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PROTOTYPE OF HEART RATE SENSOR FOR THE PROGNOSIS OF HEART PROBLEMSPROTOTIPO DE SENSOR DE FRECUENCIA CARDÍACA PARA EL PRONÓSTICO DE PROBLEMAS CARDÍACOS

PROTOTIPO DE SENSOR DE FRECUENCIA CARDÍACA PARA EL PRONÓSTICO DE PROBLEMAS CARDÍACOS

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ABSTRACT

The present article seeks to design and develop a software tool for mobile devices that helps the prediction of a person's heart complications by means of a Arduino sensor located on a bracelet or handle that communicates using computer networks to the object sending information in real time And comparing the information with a database containing information on different cases of health complications in people with heart disease or blood pressure.

KEYWORDS

Teleinformatics, Internet of Things, Heart Rate, sensors, Telecommunications Networks.

RESUMEN

El presente artículo busca diseñar y desarrollar una herramienta de software para dispositivos móviles que ayude a la predicción de las complicaciones cardíacas de una persona mediante un sensor Arduino ubicado en una pulsera o asa que se comunica mediante redes informáticas al objeto enviando información en tiempo real. Y comparar la información con una base de datos que contiene información sobre diferentes casos de complicaciones de salud en personas con enfermedades cardíacas o presión arterial.
Palabras clave: Teleinformática, Internet de las Cosas, Frecuencia Cardíaca, Sensores, Redes de Telecomunicaciones

1 INTRODUCTION

Nowadays, smartphone and smartphone applications have become very popular, which help in a fast and agile way to solve problems of daily life, some of these applications focus on the field of medicine and human body health such as the detection of insulin in the body for people who have diabetes or virtual consultation on topics such as pregnancy or diseases such as breast and the HIV.

In this project it is proposed the design and development of a software tool that helps the detection of a person's heart rhythm by means of a sensor located on a bracelet or handle, which will send the information in real time to the mobile device that has the user to have an efficient control over their heart health. The device will alert the user if it exceeds the normal beats per minute heart rate and in case the user does not notify the mobile device that it is a false alarm, a message will be sent notifying some family that the user has registered in the application since it could be a heart complication and even a heart attack.

2 BACKGROUND

Next, we will talk about different applications for mobile devices that have helped the development of the Internet of Things (IoT) focused on the health of the human body.

- Scout

It is a device that is financed by Indiegogo which is considered as a new form of medium consultation of domestic form. It contains various sensors that measure heart rate, body temperature, oxygen in blood, respiratory rate, blood pressure, electrical activity of the heart and emotional stress. This device can capture these values simply by supporting the Scout for a time of 10 seconds on the user's front. [1]

- Miriam

This device can locate cancer cells and other diseases in the user in a very short time, approximately one hour. The system is programmed to identify the patterns of microRNA (responsible for regulating the genes of our body) to detect if there is any abnormality in the body of the person. Miriam recognizes breast, lung, pancreatic and ovarian cancer.

Just place a blood sample from the user on the device. In addition to identifying the disease, it gives us information about how advanced this abnormality in the body is. [2]

- Withings Aura

This sensor helps us monitor heart rate, breathing and the number of times one moves and wakes up at night simply by placing it under the pillow where the user goes to rest. The device communicates with the user's cell phone and by means of an LED lamp generates a light tone depending on the data obtained to relax the body, based on the wavelengths adequate to favor the secretion of melatonin and thus adjust the cycles of dream. [3]

- Temp Traq

This device is designed primarily to be used on infants and control the flow of temperature for about 24 hours simply by attaching it to the skin. Basically, it consists of several adhesive bands that communicate through Bluetooth if the baby has fever at some point by means of a series of alarms. [4]

- Cellscope Oto

This device seeks to detect infections in the ears of people, mainly children using a set of lenses and an optical fiber that illuminates the area to be analyzed. It was developed by Emory University in Atlanta and according to its creators "the quality of the image is like what you get through a professional otoscope." The results can be sent to the pediatrician, so you do not have to go to the emergency center and save time and money. [5]

- Aina

Aina is a complement for Smartphone that serves to have a control and monitoring of the blood flow in the cellular. It is funded by Grand Challenges Canada. The device can perform six types of blood tests in a simple way and send the results to health centers. Additionally you can connect to an iPhone to control your blood sugar level. [6]

- Samsung EDSAP

It is a sensor located in a diadem developed by Samsung with the function of warning about possible stroke (ACV), being able to connect to the mobile phone and receive the brain waves to anticipate a possible heart attack.

- iHealt

This device consists of a tensiometer that presents the user's blood pressure data on his cell phone. It is manufactured by Xiaomi. [7]

A comparative table between the different devices mentioned above is shown below, mainly showing its advantages and disadvantages.

Table 1. Comparative between the different devices mentioned above is show below

Device	Advantage	Disadvantages
Scout	♦ Multiple sensors. ♦ Easy to use.	♦You do not have communication with cellular or other devices
Miriam	♦ Detects and provides detailed information about certain user illnesses.	♦ Invasive method for detection (blood sample)
Withings Aura	♦ Mobile communication. ♦ Helps regulate sleep from light.	♦ Does not predict possible diseases
Temp Traq	♦ Communication via Bluetooth. ♦ Use of alarms in case of problems.	♦ Focuses on Babies
Cellscope Oto	♦ Save time and money by sending user information to the doctor.	♦ Looks for only problems related to the user's listening.
Aina	♦ Communication with the cell phone. ♦ Great information about the user's blood.	♦ An IPhone is required to use all the functionalities
Samsung EDSAP	♦ Prediction of possible heart attacks. ♦ Communication with the cell phone.	♦ Compatibility with other technologies.
iHealt	♦ Communication with the cell phone.	♦ Does not predict possible diseases

3 METHODOLOGY

In the present work it is necessary to determine the user's heart rhythm in real time to be able to predict his health in a mobile application and thus help him with possible cardiac complications. For this a heart rate sensor will be used using Arduino, which will be placed on a wristband to facilitate its use by the user and thus measure the pulsations per second it generates. On the other hand, will be designed an application for devices Android 4.4 onwards and IOS which will communicate with the sensor via Bluetooth and receive the information provided by the user in real time.

The application will have a graphical interface that is quite intuitive and easy to use, having various options such as setting the sound of an alarm that will be issued in case of a possible emergency, as well as when predicting a possible discomfort in the user's heart rhythm, also the possibility of establishing one or more telephone contacts to which a message will be sent warning of the situation of the person in case it is a real complication.

As for the forecast by the application, it is proposed to use a database that allows to determine by means of the historical values of cardiac pulsations of the person, when they are in a level superior or inferior of the normal and daily rhythm of that user, but likewise the possibility of warning in situations in which the heart rate accelerates more than normal but is not a real emergency.

The application will have a database fed from a set of data on electrocardiograms (ECG) with which to determine the heart rates of a set of people with different heart problems and others without any complication.

The database contains 549 records of 290 subjects (from 17 to 87, mean 57.2, 209 men, with a mean age of 55.5 years, and 81 women, with a mean age of 61.6 years, ages were not recorded by 1 female and 14 male subjects). Each object is represented by one to five records. There are no numbered songs 124, 132, 134, or 161. Each record includes 15 measured signals simultaneously: the 12 conventional leads (i, ii, iii, avr, AVL, AVF, v1, v2, v3, v4, v5, v6) along with the 3 Frank lead ECGs (vx, vy, vs.). Each signal is scanned at 1000 samples per second, with a 16-bit resolution in a range of ± 16,384 mV. At special request to database contributors, recordings may be available at sampling rates up to 10 kHz. [8]

Most of these ECG records are a detailed clinical summary, including age, sex, diagnosis, and where applicable, data from medical history, medications and interventions, coronary pathology, ventriculography, echocardiography, and hemodynamics. The clinical summary is not available for 22 subjects. The diagnostic classes of the remaining 268 subjects are summarized below:

Table 2. Summarized of the diagnostics

Diagnostic class	Number of subjects
Myocardial infarction	148
Cardiomyopathy / heart failure	18
Branch block	15
Dysrhythmia	14
Myocardial hypertrophy	7
Valvular heart disease	6
Myocarditis	4
Diverse	4
healthy controls	52

From this data set of the 268 patients it is proposed to use information from at least 50 patients for the first tests of the tool with which it will be possible to more accurately compare the heart rate of a person when he is with some cardiac complication or when it is in a normal state.

Additionally, it is proposed to work the project using the methodology of prototypes for software development since this evolutionary development model begins with the definition of the global objectives for the software, then the known requirements are identified and the areas of the scheme where more definition is needed. This model is used to give the user a preview of part of the software. This model is basically test and error because if the user does not like a part of the prototype means that the test fails so the error must be corrected until the user is satisfied. In addition, the prototype must be built in a short time, using the right programs and should not use a lot of money because once it is approved we can start the true development of the software. But that if in constructing the prototype we ensure that our software is of better quality, besides that its interface is pleasing to the user [9].

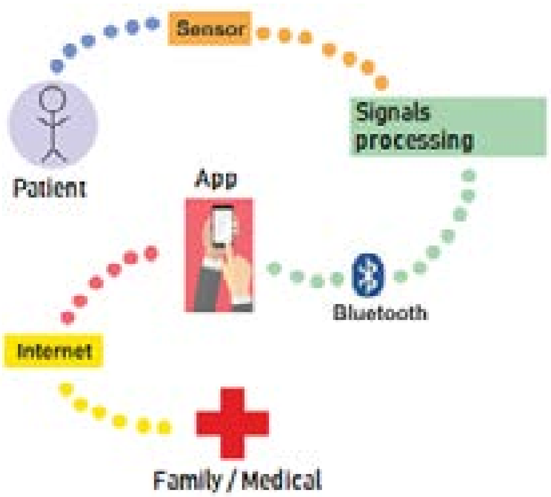

Fig. 1. General scheme of the system. Source: Authors.

As for the design of the mobile application, it is proposed that it be for devices with both the Android 4.4 and IOS operating system, in addition to having a clear and easy to use interface for any type of user, in which you can observe the data obtained by the sensor. The following is an initial design of the interface that the mobile application of this project must have.

Fig. 2. Mobile application interface design. Source: Authors

As seen in the previous figure the interface is divided into 4 main sections:

- Section 1: This is the zone where the application menu buttons are located and with which the user can interact.
- Section 2: This is the site where the title of the application is displayed with the information that is needed regarding the application developer.
- Section 3: This area shows the result of receiving the sensor data, showing the value of the heart rate that is equal to the number of beats per minute (LPM) that the user has.
- Section 4: In this part of the interface the user is presented with the state in which he is depending on his heart rate, which can result in a normal state, tachycardia, bradycardia or possible heart disease.

5 Implementation

Heart rate sensor:

Fig. 3. Heart Pulse Sensor. Source: https://pulsesensor.files.wordpress.com/2011/09/arduino-plug-in3.png?w=460&h=345

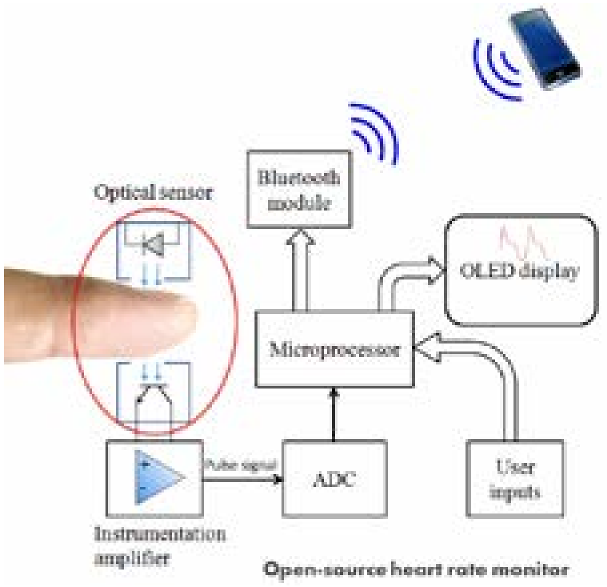

Fig. 4. Operation Heart Rate Sensor. Source: https://hackaday.io/project/2557-heart-rate-monitoring-system

SIGNAL PROCESSING MODEL

Using one of the databases obtained from the physionet page as mentioned in the methodology, we have a model to compare the results obtained by the sensor with these to be able to predict a possible cardiac complication. For this, a toolkit provided by physionet called ECG-Kit is used as Matlab plugging for the processing and reading of this type of signals. The following figure shows the operating model of this tool.

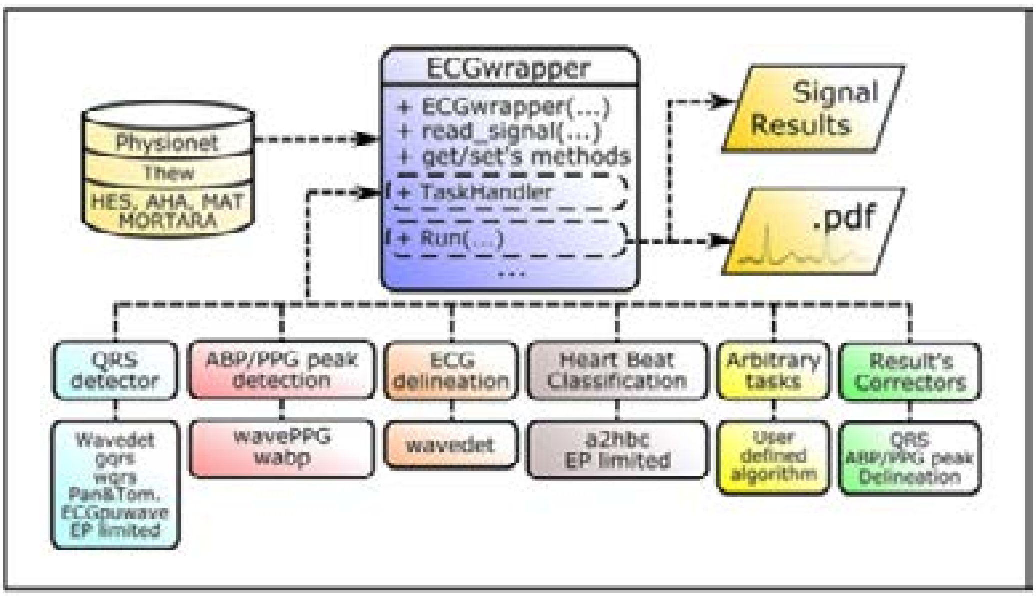

Fig. 5. ECG-Kit Operation. Source: https://physionet.org/physiotools/ecg-kit/

The installation of the toolkit in Matlab is quite simple with which only the compressed file should be downloaded with the libraries ready to be used and then from the Matlab console is called the package installation file so that we can use this tool for the signal processing.

Fig. 6. Installing ECG-Kit in Matlab. Source: Authors.

Once installed ECG-Kit can be manipulated the files with the data obtained from physionet resulting in a .pdf file with the electrocardiograms of each patient. In the following figures the example is shown with one of the cases used.

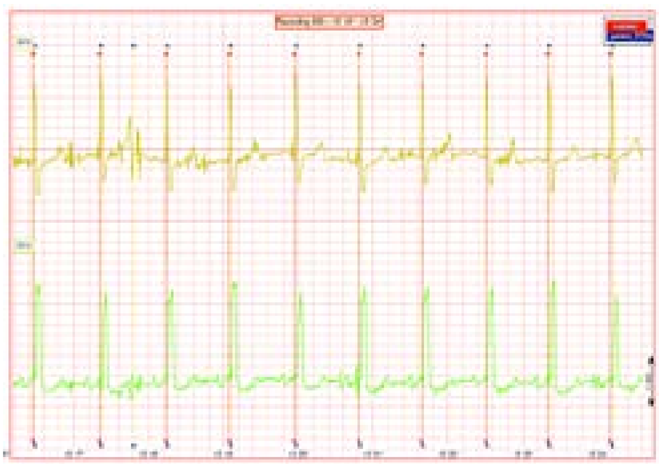

Fig. 7. Result of ECG processing. Source: Authors.

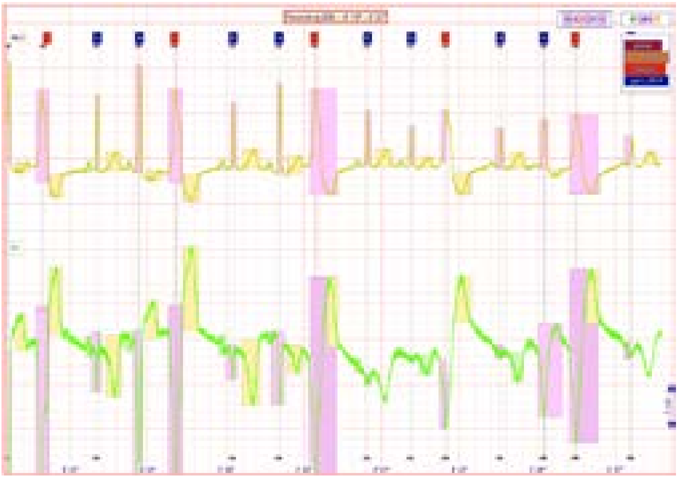

Fig. 8. Result of ECG processing. Source: Authors

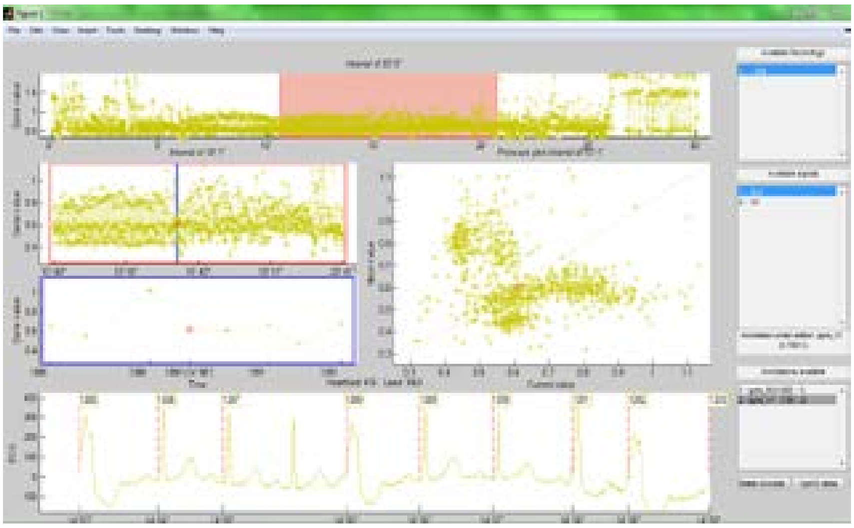

Fig. 9. Result of ECG processing. Source: Authors.

After having the ECG, it is necessary to determine the value of the heart rate that has at a given moment with each patient, for this a formula is used that consists of dividing 300 in the number of pictures that are seen in the electrocardiogram between two waves R (these are the ECG peaks), for example in Figure 7, the heart rate would be approximately 75 bpm (beats per minute) as 4 frames are observed between two adjacent peaks, which is calculated by: 300/4 = 75 mpl.

DEVELOPMENT OF THE MOBILE APPLICATION HEART UD

For the development of the application, the Unity 3D development software was used, which allows the export of applications to different platforms as well as for mobile devices with the Android 4.4 and IOS operating systems.

In the initial interface is presented the basic information to the user received by the sensor after having obtained the value of pulsations per minute. The system handles three types of states mainly depending on the heart rate that it obtains from the user, which are Bradycardia for frequencies lower than 60, a Normal state for frequencies between 60 and 100 and Tachycardia for frequencies greater than 100. [10].

Fig. 10. Presentation of the different states within the application. Source: Authors.

As for the setup menu, when the user presses the "Config" button, an interface is presented that contains a field to select the type of sound that you want to sound in case there is any complication in the heart rhythm, another field for the name of a family contact or close to the person and finally a field with an email to which a message will be sent in case of an emergency as shown in the following figure.

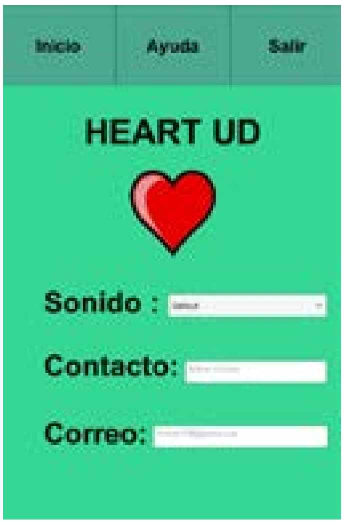

Fig. 11. Configuration interface. Source: Authors.

The last interface that the user can access within the application is the "Help" in which you will simply have the information about the developer and an email to contact you in case you need help or more information regarding the application as shown in the following figure.

Fig. 12. Help interface. Source: Authors.

A script designed in the C # programming language was used to handle the updating of the data within the application, which is shown below.

Fig. 13. Information handling script in the main interface of the application. Source: Authors

6 CONCLUSIONS

After developing the application along with the other components of the system as shown in the previous section, we can determine that this software can bring a series of strengths and weaknesses with respect to other tools analyzed in the related work section, where its main characteristics would be:

Tool	Strength	Weakness
HeartUD	♦ Mobile communication ♦ Communication via BlueTooth. ♦ Use of alarms in case of problems. ♦ Predicting heart rate abnormalities ♦ Database with information from clinical patients ♦ Send reports to the doctor about the situation of the user.	♦ Development has not yet been tested with actual patients. ♦ The efficiency and effectiveness of the prototype are not determined.

Finally, the development of the tool is open to future research with which to improve and give more functionality to the software to fit the needs of a specific target population.

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