H.R.D.A. System (Heart Rate Detector Alarm System)

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ABSTRACT: *The H.R.D.A. System is a bracelet designed to detect the pulse of a person with a cardiac condition, who doesn't benefit of permanent medical assistance, but is monitorized by at least another person, be it from the family or from a social program. This device is connected via bluetooth to the user's mobile phone and communicates with it through an app made using "Eclipse" which was created with the aid of the programming language "Java". The application receives the data captured by the proximity sensor from within the bracelet and if the pulse is either too high or too low, a warning message is sent to a phone number which is initially set by the user when the application is first installed on the phone.*

Keywords: JAVA, Bluetooth, Android Application, Mobile Interface, Cardiac Medical Assistance

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1. Introduction

This paper extends the previous work that was presented at the Ninth International Conference on Applied Informatics, Imagination, Creativity, Design and Development (ICDD 2017) [1] by presenting statistics about the need of the featured product and the new improvements added to it since then. I will cover why the system is of importance to today's society and how the purpose of the system can be achieved with as little resources as possible.

The paper presents a device and an application, made with the purpose to help people with cardiac type health issues. The H.R.D.A. System was designed to decrease the intervention time in case of a cardiac attack or a similar situation. The project consists of two main components: the electronic component and the software one. The idea of the project is that the mobile phone of the patient can help decrease the intervention time in case of a cardiac attack by always checking the pulse of the patient using a proximity sensor placed on the ear lobe of the user. If a very high or very low pulse is detected by the electronic component, the application installed on the phone of the patient kicks in and sends a message using the “Short Message Service” (SMS) to a phone number specified by the user when the application is initially started.

In the following sections, it is covered the applicability of the device, the advantages and disadvantages of using it, similar devices and the differences between them. After that, are presented the main components of the project and the existing features of both the application and the bracelet, as then to present upcoming features and future goals.

2. Applicability and Statistics

In the span of the last 20 years, the life expectancy has grown significantly, especially in the more developed countries due to the increase in technology and in medicine. With all of these being said, the cardiovascular diseases remain some of the most common causes of death on a global scale [4]. In these cases, it is especially important to monitor the cardiovascular activity of a person with such problems, as the intervention time, in case of an attack, has to be as low as possible for the patient to have a better chance to survive.

- At the time of writing this paper, Cardiovascular disease is the leading global cause of death, accounting for 17.3 million deaths per year, a number that is expected to grow to more than 23.6 million by 2030. [4]

- In 2011, in the U.S. alone, nearly 787,000 died from heart disease, stroke and other cardiovascular diseases. That’s about one of every three deaths in America. [4]

- In 2008, cardiovascular deaths represented 30 percent of all global deaths, with 80 percent of those deaths taking place in low- and middle-income countries. [4]

- Direct and indirect costs of cardiovascular diseases and stroke total more than $ 320.1 billion. That includes health expenditures and lost productivity. [4]

- Someone in the U.S. dies from heart disease about once every 90 seconds. In 2010, worldwide prevalence of stroke was 33 million, with 16.9 million people having a first stroke. Stroke was the second-leading global cause of death behind heart disease, accounting for 11.13 % of total deaths worldwide. [4] (see Figure. 1)

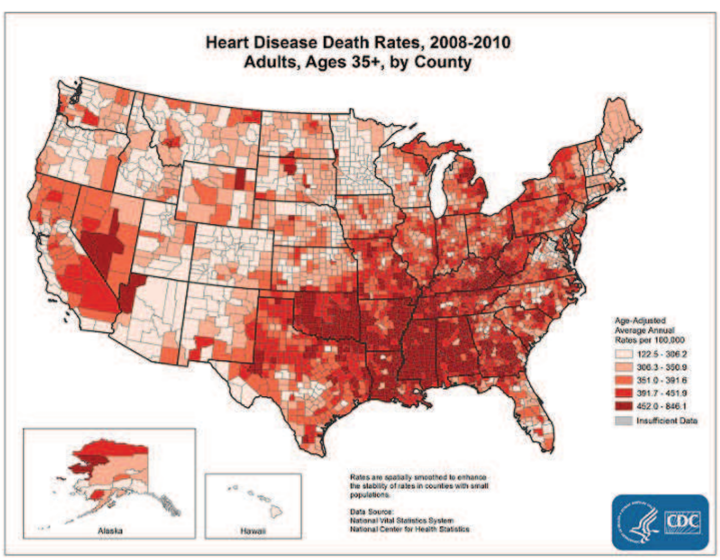

Figure 1. Statistic regarding heart disease death rates [5]

For this purpose, we designed The H.R.D.A. System as a cheap alternative mean to monitor the activity of a patient’s heart who doesn't need or doesn't benefit of hospitalization. The hospitals in many countries are often overpopulated, therefore many patients with cardiovascular diseases or who are not in need of immediate interventions are, more often than we would like to admit, left behind. To their help, we built the H.R.D.A. System device, which is cheap and accesible to anyone, made primarily out of recyclable materials and built using the Arduino technology. The H.R.D.A. System provides supervision continuously in an easy to use way, giving the patient and his supervisor an alternative way of detecting possible heart problems and making sure that it is acted fast enough in case of a health situation to stop the possible consequences which can follow a heart attack. Also, in contrast to other seemingly similar devices, the H.R.D.A. System communicates with the user's phone using the bluetooth service, which makes the whole device available everywhere and does not require any sort of internet connection in order to work. And, besides that, also in contrast to other seemingly similar technologies, the device was designed to be mobile and easy to use on a day to day basis without creating any discomfort to the patient or to the supervisor.

The H.R.D.A. System is especially designed for people within medical-social care systems, people in the care of their family or in the care of a personal assistant.

3. New Additions

Seemingly similar devices are used:

- **In Hospitals or Private Medical Cabinets:**
    - **The Holter Monitor:** Is a device used to interpret the readings of a pulse sensor with the purpose to identify possible cardiovascular diseases. This device, in contrast to The H.R.D.A. System, is not mobile, requires an activity journal and a schedule. Even more, the Holter monitor requires the patient to use it for at least 24 hours before it can precisely read the data provided by the ECG sensors. [8]
    - **The Oximeter:** Is a device used to determine the level of oxygen in the patient's blood. Like The H.R.D.A. System, the oximeter uses a proximity sensor to detect the number of heartbeats per minute, similarly to our device. In contrast to The H.R.D.A. System, the oximeter, even though is mobile, it is not recommended for every day usage, cannot provide live data or communicate with an external device and is placed on the finger, which can easily lead to some sort of discomfort to the patient. [7]
- In the sport industry
- **The Fitness Bracelets:** - are devices used especially for physical activities, are not recommended to be used with a medical purpose and are not designed to give a precise value of someone's BPM (heart beats per minute), therefore are unreliable in the case of a cardiac attack.[9]

In addition to everything mentioned previously, the H.R.D.A. System revolutionized the way we monitor patients, making it possible and easy to intervent in case the patient suffers a cardiac attack, but most importantly, it is a cheap and accessible way of doing so. In contrast to all other devices mentioned above, the H.R.D.A's components we're picked carefully, both from the point of view of functionality, but also from the point of view of accessibility and comfort which are essential considering that the device must be worn by the patient at all times for the best results.

4. Other Uses

Because of the fact that the system is based around the BPM value (heart beats per minute) and its properties, the bracelet can be used for other purposes other than the ones mentioned above.

Another really important use of this system would be monitoring elderly people or people with paralysis or semi paralysis that lack permanent supervising. The BPM value, is really important data, not just regarding the cardiac state of a person, but also of its physical state. For example, if a person with paralysis trips and falls and needs immediate help, their heart beats will be more frequent, therefore providing enough data for the H.R.D.A. System to be able to send a message and request immediate intervention to a family member or a social assistant in the case of patients from the medical-social care systems.

Other uses include detecting possible sport related injuries, finding a person that needs immediate help (because of the GPS feature currently available in the application) and detecting and requesting help in general, as most injuries influence the BPM values of a person, regarding the cause of the injury.

5. Functionality

The H.R.D.A. System is made up of two main components:

- The electronic component
- The android application

5.1 The Android Application

The application was made using the development environment Eclipse and initially was designed using MIT App Inventor 2. It has the main purpose of receiving the data sent by the device through the bluetooth module and sending a short warning message to the person in charge of the patient if values too high, or too low were detected by the electronic component.

From an algorithmic point of view, the SMS is sent using a basic function if the value received from the electronic component is higher or lower than the values initially inserted by the user in the fields mentioned previously. If the value detected is not between the "safe" parameters, a warning message is written by the application. The application reads, if available, the location of the user through the GPS service of the phone, then concatenates that information with the pulse value detected by the sensor.

```
bluetoothIn = new Handler() {
public void handleMessage(android.os.Message msg) {
readMessage = (String) msg.obj;
new CountDownTimer(1000, 1000){
public void onFinish() {
sensorView0.setText(readMessage);
i=Integer.parseInt(readMessage.replaceAll("[\\ D]", ""));
if((BPM> maximum || BPM<minimum) & & ok==0)
{
LocationManager lm =
(LocationManager)getSystemService(Context.LOCATION_SERVICE);
Location location =
lm.getLastKnownLocation(LocationManager.GPS_PROVIDER);
double longitude = location.getLongitude();
//gets the longitude value
double latitude = location.getLatitude();
// gets the latitude value
body = body+ " x=" + longitude + " , y=" + latitude
+ " ; Valoarea pulsului detectata: " + i; // making the message which will
// be sent in case of an emergency
SmsManager smsManager = SmsManager.getDefault();
smsManager.sendTextMessage(numar, null, body, null, null);
// sending the message
Toast.makeText(getBaseContext(), "Mesaj de avertizare trimis la numarul: \n"
+ numar, Toast.LENGTH_SHORT).show();
/*showing a notification on the patient's phone to notify him
that a warning message was sent in case of a false alarm*/
```

```
ok = false; /* debounce variable */
} }
public void onTick(long millisUntilFinished) {
}
} .start();
}
} ;
```

Listing 1. The method used to send a SMS

The interface (Figure. 2) is simple, and features three main interactive components. In the first text box, situated at the bottom of the screen, the user is required to write one or more telephone numbers, which can be contacted in case of an emergency. The second and the third fields represent the parameters between which the pulse values are considered to be normal and are situated on the top half of the screen, right under the title of the application. After inputting the preferred values, in order for the settings to be saved, the user must press the save button situated in the lower half of the screen.

Figure 2. The interface of the application

5.2 The Electronic Component

The device was made using Arduino technology and has in its composition an Arduino Nano microcontroller, a HC-05 bluetooth module, a proximity sensor and a couple of resistances. Though, in the future, a slight adjustment will be made by switching the Arduino Nano for an LilyPad Simblee BLE Board. The software used in order to program the board is a software made by the company Arduino [2]. The programming language used to do so was C++.

The images above show the circuit from the inside of the case (Figure. 3), and the images below (Figure.4) show the circuit in an unfolded form, on a breadboard. The circuit is made of two resistances of 2.2kΩ and 4.7kΩ, a bluetooth module HC-05, an Arduino Nano microcontroller and a proximity sensor.

The bluetooth module HC-05 - has the purpose of sending and receiving data, essentially making up a connection between the application and the device.

The Arduino Nano microcontroller - has the purpose of memorating and executing the code, therefore controlling the other components in the bracelet. The microcontroller receives the data sent by the proximity sensor, reads it, and processes it, as then to send it to the bluetooth module.

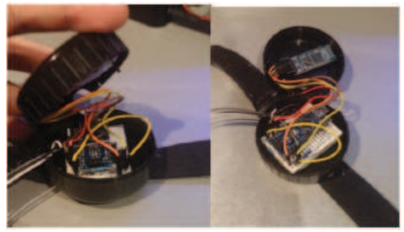

Figure 3. The interior of the bracelet prototype

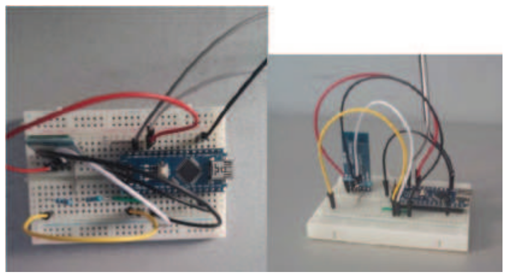

Figure 4. The circuit unfolded on a breadboard

The pulse sensor - has the purpose of detecting the values of the patient's pulse using a proximity sensor. This sensor works the best when placed on a finger tip (Figure. 5), or on a ear lobe.

The bracelet is powered using two lithium batteries or a USB Cable and also works just fine with a power bank.

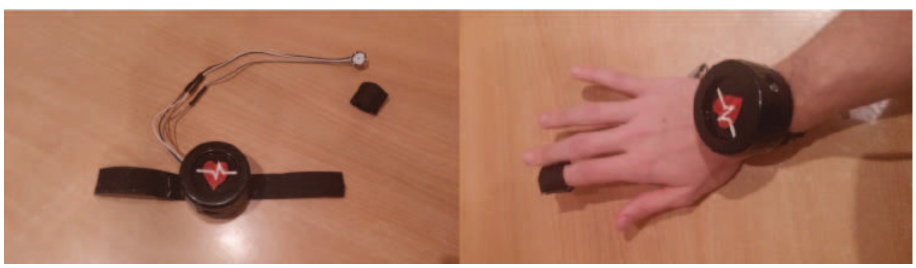

Figure 5. The circuit unfolded on a breadboard

From an algorithmic point of view, the microcontroller uses the "A0" pin to read the signal given by the proximity and calculates the number of heart beats per minute, using the time between the beats.

In order to send the data to the phone, we simply sent the data to the serial from which the bluetooth module handles it.

```
void serialOutputWhenBeatHappens() {
switch(outputType) {
case PROCESSING_VISUALIZER:
sendDataToSerial('B',BPM); //BPM-heart beats per minute
sendDataToSerial('Q',IBI); //IBI-time between 2 beats
break;
default:
break;
}
}
```

6. Execution

To sketch out the circuit, we used an online circuit designing application called EasyEDA [3] and the software Fritzing for mapping out the components. (Figure. 6)

After that, we used the designs to make two circuit boards. To corrode the copper on the boards, we used Ferric

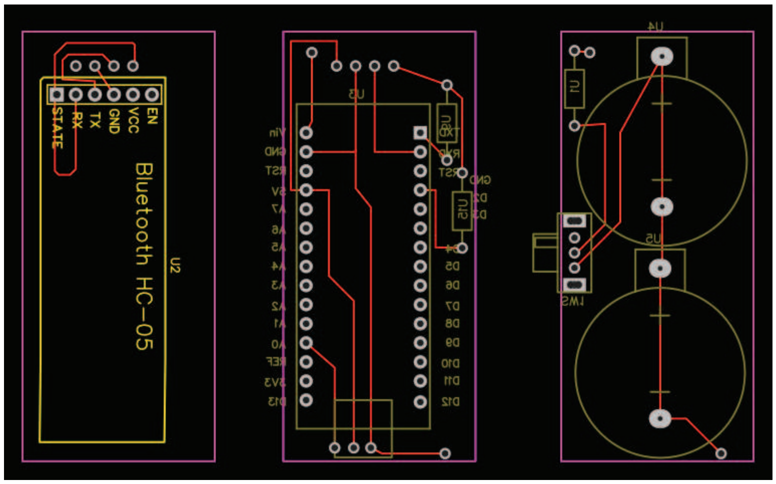

Figure 6. The main boards sketched with EasyEDA.com

Chloride, which left us with two boards which then we completed with the right arduino components. (Figure. 7)

After that, we assembled the components together and we switched the Arduino Nano from the original design for an

Figure 7. The 2 main boards in a previous version of the device

LilyPad Simblee BLE Board (Figure.8) for the main purpose of reducing the dimensions of the final product. Adding the new board to the design, completely removed the bluetooth module from the equation as the LilyPad Simblee BLE Board [6] comes with an integrated bluetooth module which will be used to send the data to the phone application.

In the future we plan to make a suitable case for the device, which, considering the current components should make the final product really small which is vital, considering the placement of the device, in order to make the product as comfortable as possible.

7. Conclusions

In conclusion, because the mobile phone is an indispensable device for almost anyone, the H.R.D.A. System (Figure. 9) is a viable solution to decrease the intervention time in case of a cardiac attack and it is, in our opinion, a fast and efficient way to send a warning a message and to inform a person in charge of supervising a patient in case of an emergency.

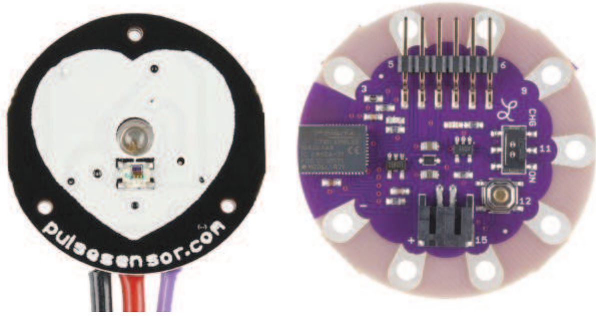

Figure 8. The two main components used: amped pulse sensor and LilyPad Simblee BLE Board

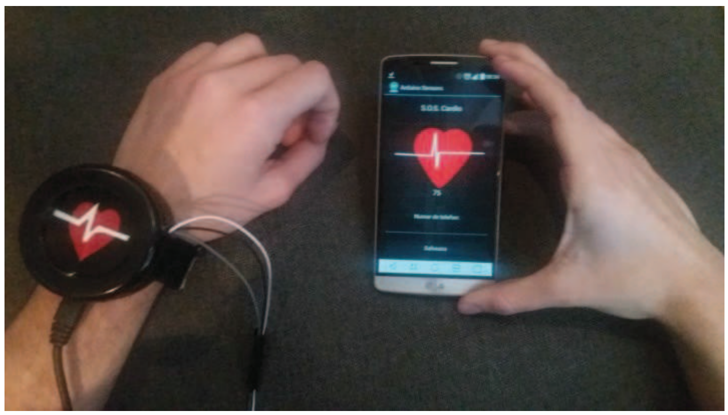

Figure 9. The current form of the bracelet and the application

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