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Data Collection Techniques in Wearable Devices for Patient Tracking in Medical Centers

Julio Barzola-Monteses, MSc.[1,2], Rosangela Caicedo-Quiroz, PhD.[1], Franklin Parrales-Bravo, PhD.[2], Allison Aroni-Mera, Ing.[2] and Joselyn Zambrano-Navarrete, Ing.[2]
[1]Universidad Bolivariana del Ecuador, Ecuador, jjbarzolam@ube.edu.ec, rcaicedoq@ube.edu.ec
[2]Universidad de Guayaquil, Ecuador, julio.barzolam@ug.edu.ec, franklin.parralesb@ug.edu.ec, alisson.aronim@ug.edu.ec, joselyn.zambranon@ug.edu.ec

Abstract*– Wearable technology or wearable represents a new generation since it paves the way for the implementation of intelligent devices of body shape that, through their design and various features, give the user a greater value of coupling with their daily activities and monitoring indicators related to their health in real time. In addition, in recent years there has been a noticeable interest in the use of this technology by medical centers to monitor their patients through these devices. Therefore, the objective of this work is to determine the appropriate method for collecting data from these wearable devices that allow the collection and visualization of indicators for the follow-up of patients who require constant monitoring. To this end, a review of the state of the art was developed based on the research and work carried out, as well as the technological advances of these devices. Then, a survey was developed and applied to adults to know their interest and knowledge about this technology and if they would agree to use it to contribute to the monitoring of their health. As a result of these studies and surveys, a comparative table shows the evolution of this technology and the methods implemented over the years to obtain the data collected by the smartwatch and thus be visualized by the experts. The developed prototype will have a great impact for the medical center, since it will be able to centralize and visualize the daily activity of its patients.

***Keywords*-- Health indicators, Data capture methods, Health 4.0, Smartwatch, Wearable technology, Wearables**

I. Introduction

Technological progress has been making inroads over the years to constant improvements in areas such as health, and entertainment, among others, likewise, human beings have been leaning towards devices that provide greater functionality and contribute to their daily activities. According to [1] "Over the years, we noticed that the orientation towards networks was weakening, giving greater emphasis to the power of people, resulting in what we know today as wearable technology" (p. 03).

According to a report by Interctiva [2], in 2019 the countries of Norway and New Zealand are the world leaders with the highest penetration of this technology and its use by their consumers, as well as Spain, the United States, and China.

In addition, many of these devices are equipped with functionalities that provide the user with facilities for managing messages, coordination of agendas and monitoring their physical state, in this last aspect are covered various indexes that, depending on the wearable device, can provide information on one or more indicators. "There are several utilities that present this type of device, covering each of the aspects that meet our needs, improve our quality of life and allow us to move forward as a technological society. [3].

In health care, it is essential to know the vital state of patients, their level of exercise, and whether their hours of rest and nutrition are favorable. A retrospective review of how medical check-ups are currently carried out in the country, in doctors' offices, medical centers, and other medical institutions, shows that it is through an exploratory analysis, which consists of asking the patient questions about their state of mind, their symptoms and a review by touch to establish what their condition is, or their current state. This is why this technology has become even more powerful in this field, thanks to the health indicators that these devices have integrated, this information can be obtained in a real, concise, and daily form of the patient's condition. However, being a technology that has had more boom in recent years due to the incorporation of new features, in addition to these health indicators, has been the level of restriction that some commercial brands have not allowed to integrate their services with those of medical institutions, as well as having strong limits on access to their data. In addition to this, the concerns of medical specialists have been the feasibility, reliability, and security of the information they would obtain from these devices.

The objective of this paper is to determine the appropriate method for collecting data from these wearable devices that allow the collection and visualization of indicators for the follow-up of patients who require constant monitoring. The prototype developed will have a great impact for the medical center, since it will be able to centralize and visualize the activity of their patients daily.

The rest of the paper is organized as follows: Section II summarizes the works that have been related to the subject of the article. Section III details the method used for data gathering to be applied based on the review of the state. Section IV explains the analysis of the results obtained in the study, and Section V focuses the article on determining the conclusions and future work that can be guided by the article.

II. Related Tasks

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In this section, papers that have provided guidance and insight into the methods to be used for capturing and visualizing data in wearables will be presented. As well as to know in which area they used this new technology.

The study entitled: "An IOT approach to help sedentary people" focuses on using ASP architecture to monitor the physical activity of people, storing their information to be subsequently used by a medical specialist to keep track of the state of his patient, thereby evaluating a treatment and an exercise routine that is beneficial to the patient's health.[4].

The study, entitled "Mobile and web application for monitoring data collected by the Mi Band 2 smart bracelet using BLE and the Fi-ware platform," explains how the use of wearable devices allows important health-related data to be collected using a mobile application with BLE technology and this information to be visualized on a web portal. [5].

The study titled: "BleesYou-The current way to connect people and health professionals" uses new technologies, making use of AngularJS, MySQL and Google Apis among others. Their work focuses on connecting patients with their specialists, using Google Fit to gather the data and send it to the medical experts.[6].

The paper, titled "Data capture from wearables and their use for the classification of the type of activity performed by a person," uses data mining and machine learning techniques to collect data from commercially available wearable devices to classify them and determine what type of activity is being performed.[7].

The study in [8] mentions the detail of a mobile application capable of being counted via Bluetooth with a Mi band 2 to monitor cardiovascular disease in people and when detecting high frequencies alert their relatives by SMS.

The study reviewed in [9] focuses on capturing the data of physiological variables of patients with reduced mobility so that they can keep track, they developed an app that connects via Bluetooth with a smartwatch, which will be able to show the data and also be able to save it to consult it at any time.

In the study entitled: "Heart rate monitoring in people with reduced mobility using noninvasive technology", the author here explains the development of an application for the smartwatch and another application for the mobile phone that will be able to collect the data and show the record to the patient. The watch application will be able to send the data to the mobile application and store it, allowing the user to download the record and visualize it in Excel [10].

The study in [11] presents the development of a mobile app of activities that connects via Bluetooth to calculate the patient's heart rate, in addition, this application provides different modules for recording different activities such as exercise, and personal information of the patient and can set goals and goals to meet in activities and control their health.

The work titled as: "The data recorded by our cell phones, a digital autobiography", where the author tries to provide information on the importance of wearable devices, how they can store a person's history, and how they would contribute to the knowledge of their health. It also offers a vision of what could be done with the data collected and how it could contribute to the future [12].

The work in [13] was developed to raise awareness of the importance of technology and how it contributes to health. It provides information about wearables, their types, functionality, and applicability in nursing.

Each of these works has contributed to the analysis and processes used to capture data in wearable devices, particularly smartwatches. Over the years, data collection in these devices has been used in the health field. The authors have focused their work on control and monitoring in order to contribute and provide users with a more modern vision of the data they can generate.

Much of the work reviewed is focused on capturing and displaying the heart rate of its users, which is why it is evident that the most used device is the Xiaomi Mi band 2 due to its price and because it has a heart rate sensor to test. The related works follow a pattern in the development of an intermediary app that serves as a bridge for sending the data generated by the wearable device.

It should be noted that the works reviewed only work with one health indicator, so it would be very helpful to use more sensors to have a broader overview of a patient's health. Currently, wearables already integrate sensors to measure stress levels, blood oxygenation, sleep hours, or blood pressure. Therefore, with the help of these reviewed articles, the best methods used have been identified and a method capable of visualizing other data generated by sensors is proposed, thus contributing to a more complete monitoring of the patient.

III. Method And Experimental Design

According to the results of the survey conducted with patients, Fig. 1 shows that 76% of the population expressed a high level of interest in using these devices, while 24% of patients decided not to purchase them due to a lack of knowledge about the technology. More details of the survey can be found in [14].

Similarly, 60% of patients responded positively to the use of this technology for health monitoring. According to [15] In the long run, more continuous health monitoring can contribute to the detection of possible diseases and the management of risk factors.

Considering the results of the survey and the analysis of the methods used in other studies, this work has chosen to use Google Fit services.

Fig. 2 shows the methodological design of the proposal. A mobile application can extract the data collected by the smartwatch and store it with the help of Google Fit through synchronization. To use this data, we will use the Google Fit Rest API because it allows you to store and read health and wellness data, and it also has the ability to store wearable device data so you can access it and view it in a web application.

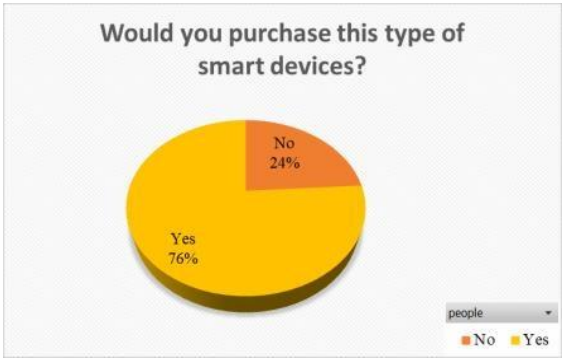

Fig. 1 Device utilization graph

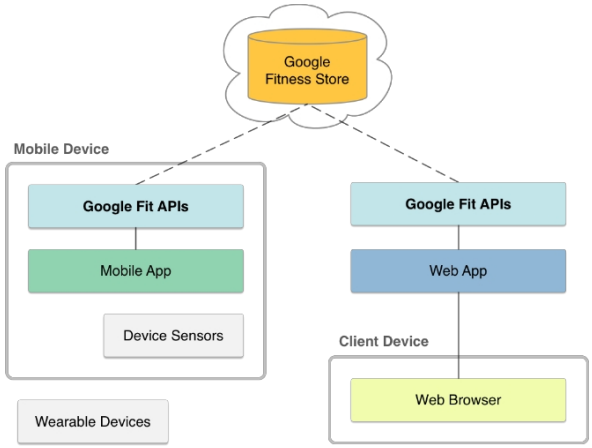

Fig. 2 Api Rest Google Fit

A prototype was developed using the Flutter development kit created by Google, which allows us to develop mobile and web applications in one code base and allows us to create applications for both Android and IOS devices. Additionally, in order to use the Google Rest API, we need to have an OAuth 2.0 client ID, which will be used to manage our application, restrict access, and enter the users who will be able to test our application.

Once the mobile application extracts the data stored in Google Fit and sends it to the Firebase database where it is hosted, it will record and allow us to view the data of the registered user, we will be able to access the data collected by time and date of the sleep, step and heart rate sensors. In addition, we will have a section where you can view the device from which the data is extracted, since it can be from an app, mobile device or smartwatch.

IV. Results And Discussion

A. *State-of-the-Art*

Table 1 shows the main results of the study, based on the state-of-the-art methods that contributed to the realization of the mobile and web prototypes, as well as the data collection from the wearable devices.

B. *Data Capture*

For this process, the Google Fit application developed by Google was used, since it is an application focused on health monitoring and control, capable of collecting data generated by mobile devices, smartwatches (wearables), health applications, fitness, among others.

The testing of this proposal was done using a Band 7 smartwatch of the Xiaomi brand. We also used the app recommended by the watch (Zepp) to view the data we generated, such as sleep, heart rhythm, blood oxygenation or steps. These data may vary depending on the brand of watch used.

With the watch connected to the phone via Bluetooth and the app synchronized with the watch, we need to access the option to add accounts in the settings and enable the Google Fit option as shown in Fig. 3, this will allow Google Fit to collect and store the data generated by the watch.

For high-end watches, you can configure or download the Google Fit app from the watch itself and enable the permissions for the app to collect and store the data.

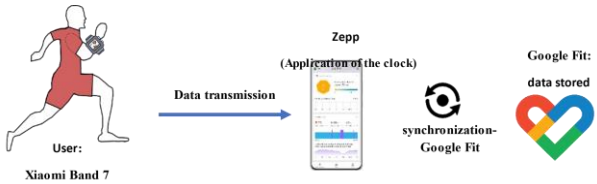

Fig. 3 Data Capture

C. *Data Extraction – Mobile Application*

A prototype of a mobile application has been developed that allows the synchronization of the data stored by the Xiaomi Band 7 in Google Fit. This application will allow us to update the data so that it can be sent and stored in a Firebase database. Once the data is sent to the database, it can be viewed through a web portal.

Fig. 4 shows the process of extracting data collected by Google Fit from the Xiaomi band 7, the mobile application will be responsible for allowing the user to log in with a user previously created by the specialist; access will be through the Google account, where Google Fit permissions can be activated, which once activated will allow us to extract the collected data and thus be able to send it to the Firebase database.

TABLE I
STATE OF ART RESULTS IN THE STUDY

Technique	Method	Type of Access	Brand Wearable	Tool	Advantages	Limitations	Requirements
Online	SDK	Open	Samsung	Tizen Studio	-Real-time connection between the wearable device and the web application. -Health indicator data is captured at the time of activity and stored in the web portal database. It includes the necessary development functionality to retrieve the data directly.	-Although the brand provides open access to its SDKs, it requires the use of an author certificate, which may limit the development of the project if you do not receive a response from the brand. - It does not allow downloading the Wearable package to be used in the tool.	Author's Certificate Distributor certificate
		Closed	Xiaomi	Android Studio	-Enables developers to create applications with multiple interfaces faster and more efficiently.	-Because they do not provide access to their SDKs, it is not possible to query or collect data directly from the wearable device.	---
Offline	Export data Manually	Provided by the brand	Xiaomi	Zepp Application, Zeep Life	-Provides the user with information on the data immediately collected with your wearable device. -Sends all information in Excel format for viewing and database storage.	The user must provide the specialist with the documents provided by the brand via e-mail. -If automation of the process is required, this method is not considered.	Registration in the Zeep or Zeep Life application
			Garmin	Web connect Portal	-Displays data collected from the user. -Allows immediate export of data in TCX format for transformation and manual loading into a database.	-The user should provide the specialist with the documents provided by the brand via e-mail. -The price of the brand's wearable device is highly expensive, so its acquisition was not considered feasible.	---
	Data synchronization	Bluetooth	Xiaomi	Android Studio	-Direct connection via unidirectional bridge between wearable and and the mobile application for data collection and storage. -Automated data visualization through the web portal.	-It did not allow the connection between the wearable device and the mobile application due to the operating system that did not have Android 12, currently, this Android update is active only for mobile devices.	Wearable device with Android 12 operating system
		Bluetooth Google Fit	Xiaomi Mobvoi	Flutter	-Direct connection through a unidirectional bridge between the wearable and the mobile application for data collection and storage. -Automated data visualization through the web portal. -Does not require the portable device to have an operating system. -Stores information in the cloud through Firebase. -Leverage Google Fit, which the medical center already manages. -Ability to integrate the prototype in the future with the tools and platforms already managed by the medical center.	-Since there is no direct connection between Google Fit and Firebase, it is necessary to use a mobile application to send the data from the Google Fit account directly and store them in Firebase.	Internet connection Google fit account Active connection permissions with Google Fit

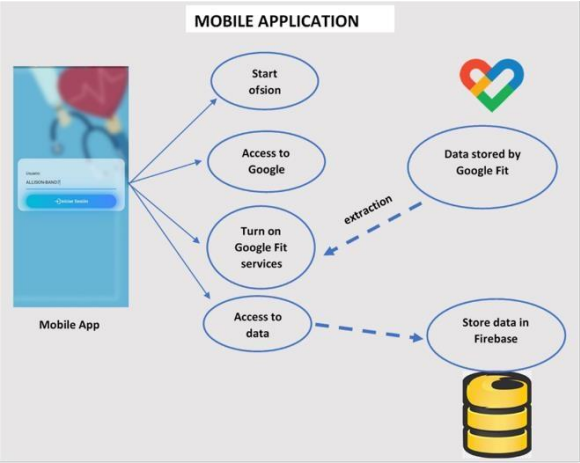

Fig. 4 Google Data Extraction

After that, the user must update the records as shown in Fig. 5 so that they can be sent to the database.The records updated in the Firebase database, such as the number of steps, heart rate frequency, and sleep, can be constantly updated according to the activity performed by the user.

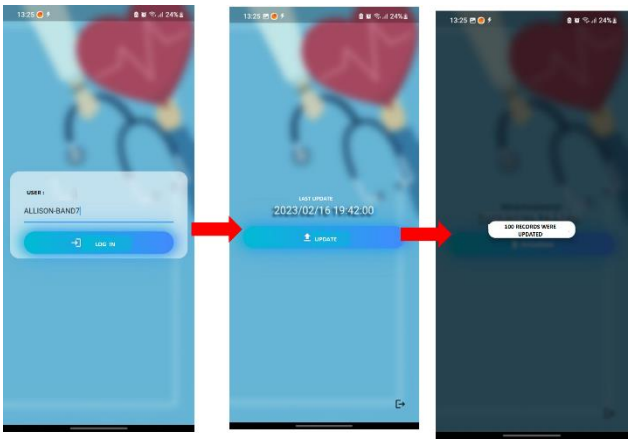

Fig. 5 Updating records

D. Data viewing – Web portal

Once the data is updated, the specialist will be able to access this data through the web portal; the specialist will need to select the user, and once selected, he will need to perform the search according to the date of the data he wants to view, click on consult, and thus the data collected by the Xiaomi Band 7 will be displayed, as shown in Fig. 6. In addition to this information, the web portal will provide the specialist with information about the patient such as full name, ID number, email and phone number.

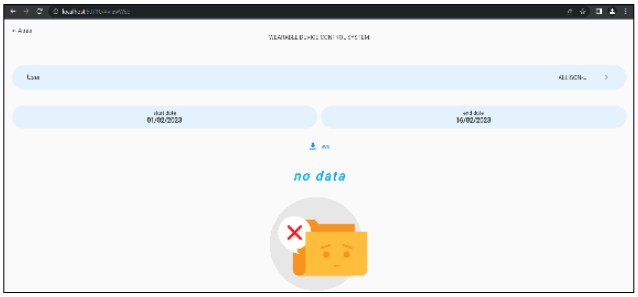

Fig. 6 Portal Web

When the user is selected and the date range to be consultedis set, the health indicators used in this research can be displayed. Fig.7 shows the date and the number of steps the user has taken.

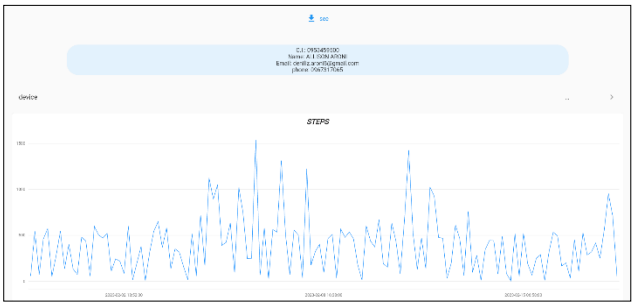

Fig. 7 Data: Steps

Likewise, we have the Heart Rate Indicator which, as in Fig. 7, will give us the information according to the date initially set. In Fig. 8 we can see the heart rate of the patient.

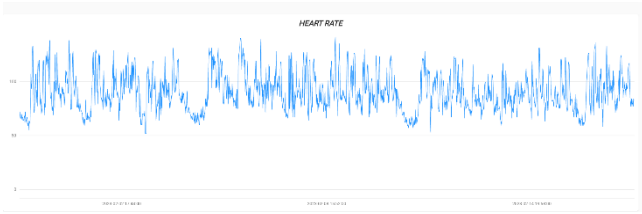

Fig. 8 Heart Rate

Then we will have the sleep section; in Fig. 9 it is possible to visualize the sleep section which refers to light sleep; the sleep section indicates the time when the patient is in deep sleep.

Finally, a section will be displayed as a table (Fig. 10), where you will have a better view of the date, the type of data (steps, heart rate, and sleep), the value it had on that date, and finally we can know the type of device that collected the data, note that the data was collected by a Xiaomi band.

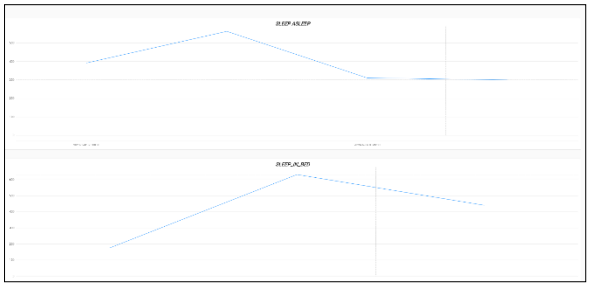

Fig. 9 Data: Sleep

DATE	TYPE	VALUE	DEVICE
2023-02-01 00:01:00	STEPS	59	com.xiaomi.hm.health | ...
2023-02-01 00:02:00	HEART RATE	72.0	com.xiaomi.hm.health | ...
2023-02-01 00:12:00	HEART RATE	69.0	com.xiaomi.hm.health | ...
2023-02-01 00:22:00	HEART RATE	66.0	com.xiaomi.hm.health | ...
2023-02-01 00:32:00	HEART RATE	66.0	com.xiaomi.hm.health | ...
2023-02-01 00:42:00	HEART RATE	67.0	com.xiaomi.hm.health | ...
2023-02-01 00:52:00	HEART RATE	70.0	com.xiaomi.hm.health | ...
2023-02-01 01:02:00	HEART RATE	69.0	com.xiaomi.hm.health | ...

Fig. 10 Capture Data Records

V. Conclusions

Bibliographical information was compiled, which contributed to having more knowledge about this technology and the work that could be done with it, in addition, this information helped us to find the right method for the Medical Center to implement and be able to use the data collected by smartwatches. Thanks to the surveys conducted, we were able to obtain a broader knowledge about this technology in the city of Guayaquil and how the elderly are willing to acquire this new technology to contribute to better control of their health. With this result, we could start the research of a method capable of capturing the data generated by the wearables and use them to keep a broader control of a patient and contribute in the future to the detection of possible diseases.

Future work to be done: A project 100% focused on the development of a functional platform that contributes to the medical center in the analysis of the data obtained, such as reporting, visualization of statistical tables, and incorporation of a patient advisor to visualize their data. Another future work is the implementation of an automatic and online method for synchronizing patient data with the web portal, without requiring the user to send his data to be synchronized but using a parameterizable time interval for automatic synchronization.

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