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Sensor That Detects Cardiac Press with Record in Database and email notification

Fredy Alexander Vargas Alvarado [1], Octavio José Salcedo Parra[1, 2], Giovanny Mauricio Tarazona Bermudez[1]

[1]*Faculty of Engineering - Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia.*

[2]*Faculty of Engineering - Universidad Nacional de Colombia, Bogotá D.C., Colombia.*

Abstract

Given the new trends in the Big Data, you can use this to study the health of a person through his heart rate, in addition to develop strategies to improve it, as exercise routines. This article discusses the development of this sensor heartbeat, as well as the development of the database and the application that allows capture the heart pulses and send emails. A sensor that captures the heart pulse can save these pulses saved in a database, thus having much collected over time, which can be used for different purposes depending on the individual information. An application can send the user email periodic reports on the heart rate also, if an abnormal heartbeat is recorded, you can send an email to a person or group of persons to report that something may be happening. The methodology consists of three phases, the first phase existing cardiac sensors were sought on the market and new technologies to capture the heart pulses, for example, through the flow of air from the mouth, in the second phase of the implementation is done , cardiac sensor will be done with Arduino UNO. While the application is programmed in Python 2.7 and the database will be made in Mysql 10.1, in the third phase tests were carried out comparing the measurements of cardiac sensor developed in this article with other existing market to determine accuracy. Cardiac sensor raised with this paper works accurately at rest, while in a state of mild physical activity scatters on data regarding Xiaomi sensors and Smartphone Samsung S5, besides the application is able to detect "abnormal" heart pulses and send an email to a family member or friend to stay alert this emergency. The time interval used to forecast sickened can vary from a few hours to a week.

Keywords: Heartbeat, Heart Sensor, Big Data, Cardiac Abnormalities, Resting State, State Of Mild Physical Activity.

INTRODUCTIÓN

There are numerous sensors heart rate on the market, in different versions ranging from simple bracelets to sophisticated watches, even so, very few products that offer storing pulses captured in a database, which limits the real potential which can have this information such as diagnosis of diseases, comparisons of heart rate in different time periods to assess the situation with heart conditions perform routine of exercise, among others.

The objective is simple, to develop a sensor heart rate that allows save the pulses in a database to be able to analyses and study it later, which can be used as a clinical follow-up or athletes, or can also be used to predict disease, in addition, to develop an application that allows you to send a periodic report to the email address of the user and in cases of emergency, when the sensor detects abnormal pulses I sent an email to a person or group of people to warn of a possible emergency situation. The application allows you to define user cardiac pulse period to predict disease, as this varies depending on the disease.

BACKGROUND

There are many sensors in the market, in different forms and with different functions. An example of this is Sensor cardiac Polar H7, which is mainly oriented workouts, i.e. that only records the heart pulses in a small period of time. This sensor has Bluetooth technology to view data on Smartphone or on screens that have this technology.

Xiaomi my Band 1S sensor is a sensor bracelet type, which allows you to record heart rate throughout the day, in addition to also record the number of steps that occur, the time and the quality of sleep. This sensor also provides the services of social networks, email notifications, can be used even as alarm clock. It allows to synchronize with Smartphone to view reports and statistics with the data obtained.

Sigma Sport PC14 clock provides, in addition to the regular services of a clock, the heart rate sensor, counter turns, and calories burned. This watch does not allow synchronization with any other device and appreciated readings are instant, IE that does not save any information.

New technologies have been developed to measure heart rate, one of them is by examining the flow of air from the mouth, through the use of a catheter sensor, [1] another technology developed is through a device that does not come into contact with the skin, the signals coming from the chest and wrists are captured by electrodes and an LC oscillator which is a portable sensor. [2]. A sensor that works through wireless technology has been developed, which allows to detect the heart rate of the elderly without having to deal with annoying cables. This sensor is processing ultra-low power and low duty cycle. [3] a similar sensor (wireless technology) but compactly uses 24 GHz frequency band was developed using electromagnetic

waves polarized in a single antenna, the system consists of radio frequency, a block of signal conditioning circuits, a data acquisition and signal processing unit. This sensor identifies heart rate and respiratory rate. [4]

Using Throwie and (LED) light emitting diodes built a sensor of the heart rate, which amplifies their signals using signal conditioning circuitry and these are processed by a controller. This sensor in particular offers a solution more precise, simple and cheap than other proposed systems. [5]. By inserting a section of the multimode fibre strips is achieved gross deviation, in such a way that allows to detect the heart beats and breathing rate of a person. This is accomplished with this textile fibre is elastic, which can be used when a foot or the lying person. [6]. There is a system that allows you to monitor in real time to the people in a home for the elderly, using data analysis and data visualization, this system is low-cost energy. [7]

Using a framework can be achieved easier access to the information of the patients, implementing the internet of things, which can be accessed on the health of patients remotely in something as everyday as a Tablet, in this way it is much easier to carry out a monitoring and monitor each of the patients. [8]. Via radio waves, it is possible to identify cardiac pulse and heart rate of a person without the need of connecting devices to the skin, based on the analysis of a block of the wavelet coefficients. [9]. A clock can capture the heart rate and temperature of a person through infrared rays and Throwie, thus helping to which the user can monitor their heart rate and body temperature at any time and in any place. [10, 11]

Sepsis is a disease in which the body has a serious response to bacteria or other organisms. Through the monitoring of heart rate over a period of 5 days to preterm infants with one gestational age less than 33 weeks, you can see if there are frequent bradycardias (slow or irregular heart rhythm) and with this forecast if the infant can suffer from sepsis until this occurs. [12]. In a period of 3 days, an analysis of heart rate and brain circulation in preterm infants between 23 and 31 weeks of SGA, weighing at birth between 605 g and 1081 g, and found that 53% of infants any alteration in the self-regulation stroke, developed with certain patterns in the cerebral circulation. [13]

Taking elderly patients at 53 years with moderate or severe chronic heart failure, determined to take the heart rate under a situation of control to determine if it could predict the death of the patient because of this heart condition. Found that the heart rate with a breath taking controlled (12 to 15 breaths per minute) in the range of four hours, found that it is a powerful predictor of death, thus determining if a patient would need a prophylactic implantation of a cardiac defibrillator to avoid the fatal outcome. [14]. Through technical acoustic of passively and non-invasive fetal heart rate can be. It is based on methods of fono-cardiogramas. Low consumption stethoscope is customized to make sounds and thus capture the fetal heart rate. [15]

A bracelet with LED diodes that identify the heart rate of an athlete, through a color code makes it easier for this to control the range of heart rate at any given time. [16]. Heart rate through the skin sensors are the most used, but in the case of scars or burns to tissues fail, this is that you could create a heart rate sensor that allows capturing pulses without contact, through light, which detects the reflection of this in contact with blood. [17]

All these elements are aimed at only one thing, obtaining cardiac pulses, i.e. only occupy obtain them either way wired or wireless, in contact with skin or studying the flow of air. However, none of the investigations and none of the existing products is what to do with the information already obtained. In this case is raises save each pulse in a database for to perform studies and predictions from these, in addition to develop an application that sent reports to the mail electronic and warned of a possible emergency to certain people through the mail electronic.

We found that the heart rate can be used as a factor to predict diseases until they appear, identifying diseases such as sepsis and related self-regulation stroke, even coming to identify whether a person with chronic heart failure can die from this disease. The time interval used to predict disease varies, from a few hours up to a week.

METHODOLOGY

A. Research and Design Phase

In this phase we conducted a search of already existing on the market products and heart sensors of many kinds, such as bracelets, were found on watches, on devices to arms or abdomen, each aimed at different services, such as health or simply exercise routine.

We also investigated about technologies to capture the pulse of the heart, for example through the flow of air in the mouth or with devices that do not come in contact with the skin.

B. Implementation Phase

The implementation of the heart rate sensor will be made with an Arduino 1.6-compatible heart rate sensor. This plate will be scheduled so that you can capture the pulse of the heart, send them to the application so that it can store in the database. This application will be programmed in Python 2.7 and the database in Mysql 10.1. A library will be used for Python to be able to send data via email call smtplib. Plate Arduino UNO must be connected to a computer, where it will run the application and the database at all times.

C. Phase Tests and Corrections

Is will be comparisons between the sensor heart developed in this article with the sensor heart available in a Samsung S5 and with the Xiaomi my Band 1s to determine the precision, in addition to perform tests to it application developed in Python 2.7 for evaluate that them reports and post arrive in a time acceptable.

DESIGN

The design of the sensor is relatively simple, since it is a heart rate sensor connected to a plate Arduino UNO, and it connects

to a computer using a USB cable. In Figure 1 you can see the connection.

Figure 1. Connection diagram sensor. Source: Authors

Heart rate sensor must be connected to the computer to capture data and store it in the database in this, in addition to the computer running application that it will sent to email, either a regular user report or an alert message to a person or group of persons. This connection can be seen in Figure 2.

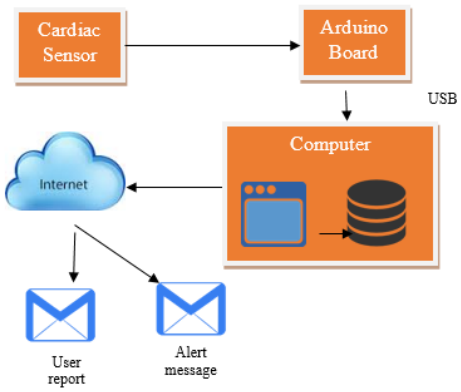

Figure 2. Architectural view. Source: Authors

The application will program in Python 2.7, and it has as main function save pulses captured by the sensor in a database in Mysql 10.1, send via e-mail periodic reports, and eventually in which abnormal pulses occur, to send an alert message to one or more persons, thus it is preparing for a possible emergency.

IMPLEMENTATION

The heart rate sensor was designed with a plate Arduino UNO and a heart rate sensor was used as that you can see in Figure 3. This heart rate sensor was connected to the Arduino pins one analog 0 (to receive signals), 3.3V and GND to power sensor.

Figure 3. Sensor heart rate. Source: [18]

Plate Arduino UNO must be connected via the USB port to the computer, thus the application on the computer can receive the signals.

The script that was used to control the Arduino UNO was programmed in Arduino 1.6. This way the implementation of the heart rate sensor, ends so it subtracts the application that allows you to capture data, store it in a database and send emails.

The application was programmed in Python 2.7 and the smtplib libraries were used for the sent e-mails, serial to allow the connection between Python and plate Arduino UNO and mysql.connector to connect to Python with the database in Mysql 10.1.

In the application, at the time of start it, requested a few values as control, these are minimum heart rate and maximum heart rate. This sensor can be used to measure heart rate in rest mode or State of physical activity, so that maximum and minimum heart rate values vary in both cases. These values must be entered by taking into account the State that is to be used, in such a way that the algorithm is necessary to detect abnormalities in the heart rate and can send an email to alert of a possible emergency.

For example, in State of rest heart rate ranges between 50 and 100 beats per minute, while in physical activity can have a maximum of 190 beats per minute without endangering the person [11]

This is that the initial values of the application must be entered by taking into account the State.

```
Por favor digite el pulso cardiaco minimo: 40
Por favor digite el pulso cardiaco maximo: 80
```

Figure 4. You can see values entered to perform a test. Source: Authors

Depending on the disease that you want to predict, the period of cardiac pulses needed changes, as can be seen from [12], [13] and [14], so it is important that that period is defined by the same user in the application, as shown in Figure 5.

```
Por favor ingrese EN HORAS el periodo en
que se guardaran los pulsos cardiacos: 4
```

Figure 5. Period of cardiac pulse user definable. Source: Authors

In Figure 6, you can see the application receiving signals from the plate Arduino UNO, these received cardiac pulses are captured while the person is in a State of rest, and lies between the previously entered values.

```
pulso cardiaco: 62
pulso cardiaco: 61
pulso cardiaco: 61
pulso cardiaco: 61
pulso cardiaco: 61
pulso cardiaco: 61
pulso cardiaco: 61
pulso cardiaco: 60
pulso cardiaco: 61
pulso cardiaco: 63
pulso cardiaco: 63
```

Figure 6. Cardiac normal pulses received. Source: Authors

Figure 7 captured heart pulses can be seen when the person is not in sleep mode, in this case is in State of physical activity, by what increase cardiac pulses. As you can see, these cardiac pulses are far greater to control values previously entered, so the application will take them as abnormal cardiac pulses and send an email alert to a friend or family member.

```
pulso cardiaco: 117
pulso cardiaco: 115
pulso cardiaco: 114
pulso cardiaco: 111
pulso cardiaco: 109
pulso cardiaco: 108
pulso cardiaco: 106
pulso cardiaco: 106
pulso cardiaco: 105
pulso cardiaco: 105
```

Figure 7. Pulse heart "abnormal" received. Source: Authors

In Figure 8 can be seen as application sends an email to detect cardiac pulses "abnormal", Figure 9 shows the time of the reception of the email on the account of the recipient, and the body of the email, may be seen in Figure 10.

```
pulso cardiaco: 106
pulso cardiaco: 105
pulso cardiaco: 105
Correo enviado 24/04/2016 17:57:39
```

Figure 8. Sent an e-mail by the application. Source: Authors

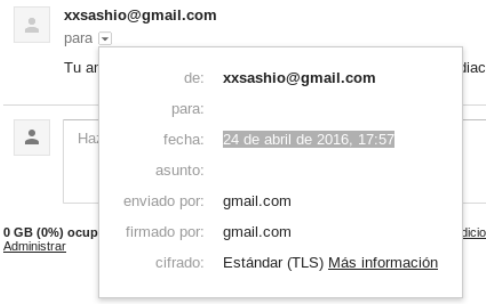

Figure 9. Date and time of the reception of the mail. Source: Authors

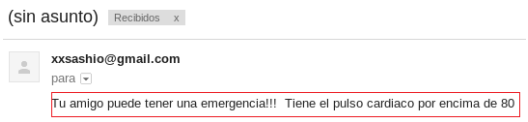

Figure 10. Body of the email. Source: Authors

You can see that the application automatically sends an email to detect abnormal cardiac pulses. Finally, all the heart pulses that are captured by the application are stored in a database, where then can be used for various purposes, such as medical monitoring or control by athletes, resource to be able to predict heart disease, etc. In Figure 11 you can see the database with some cardiac pulse stored in it.

id	valor	fecha
730	107	2016-04-24 17:48:20
731	92	2016-04-24 17:48:21
732	87	2016-04-24 17:48:22
733	81	2016-04-24 17:48:23
734	77	2016-04-24 17:48:24
735	73	2016-04-24 17:48:25
736	69	2016-04-24 17:48:26
737	65	2016-04-24 17:48:27
738	63	2016-04-24 17:48:28
739	60	2016-04-24 17:48:29
740	56	2016-04-24 17:48:30
741	59	2016-04-24 17:48:31
742	58	2016-04-24 17:48:32
743	58	2016-04-24 17:48:34
744	58	2016-04-24 17:48:34
745	58	2016-04-24 17:48:35
746	58	2016-04-24 17:48:36

Figure 11. Database of cardiac pulses. Source: Authors

DISCUSSION OF RESULTS

To determine the accuracy of heart rate raised in this paper sensor, a test was performed using it together with the heart rate sensor that brings the Smartphone Samsung S5 and the heart rate sensor Xiaomi my Band 1s. Two tests, one in sleep mode and the other in a State of mild physical activity were carried out. The heart pulses in sleep mode can be observed in Figure 12 captured by three heart sensors in a span of one minute.

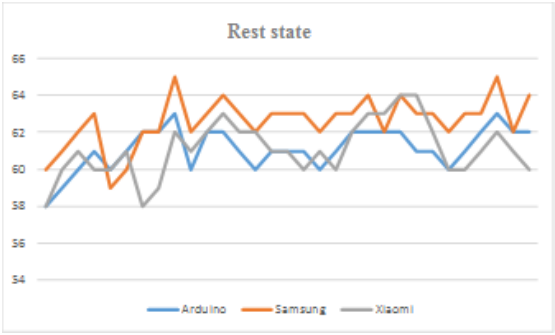

Figure 12. Registration cardiac pulses dormant. Source: Authors

In Figure 13, you can see a diagram of dispersion on cardiac pulses recorded by three sensors in sleep mode. You can see that the sensor in this paper marked as Arduino, presents accurate results with respect to the other two sensors, but with a closer relationship with Xiaomi sensor, which is good since Xiaomi heart rate sensor is a device developed primarily for this purpose.

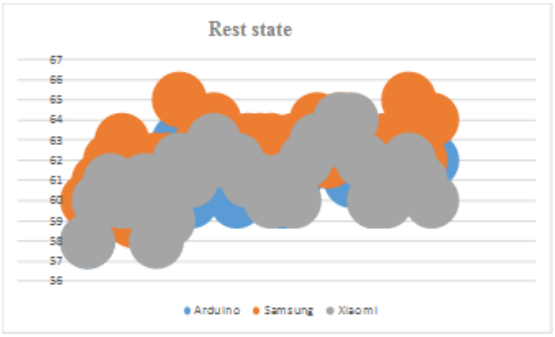

Figure 13. Diagram of dispersion of the heart rate in rest mode. Source: Authors

In the second part of the test is the person to do light physical activity and your heart rate with three sensors is taken for one minute. Cardiac pulses captured by three sensors can be seen in Figure 14.

This figure shows that the sensors Xiaomi my Band 1s and the Samsung S5 sensor have similar results, that is the relationship between these two is minimal, allowing to conclude that they are prices. Unfortunately the heart pulses captured by the heart rate sensor raised in this paper are totally different from those captured by the other two sensors, it can be seen in the graph that some captured heart pulses are excessively high or low, generating a diagram with peaks that are inconsistent with those generated by the two sensors. This leads to the conclusion that the heart rate sensor raised in this paper is not adapting to capture heart pulses in physical activity environments, serves only for environments in sleep mode.

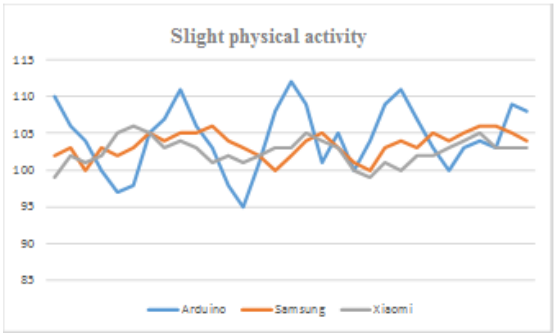

Figure 14. Registration heart pulses in a State of mild physical activity . Source: Authors

In Figure 15, you can see a diagram of dispersion for cardiac pulses captured by three sensors in a State of mild physical activity. You can see that the dispersion is higher compared to that obtained in the resting State, mainly by the Arduino sensor, which generated a record very different from those generated by the other two sensors. The heart rate sensor Xiaomi is estimated to be more accurate since it is a device designed for that purpose, while the heart rate sensor of the Samsung S5 is not designed to take the screenshot in a different State than the rest because of its design (must be pressed the finger all time against this), obtains good results compared with the sensor Xiaomi However, the sensor in this paper has a high dispersion, it may be due to the quality of the used heart rate sensor, or by design (since must also pressure with the finger).

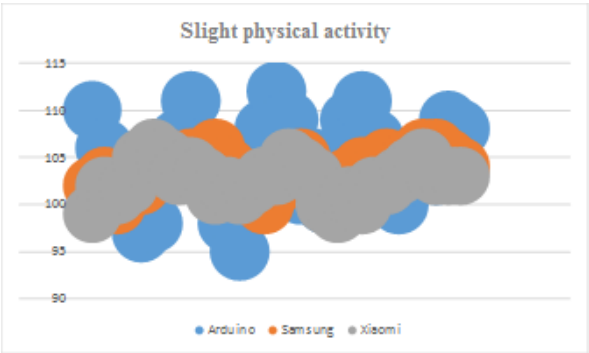

Figure 15. Diagram of dispersion of the heart rate in a State of mild physical activity. Source: Authors

With regard to the sent e-mail, obtained better results, since the tests late mail less than 30 seconds to go, the average arrival time of the post was 12 seconds. In figures 8 and 9, you can see that the mail has arrived in the same minute, and understated 21 seconds so the minute it was over.

Table 1 compares the pulse sensor heart posed in this paper with the raised in [1] and [4], highlighting the main features of each.

Table 1: Comparison of different cardiac sensors. Source: Authors

	Sensor [1]	Sensor [4]	Raised sensor
How to grasp the heart wrists	Mouth air flow	Chest contact	Contact with fingers
Sensor structure	Wired	Wireless	Wired
Can you capture other things besides heart rate?	No	Yes, it also captures the respiratory rate	No
Does it serve in any state?	Yes	Yes	No, just rest state
Can non-specialized personnel operate it?	Yes	No	Yes
Can you see the pulses obtained?	Yes	Yes	Yes
Can you keep the captured pulses?	No	No	Yes
Do you notify the users?	Only emergencies	Only emergencies	Emergencies and periodical reports

CONCLUSIONS

Sensor presented in this paper presents precise screenshots concerning Xiaomi sensor and the Smartphone Samsung S5 in a controlled environment where the patient is in sleep mode (Figure 12), unfortunately, not very good results showed against an environment of mild physical activity, throwing results scattered, as 113 pulses when the other two sensors recorded 102 pulses. If physical activity was more intense, likely that the results captured by the sensor in this paper would have been even more dispersed, so it is recommended that raised in this paper sensor is used for States of repose. In addition, found that the sensor keeps each cardiac pulses recorded in the database successfully, proof of this can be seen in Figure 11.

The application is able to identify when abnormal cardiac pulses occur and send an email to a friend or relative to make this alert in the event of an emergency. Email is delayed in arriving on average 12 seconds. The application is able to capture the heart pulses and store them in the database, and send the email without any problem or delay.

To compare the cardiac sensors [1] and [4] with raised in this paper, it should be noted that the main disadvantage of raised heart rate sensor is that it is not necessary in States that are not the rest, and as main advantage over others is that you can save the heart pulses and notify users. Future could improve the structure of the sensor, which works wirelessly (apart from the precision in States other than the rest) and stop using wires that might be annoying for patients.

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