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The Development of FitMe – Integrated Wearable Vest and Fitness Application

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ABSTRACT

Wearable technology usage is widely increasing due to its significant function in various domains, including health. For example, the activity tracker is the most used wearable device in the health domain. However, the issue of existing fitness trackers like wristbands and smartwatches was reported due to the screen size restricting the interactive interface. With the various forms of wearable technology, there is a potential to design a solution using the wearable vest. Therefore, the integrated wearable vest and fitness application named FitMe was developed in this study. The vest was embedded with a wearable device comprised of accelerometer sensors that detect user movement when worn, such as steps count. Meanwhile, the fitness application is responsible for displaying the detected data and other fitness information such as total travelled distance and burned calories. The development framework was first determined before successfully developing the integrated wearable vest and application. Consequently, three main phases, analysis, design and implementation, were identified, whereby every phase consists of activities that must be completed before moving to the next stage. In addition, this study plans to conduct an empirical study to evaluate the system's effectiveness. The development of this study also hoped to benefit other researchers and developers, especially in the wearable fields.

Keywords: development framework, fitness tracker, fitness application, wearable vest, wearable technology

INTRODUCTION

Recently, with the emergence of more technologically advanced wearable technology such as fitness trackers and smartwatches, users are no longer satisfied with only tracking their weight loss goals or step count. The rise of various fitness trackers has also been proven to help benefit users when exercising. One of the perceived benefits is ease of use, where users will have a better experience exercising if they have access to a fitness tracker that has a user-friendly interface (Jin et al., 2020). Moreover, exercise tracking can also increase users' motivation due to the positive effect of fitness trackers on task motivation in goal-directed activities. Additionally, exercise tracking can enhance the exercise experience because most users find it fun to use fitness-tracking apps, and they would enjoy an activity less if it is not tracked (Maitland et al., 2006). Not to mention, monitoring exercise progress increases physical activity levels. For example, a fitness tracker will have a more substantial positive effect on physical activity levels if there is a feature to share their exercise on social media.

The most popular wearable fitness tracker is a wristband that comes in various brands and offers different features. However, Motti and Caine (2016) found that the main design challenge for wrist-worn interfaces includes the limited interactive surfaces due to small screen sizes that restrict input and output possibilities. Furthermore, because of the restricted technology available in such devices, they tend to have lower computing power and shorter battery life. In addition, the visual blockage caused by plump fingers hinders user engagement with tactile graphical user interfaces (GUIs). At the same time, gestural input commands are plagued with Midas gestures, such as accidental user motions that initiate a system action.

Fortunately, besides wristbands and watches (Atallah et al., 2010), wearable technology can take many forms, including jackets (Keng et al., 2008), shoes (Spelmezan, 2012), and shirts (Knight et al., 2004). Furthermore, the next generation of wearables is expected to include augmented-, virtual-, mixed-, and improved-reality devices, various smart garments and industrial wearable equipment (Ometov et al., 2021). Therefore, there is a possibility of developing the fitness tracker using other kinds of wearable forms. Thus, an integrated wearable vest and fitness application were developed in this study. In addition, the wearable vest is expected to solve the issues regarding the screen size since all the input and output are displayed through the integrated mobile application. Hence, the detailed development process of the integrated wearable vest and fitness application will be elucidated in this article.

LITERATURE REVIEW

Wearable technology is small electronic and mobile devices or computers with wireless communications capability. The wearables or wearable devices can be embedded into gadgets, accessories, clothes worn on a human body, or even invasive versions such as microchips or intelligent tattoos (Luczak et al., 2020). In the Information and Communications Technology (ICT) industry, wearable technology has a significant influence as smart wearables are predicted to disrupt a wide range of personal and corporate sectors, including manufacturing, healthcare and sport (Ometov et al., 2021). In addition, the enhancement in its technological components, including embedded sensors and a more efficient power solution, has also grown in popularity as people use it as an activity tracker and assistive technologies to support user interaction and communication (Motti & Caine, 2016).

Past Research on Wearable Technology in Physical Activity: The wearable systems were used for various purposes, including injury prevention, assessing skill levels and experience, enhancing procedures, and defining movements. The first application of wearable technology in sports is to avoid injuries. In the running, for example, high tibial peak-positive accelerations (PPAs) are linked to tibial structural risk, and auditory feedback was found to be effective in temporarily lowering PPAs in participants (Wood & Kipp, 2014). By correlating the tone of the signal output to the degree of PPAs, athletes could audibly grasp the impact they were having during each step. In addition, Australian football is currently adopting Global Positioning System (GPS) devices to monitor player workload, which has allowed for the tracking of energy expenditure, which was previously done using heart rate monitors (Wisbey & Montgomery, 2008). Wearable sensors have also been used in American football to diagnose concussions by monitoring linear and angular head accelerations when a player collides (Siegmund et al., 2016).

Furthermore, wearable technology is also utilised to measure skill level and expertise during physical exercise and fitness. For example, the inertial measurement unit (IMU) used to assess volleyball players' skill level has a 94 per cent accuracy rate in estimating a player's ability. The data was also stored in a database, allowing sports scientists and professional coaches to use it, increasing the sensor's influence (Wang et al., 2018). Movement recognition is also aided in physical activities to assess whether a user's movement is performed correctly or incorrectly. For instance, the hand monitoring module (HMM) used to monitor badminton grips only had a 70% detection rate across five grips (Jacob et al., 2017).

The Implication of Wearable Technology in Fitness: The significance of wearable technology in fitness and physical activities has become increasingly significant in the past years, as shown in Figure 1. Wearable technology is now widely and popularly used in physical activities. The preliminary study also discovered that 47.1 per cent of respondents own a fitness tracker, while 45.1 per cent of them used the tracker to become more active.

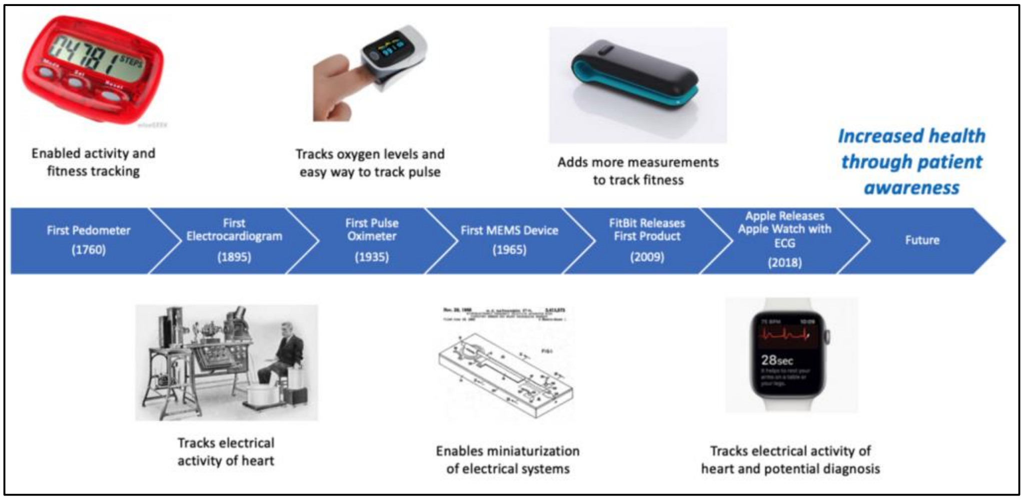

Figure 1: The health monitoring technologies evolution.
Source: Suematsu, 2020

Stiglbauer et al. (2019) found that fitness trackers have a favourable impact on physical and psychological well-being, such as a sense of success, happy emotions, or quality of life). However, individuals with high extrinsic motivation (e.g., to be fitter, to look better, or to lose weight), high need for cognitive closure (e.g., avoid ambiguous situations), and low hope of success (e.g., low approach tendency) will have lower motivation for physical activities without the fitness tracker (Attig & Franke, 2019). Therefore, it is possible to develop a wearable fitness tracker besides the existing device to provide users with various tools that can cater to their needs, motivating them to monitor their fitness progress.

RESEARCH METHODOLOGY

Before developing the application, the phases of the development framework were determined. This project adopts the three main phases (as illustrated in Figure 2) of most system development: analysis, design, and implementation. In each phase, several activities were also identified for completing the project. A detailed explanation for every phase will be discussed in the next section.

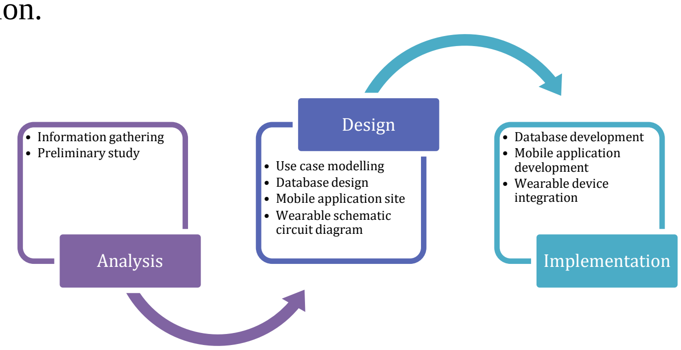

Figure 2: The development framework.

Analysis Phase: The analysis is an initial step before developing the system, which involves two activities: information gathering and preliminary study. In the first activity, the literature review was conducted using various sources such as articles, books, journals, and other verified resources for the information gathering. Consequently, the gathered information was pertinent to related topics such as health monitoring, fitness trackers, and software and hardware requirements.

Next, a preliminary study was conducted to gain more profound information about this project. The survey aims to collect information regarding respondents' fitness tracking purposes, ownership of tracking tools and their opinion about the proposed wearable application. This activity was participated by 50 respondents who responded to the distributed online questionnaire via social and messaging platforms such as WhatsApp, Telegram, Instagram, and Twitter.

Design Phase: The logical and physical designs were provided in this phase to illustrate how the proposed system worked. In this phase, the activities include preparing the use case modelling, database design, mobile application sitemap and wearable schematic diagram. The use case model, as demonstrated in Figure 3, was created to describe how the user will interact with the application. The use case diagram shows that users must register and log in to the application to record their exercise activity. They also can view their previous record stored in the database to track their progress.

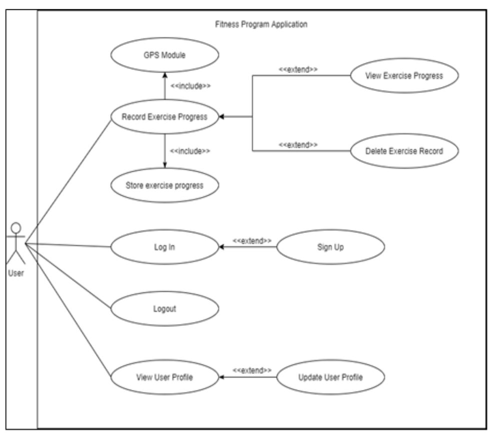

Figure 3: Use case diagram.

For the database design, the entity-relationship diagram (ERD), as shown in Figure 4, was constructed to depict the relationship of entities. Only two entities are identified for this project: User, which consists of attributes regarding user details, and exercise, which comprises attributes for user exercise records.

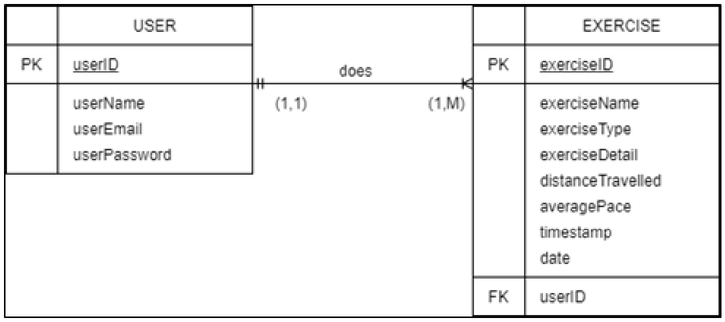

Figure 4: Entity-relationship diagram (ERD)

Next, the mobile application sitemap was designed using a flowchart to portray the system's flow, the link between the screens and the navigation of every screen. Figure 5 is an example of a flowchart for the login module that elucidates that if the user successfully enters their login details without any errors, they will be directed to the application home screen. However, the application will display an error message for the unsuccessful logging-in process, and the user has to re-enter their login details. After the user has been directed to the home screen, they can continue to use or log out of the application.

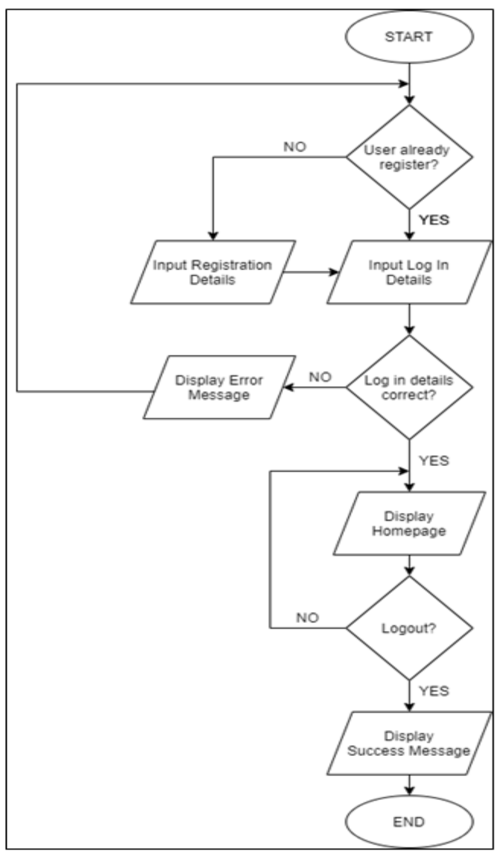

Figure 5: Flowchart for login module.

Figure 6 is the wearable schematic diagram designed to represent the connection of the circuit elements and their interdependence on one another. The circuit comprises two main modules: an accelerometer sensor to detect user movement and Bluetooth to allow communication between the application and wearable devices.

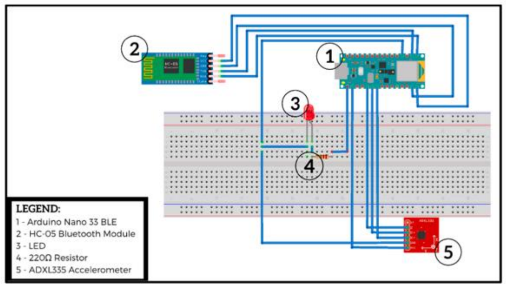

Figure 6: Wearable schematic circuit diagram.

The accelerometer sensor modules used five pins: the 3v3 pin, GND pin, X pin, Y pin, and Z pin. 3v3 pin is used to supply 3V of power to the accelerometer and is connected to the 3v3 pin of the Arduino Nano 33 BLE board. The GND pin is the reference point for all signals or a familiar path in an electrical circuit where all the voltages can be measured and connected to the GND pin of the board. The accelerometer's X, Y, and Z pins are used to measure the X, Y, and Z coordinates. The X pin is connected to the A3 pin, the Y pin is connected to the A2 pin, and the Z pin is connected to the A1 pin of the board.

Meanwhile, the Bluetooth HC-05 module used four pins: RXD pin, TXD pin, GND pin, and VCC pin. The RXD pin is connected to the TX1 pin of the board, while the TXD pin is connected to the RX0 pin of the Arduino microcontroller. The VCC pin is the power supply that is connected to the VIN pin of the Arduino microcontroller.

Implementation Phase: In the implementation phase, all the prepared guidelines designed in the previous phase were transformed into an actual product. Therefore, the database and mobile application were developed in this phase, and the wearable device was integrated. Based on the ERD, as illustrated in Figure 7, the database was constructed using the Firebase database, consisting of two tables and the determined attributes.

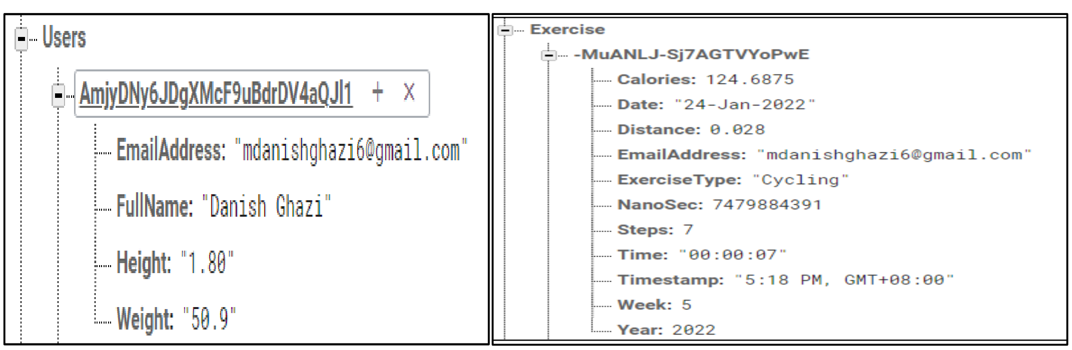

Figure 7: Tables in the database.

The development continued by developing the user interface for the mobile application using the Android Studio software. All the screens were built according to the flow between the screen navigation decided in the flowchart. Then, the wearable device was assembled based on the schematic circuit diagram, as illustrated in Figure 8. Finally, the wearable device was integrated with the mobile application through Bluetooth to allow communication between both devices.

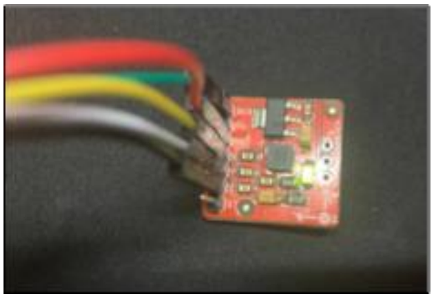

Figure 8: Wearable device

FINDINGS AND DISCUSSIONS

Figure 8 is the sample of mobile screens for the login module, which requires users to enter their details to sign up for the application first. After that, they must enter their email address and password to be authenticated to log in. If the authentication fails, the application will notify them with an error message to re-login.

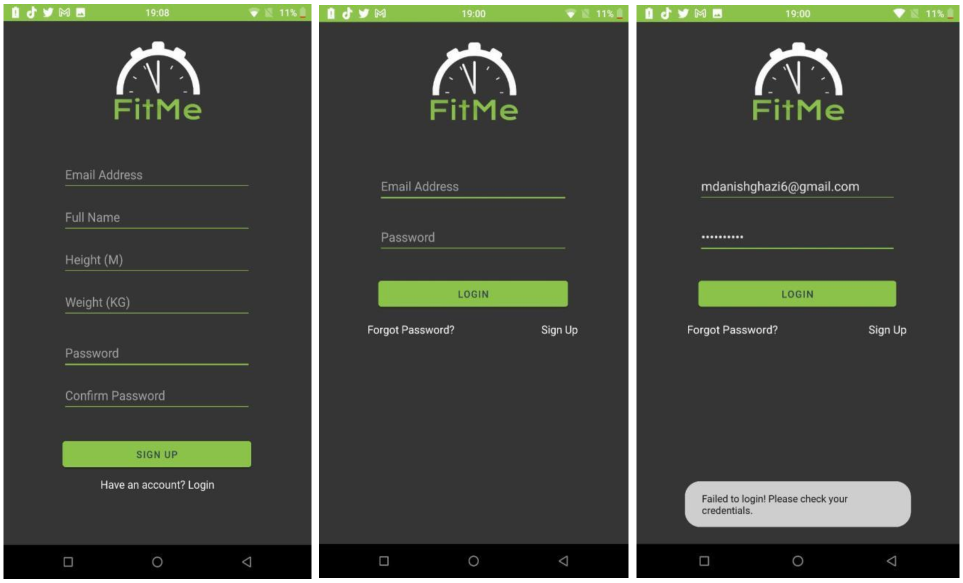

Figure 9: Mobile user interface

Meanwhile, the wearable device is kept in a container and inserted into a vest, as shown in Figure 10, to make it "wearable". The vest is also designed with a compartment for the mobile phone and is washable because the container is attached using Velcro tape so that it can be unattached and re-attached.

Figure 10: Wearable fitness tracker vest

As a result, when users wear the vest and start recording their activity, the detected data, such as user steps count, will be displayed on the screens depicted in Figure 11. Based on the steps count, the distance travelled and calories burned are calculated to provide more valuable information to the user. In addition, the application also provides users with a summary of their activities so that they can keep track of their fitness progress.

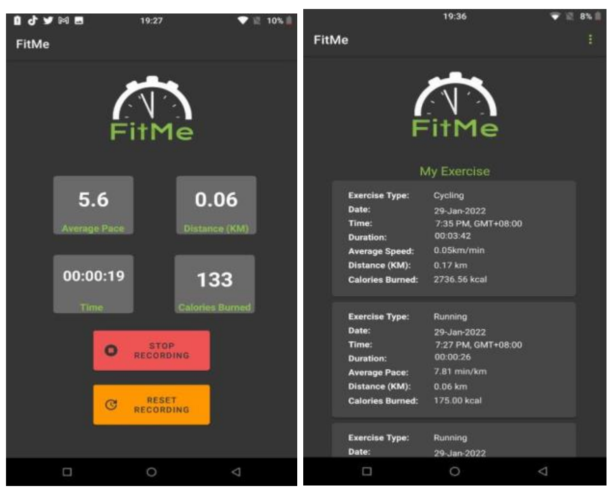

Figure 11. Integrated wearable application.

CONCLUSION

This study successfully developed a wearable application for fitness tracking. By referring to the designed framework, the development process begins with analysing relevant sources for information gathering, followed by designing the required guidelines for the implementation phase. As a result, the developed wearable application comprised two main components: the wearable vest and the mobile application. The wearable vest allows the user's movement to be detected, while the mobile application acts as the information tool that enables the user to track their fitness progress.

Despite the successful development of the wearable application, this study believes that with several enhancements, the usefulness of the wearable application could be elevated. For example, the wearable device can be added with other sensors, such as the heartbeat, temperature, and respiratory sensor that can detect heart rate. Thus, the application can deliver more comprehensive information to the user, such as emotion, as evidenced in a study by Zaveri et al., (2022) that can also help them improve their mental health. It is evident that the sudden increase in heart rate is one of the indicators of mental illness, such as stress and depression. In addition, it is also suggested to integrate other powerful technologies such as persuasive and multimedia that could persuade users toward behaviour change in an attractive way. Embedding persuasive principles such as cause and effect and praise is believed could motivate and enhance their awareness in monitoring their health.

The wearable application is expected could provide users with the opts for their fitness tracking tools. Therefore, the wearable application is anticipated to undergo an empirical test to assess its effectiveness as a wearable fitness-tracking tool. Hopefully, this study could also deliver beneficial information and unfold new opportunities to other developers or researchers not limited to wearable technology and the health domain but also in various domains and technologies such as persuasive and multimedia.

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