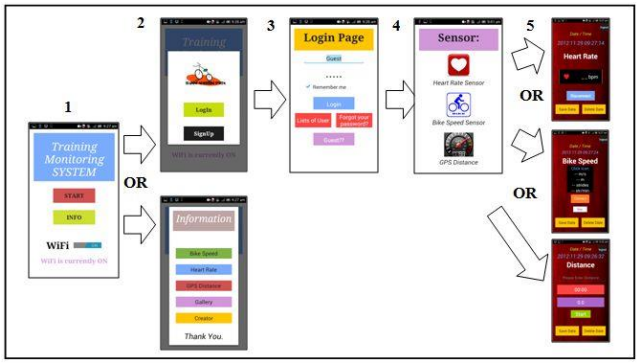


Figure 8 Flow of application

Figure 9 depicts the setup for sensors for real time experiment while Figure 10 shows the location of the smartphone on the bicycle.

(a) (b)

Figure 9 Setup for sensor. (a) Bike sensor (b) Heart rate sensor

Figure 10 The location of the smartphone on the bicycle

Overall, a cyclist monitoring system has been successfully developed in this work. In order to verify that this system is comparable with other fitness applications, we have made a performance comparison to measure the setup time to establish the connection. In other word, we measure the time between the first data sensed by the sensors and the first data received at the smartphone. Table 1 shows the comparison of our developed training monitoring system with other applications such as Sport Pal, Heart Performance Rate monitor and many other applications such as listed in the table below. Despite this is our initial work, it

can be seen that our system is at par if not better from other systems. Further improvements can be made by customizing the application according to specific requirements by the athletes.

Table 1 Comparison between cyclist apps. & other apps

Cyclist App.	Setup (s)	Other Apps	Setup (s)
Heart Rate	1.25s	**Sport Pal**	1.11s
		Heart rate monitor	1.87s
		ANT+ Demo	1.28s
Bike Speed and Cadence	15s	**IpBike**	8s
		Biketrack	11.37s
		Bike Display	12s
GPS Distance	16.51s	**Sport Tracker**	11s
		MyTracks	15.3s
		MapMyRide GPS Cycling Riding	10s

■5.0 CONCLUSION

This paper presented a development of training monitoring system for cyclist based on Android as the main platform. The system consists of ANT+ sensors, which are connected to the smartphone using ANT+ protocol wireless connection for data transfer. The whole system connects the sensors and smartphone, as well as the smartphone and the storage. There are two types of storage that have been developed for this application which are internal memory and Dropbox. The data needs to be saved in an internal memory first before it can be transferred to the server such as Dropbox. This application uses simple interface and simple programming language. Hence, it is easy for customization if further improvements are required. Finally, a performance comparison with other applications has proved that it is comparable among current fitness applications. This system can be further enhanced by customizing the application according to the specific requirement by athletes and trainers. Further work includes the development of the feedback system for the trainer where the trainer can access the data sensed by the sensors and send the message to the cyclist on training within a short time.

Acknowledgement

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