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Oxygen Saturation and Heart Rate Monitoring System by Mobile

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Abstract— COVID-19 changed the way people live, causing a high mortality rate and making the entire health system in the world difficult due to the lack of equipment and infrastructure, causing many people to be treated from home, constantly measuring their saturation level and heart rate with the help of a pulse oximeter, since the virus directly affects the respiratory system, it has been added that people with lung or cardiovascular problems also have to perform the constant measurement of both vital signs to visualize that they are in a normal range, otherwise, they would have to attend a medical center, so it is important to monitor both vital signs. In view of this problem, in this article a monitoring system of oxygen saturation and heart rate was carried out by mobile application, in such a way that both vital signs can be constantly monitored and an alert can be given to the health center with the coordinates of the person when the system detects a measurement outside the normal range, with this, it would help people who may need medical attention immediately, being able to save their lives. Through the development of the monitoring system, it was possible to observe the operation of the mobile application with an efficiency of 99.15% in monitoring the level of oxygen saturation and 98.78% in monitoring the heart rate, taking 4 seconds to send the alert to the health center to assist the patient.

Keywords- Bluetooth, COVID-19, Cardiovascular, Heart rate, Microcontroller, Saturation level.

I. INTRODUCTION

The coronavirus disease (COVID-19) generated by SARS-CoV-2 resulted, since its appearance in the city of Wuhan (China), a devastation for humanity in the part of health, economy, and way of life [1]. Due to its rapid transmission of contagion, the SARS-CoV-2 virus was spreading throughout all countries [2], opting to comply with the prevention measures recommended by the World Health Organization (WHO) [3]. Despite that, until August 2021, more than 164 million people worldwide were infected [4], complicating the entire health system and exposing the health crisis in Peru.[5]

Given the lack of medical equipment and the few health facilities in the country [6], many patients were treated from home without the constant monitoring of a doctor [7], using the pulse oximeter for continuous monitoring of their oxygen saturation and heart rate because the main symptom presented by patients with COVID-19 was the low concentration of oxygen in the blood or hypoxemia [8], causing respiratory failure in patients. On the other hand, continuous monitoring of oxygen saturation and heart rate with the pulse oximeter is essential for the non-invasive diagnosis of patients with lung or cardiovascular diseases, as it shows two of the most critical vital signs of the human body with an instant measurement[9].

Oxygen saturation levels normally in resting condition are between 95% to 100%. If the saturation is below 95%, the patient may have trouble breathing [10]. The heart rate normally in resting condition is between 100 beats per minute [11], if it has a higher value, the patient may present tachycardia since his heart beats quickly or he may suffer from heart failure due to a low pumping of blood throughout the body. It should be noted that the measurement of both vital signs can vary according to the activity of the patient, therefore, it is important to monitor

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these vital signs to visualize the state of health of the patients and take the corresponding measures if any emergency occurs.

The objective of this research work is to conduct a monitoring system of oxygen saturation and heart rate to acquire measurements of these disorders and alert the health center with the coordinates of the patient's global positioning system (GPS) through a mobile application if the level of oxygen saturation and / or the heart rate is outside the normal range. For the realization of the system, the Onyx II 9560 pulse oximeter, a Bluetooth module, a GSM/GPRS module and a PIC 18f4550 microcontroller programmed in MPLAB were used. MPLAB is a software to program and develop applications focused on microcontrollers.

In section II, the literature review of some previously developed research works was conducted. In section III, the methodology shall indicate the block diagram of the system. In section IV, the development of the mobile application was conducted to visualize the measurements of the pulse oximeter. The results of the proposed system will be presented in section V. In section VI, the discussion will be presented, highlighting the importance of the proposed system. Finally, section VII will present the conclusion and recommendation of the proposed system.

II. LITERATURE REVIEW

Lung or cardiovascular diseases are a disease that cannot be seen with the naked eye, if not treated in time, can generate serious complications in patients suffering from these diseases. Therefore, it is necessary to monitor these vital signs to visualize the health status of patients. For example: In [12], the authors mention that the oxygen level and heart rate play an important role in the patient's health, since they indicate how the patient's health is, inside or outside the normal measures, which is why they proposed to develop a centralized system for monitoring patients of oxygen saturation and heart rate using Li-Fi. The proposed methodology consists of using Li-Fi technology for wireless communication between hospitals, On-Off-Keying modulation for the transmission of patient data with an Arduino Nano. Obtaining as a result an efficiency of 90.75% in monitoring the level of oxygen saturation and 91.87% in monitoring the heart rate, concluding that its proposed system efficiently monitors the level of saturation and heart rate without any inconvenience.

In [13], the authors mention that the continuous measurement of heart rate and oxygen saturation reflect the state of health, as well as the continuous monitoring of patient diseases by means of these physiological parameters, which is why they proposed to develop a stretchable optical detection patch system for the measurement of heart rate and oxygen saturation. The proposed methodology consists of using an optical sensor together with a microcontroller chip to make the measurements and transmit it to a phone through Bluetooth technology. Obtaining as a result an efficiency of 79.12% accuracy in the measurement of heart rate and saturation level, concluding that the detection of both vital signs was achieved through an optical sensor used in the system.

In [14], the authors mention that mobile communication in health centers is important for an interaction between the doctor and the patient without the need to attend the health center to monitor their saturation level and heart rate, which is why they proposed to develop a wireless system with mobile application for monitoring the oxygen saturation and heart rate of patients. The proposed methodology consists of using a sensor module for the measurement of saturation and heart rate, an ESP32 microcontroller with a wireless module for the transmission and reception of data through the mobile application. Obtaining as a result an efficiency of 92.77% in the measurement of the two vital signs, concluding that his system employs a non-painful technique for the measurement of oxygen saturation and heart rate.

In [15], the authors mention that it is necessary to develop a device to control the saturation level and heart rate non-invasively, that is, without hurting the patient, to prevent hypoxia from damaging other organs of the patient, which is why they proposed to develop a hypoxic symptom detection system based on oxygen saturation and heart rate using the diffuse method based on Arduino. The proposed methodology consists of using a Max30100 sensor to measure the two vital signs and process them with Surgeon’s diffuse method together with an Arduino and a Bluetooth module to send this information to a mobile phone. Obtaining as a result an efficiency of 94.33% accuracy in the measurement, concluding that your system by using the diffuse method of Surgeon can process the data efficiently.

III. METHODOLOGY

In this part, the block diagram of the oxygen saturation and heart rate monitoring system was made, describing the operation of the set of electronic devices that will allow us to monitor the two vital signs through a mobile application, as shown in Figure 1.

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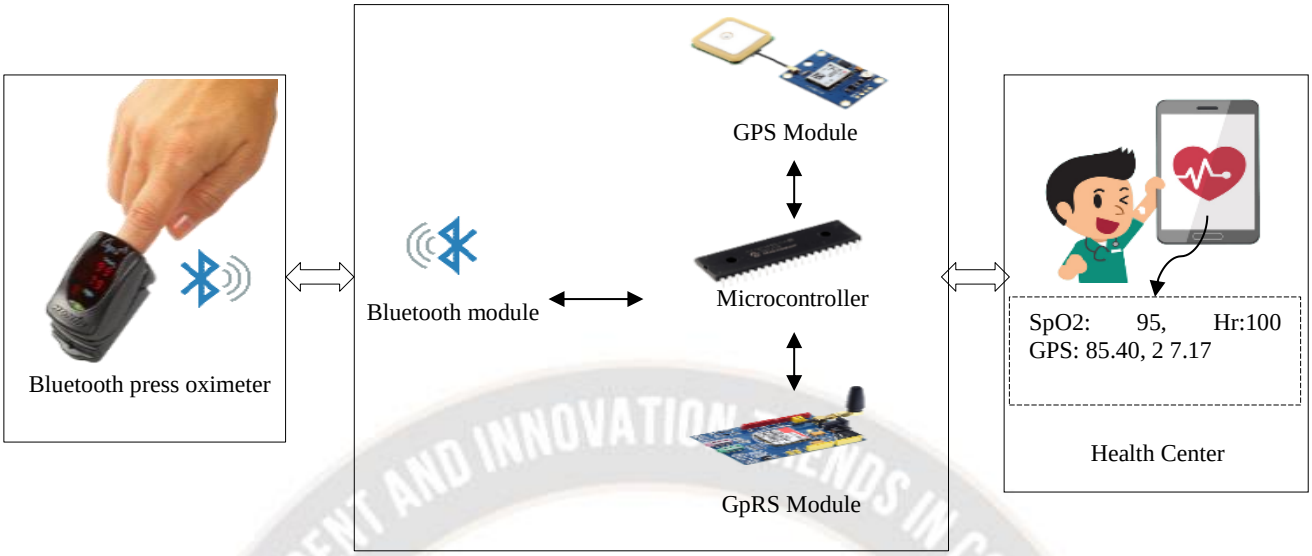

Figure 1. System block diagram

In the first stage, the measurement of the level of oxygen saturation and heart rate are obtained by means of a pulse oximeter Onyx II 9560, it was thought to use this model of pulse oximeter since it has Bluetooth technology, presenting a range of 100 meters and with a measurement accuracy of ± 2 digits for oxygen saturation and ± 3 digits for heart rate [16], allowing us to obtain the reading of both vital signs of the patient in real time.

In the second stage, the readings obtained from the patient are received through a Bluetooth module linked to the pulse oximeter for the transmission and reception of the signal and then processes it. This Bluetooth module used as a receiver, is connected to a PIC 18F4550 microcontroller, which has precise characteristics that adapt to our system, allowing us to perform and / or control other electronic devices for a certain function. The microcontroller is connected to a GPS module in one of its serial ports to provide us with the coordinates of the latitude and longitude of the place where the patient is. Once the microcontroller processes the readings obtained from the pulse oximeter or about the saturation level and heart rate, it will perform an analysis of the measurement value, as shown in Figure 2. Once the measurement has been analyzed, the microcontroller will send an SMS to a mobile phone of the medical center if both vital signs of the patient are at risk, with the GPS coordinates and the 4-byte package of the pulse oximeter by means of a GPRS module.

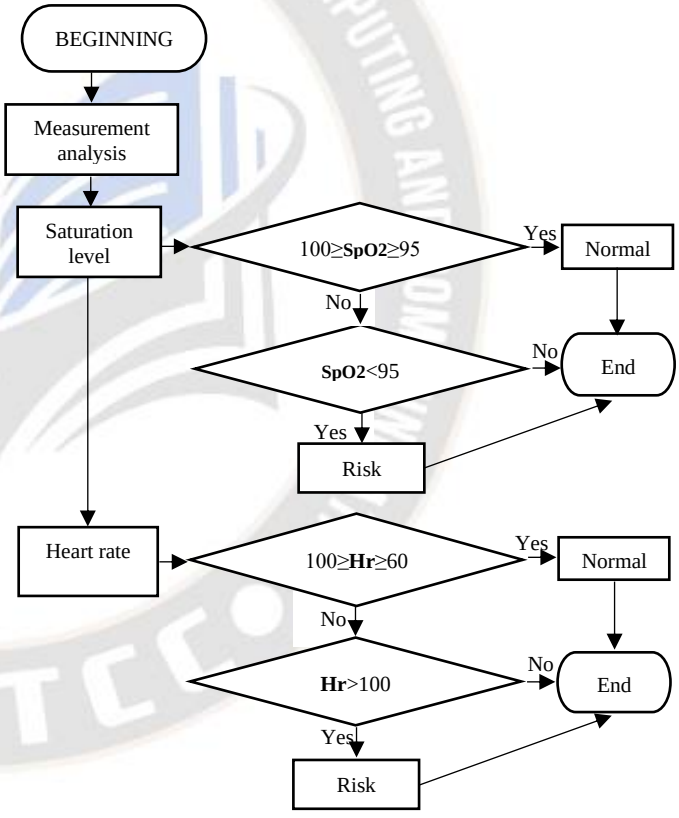

Figure 2. Microcontroller flowchart

Once the complete patient information has been sent, the doctor can view it through a mobile application.

IV. DEVELOPMENT OF THE MOBIEL APPLICATION

For the development of the mobile application, the App Inventor 2 tool was used, as shown in Figure 3. This application will illustrate the values of the pulse oximeter such as the oxygen saturation level (SpO2), the heart rate (HR) and the GPS

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coordinates of the place where the patient is located; App Inventor 2 is a platform that allows us to develop applications through internal block diagrams, this platform allows us to connect the application developed for Android devices through the use of Bluetooth technology or compatibility through an SMS.

The values displayed through the mobile application, were compared two with the same values measured by the pulse oximeter, observing an identity in both parts with respect to the readings, validating the process of sending or SMS without any error. To test the operation of sending SMS of the system, it had to manipulate the data received from the level of saturation received from the healthy patient so that it is out of the ordinary and the SMS alarm system was activated to the medical center, similar was with the heart rate of the healthy patient, the data received had to be manipulated to activate the system alarm.

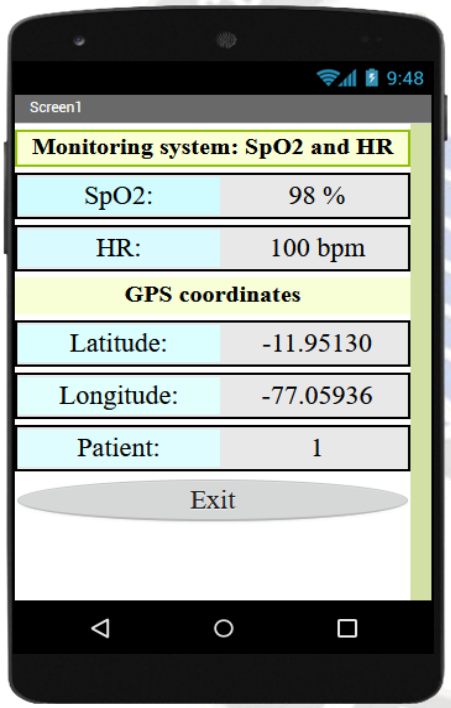

Figure 3. Mobile application

V. RESULTS

With the development of this system, the objective of monitoring the level of oxygen saturation and the patient's heart rate through a mobile application is met. With this, the health center would be alerted so that it can intervene helping the patient in an emergency, if the system detects unusual measurements.

The system was developed in the best way, it was evaluated to verify the accuracy of the readings of the saturation level and the patient's heart rate, being visualized in the mobile application with an efficiency of 99.15% in monitoring the level of oxygen saturation and 98.78% in monitoring the heart rate.

For the operation of the system, it is essential that the pulse oximeter performs the correct measurement of both vital signs without any problem, since, depending on those measurement values, the microcontroller will analyze and send an alarm to the health center if the measurement is out of range.

With the precise measurement of the two vital signs, the system is important to combat these disorders and prevent a patient from being affected by not being able to alert a health center so that they can assist them.

The implementation of this system would help patients who are far from a medical center, since it would notify the health center closer to the place where it is located so that it can assist you in an emergency, it should be noted that low-cost electronic devices were used, so that their implementation is not expensive. Adapting to any health facility so that it can constantly remotely monitor the two vital signs of high-risk patients who may be able to live alone.

VI. DISCUSSION

This proposed system is a new team that will help monitor the vital signs of patients with lung or cardiovascular diseases, therefore, it differs from other research papers, for example, the work done [12], where the authors proposed to develop a centralized system of monitoring patients of oxygen saturation and heart rate using Li-Fi. Where they obtained a result of 90.75% in monitoring the oxygen level and 91.87% in monitoring the heart rate, but this system when using wireless technology presents interference between the communication of the transmitter and the receiver.

We also have the work developed by [13], where the authors proposed to develop a stretchable optical detection patch system for the measurement of heart rate and oxygen saturation. Where they obtained a result of 79.12% efficiency, but this system is limited in the measurement of both vital signs in sweaty patients due to the optical sensor used to measure.

We also have the work developed by [14], where the authors proposed to develop a wireless system with mobile application for monitoring the oxygen saturation and heart rate of patients. Where they obtained a result of 92.77% efficiency, but this system presents its results based on a virtual simulation of its operation and not in real patient tests.

We also have the work developed by [15], where the authors proposed to develop a hypoxic symptom detection system based on oxygen saturation and heart rate using the diffuse Arduino-based method. Where they obtained a result of 94.33% efficiency, but this system has a mishap with the distance of the Bluetooth module, since it could not establish a correct communication, and this would imply an error in the sending of measurement data.

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VII. CONCLUSION AND RECOMMENDATION

It is concluded that the monitoring system of oxygen saturation and heart rate works efficiently, taking 4 seconds to send the alert to the health center so that it can be viewed through the mobile application in an emergency.

It is concluded that the system does not require any manipulation to send the measurements to the health center, since it is an automatic system, being safe for the patient when performing the measures instantaneously.

It is concluded that the system can be used by any patient, its manipulation is not complex, the pulse oximeter will perform the measurement and the system will be responsible for alerting the health center if it observes any measurement out of range.

As a future work, a database will be added to the system so that the patient's data and his location of the place where he lives is stored.

It is recommended that the patient perform the measurement of the two vital signs without any metal object in the hand where the pulse oximeter will be placed.

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