Design of a Mobile Application to Improve the Treatment of Patients with Heart Problems using Pulse Sensors with Arduino

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Abstract— Currently, all citizens can suffer a heart attack, whether you are young or an adult, because it happens suddenly and as we know it is a fatal emergency that can happen anywhere, with one of the consequences being loss of consciousness. In addition, in order to prevent it, you need better control with doctors, but as we know, a heart attack can happen to us on any day and at any time. For this reason, a mobile application was designed to help prevent people suffering from heart problems and have a better follow-up of the check-ups and daily activities that they carry out. In addition, as the pulse sensor used with Arduino is connected to the application via Bluetooth, it will be able to alert trusted people that you are in danger and will also send a message to the nearest hospital. In this work, the Scrum methodology was used for the development and the Balsamiq tool for the design of the prototype. The results obtained from the research will be to prevent heart attack and have greater security where you are.

Keywords— Problemas Cardiacos; Scrum; Balsamiq; Prototipos; Aplicaciones móviles; Arduino.

I. INTRODUCTION

Currently, the main causes of death throughout the world are heart problems, because they affect the heart, since they can start as abnormalities that are genetic or blood vessel problems, in addition, it attacks women and men regardless of the age. According to the World Health Organization, 32% of deaths were caused by these causes, it was also calculated that by the year 2030 about 23.6 million people may die and being one of the main causes that is affecting globally[1].

According to statistics from the year 2018, 30.3 million adults who are from the US had a result that they were diagnosed with heart disease. Approximately 647,000 Americans die from heart disease each year, making it one of the leading causes in the US, with 12% of people who have symptoms of cardiac arrest dying from it[2].

In Peru, cardiovascular diseases are the main death rates, obtaining a third place according to the National Institute of Statistics and Informatics. In addition, PAHO, which means Pan American Health Organization, 16% of people in Peru over 20 years of age suffer from some cardiac complication. [3].

As a result, people who have heart attacks are increasingly repetitive, since around 15.5% die and 56% of Peruvians have high triglycerides. Likewise, 17% of Peruvians suffer from obesity, which increases cardiovascular disease, endangering life, with 20% being women and 15% men[4].

So, cardiac arrest is a condition where the heart suddenly stops beating. At the moment, as it happens, the blood will stop flowing to the brain and other organs that are vital to being human and if it is not controlled at the right time, it will die in minutes and therefore, rapid measures must be taken. and try to control it[5]. Also, when people are having a heart attack, they don't know exactly when it's going to happen and they can't take any action to fight it.

A cardiovascular risk factor that is very important is age, because one of the studies shows that 70% of heart attacks may be happening to people over 60 years of age, also another important factor is being overweight and high blood pressure[6].

As we know in 2019 the disease caused by a new coronavirus called SARS-CoV-2 appeared, where the WHO had the news that on December 31 it appeared and began to give a type 2 severe respiratory syndrome, where people can spread among them with just a few respiratory droplets, infecting when sneezing and talking[7].

According to cardiologist Marco Almerí, he warned that COVID is not only affecting the lungs but also the heart, due to the fact that 80% of patients who were discharged post-COVID have sequelae in the heart, according to some studies that were made in Germany.

For this reason, there are many consequences that they leave on the heart, such as palpitations, chest pains, tachycardias, heart attacks and even cardiac arrest. Also, what is very important to know is that mortality from heart attacks increased and is now double during the pandemic[8].

In order to solve the problem and have better control for people who suffer heart attacks, a good way is to use technology, according to our times, which would be Smartphones, since now everyone has a device. For this reason, the application will be able to better monitor people because it will allow them to see their heart rate, in addition to keeping better track of daily activities. Also, if he suffers a heart attack on the street, the alarm will be turned on and the exact location will be sent to the trusted people added by the patient and to the closest hospital.

The objective of the article will be to develop a mobile application to improve the treatment of patients with heart problems using pulse sensors made with Arduino.

The rest of the document was organized in the following ways, section II will define the Scrum methodology and tools to be used, section III will show the case study, section IV will show the discussions, V will show the results and finally section VI will show the conclusion.

II. Literature Review

According to the author[9]. Heart failure, were considered as disabilities of the hearts that are providing blood and that can give oxygen, since it is a rate that is in accordance with the metabolic requirements that are in the body. These disabilities that have the heart can bring a heart problem. In order to carry out the design and development of a system that performs telemonitoring, which may be called cardiac arrest, the system is including a mobile application that is developed in Android, which is based on a web application for health personnel and a of the data or information interfaces between the applications that patients and health personnel will use. In order to be able to carry out an evaluation of the impacts of the telemonitoring system in a population of patients with heart problems, through the studies that will be carried out, for example, quality of life, knowledge of patients about the disease, adherence to pharmacological treatments for 3 months.

According to the author [10]. The main causes that are fatal in the countries, for 15 years, where in 2016 it could cause 15.2 million registered deaths. For this reason, the problem is rooted in the lack of devices that detect cardiac arrest and despite there being several investigations into the causes of heart disease, there are no statistics in the locality that are related to devices that can detect cardiac arrest. cardiac. In addition, he was able to carry out an investigation on the factors that can cause a cardiac arrest, in order to determine the variables that are necessary for his project development, for this reason, he proposes a solution of an electronic bracelet that can measure the heart rate, temperature and level of sweating that the user was having where he can use sensors on the inside and can capture the signals of the body.

According to the author [11]. Heart problems can have a significant impact on people's quality of life. Through the widespread uses of new technology, there is enormous potential for health systems that are highly advanced. In the developments of a smart wearable IoT system for better health monitoring that life is evolving. One of the objectives of the IoT is to be able to allow devices or things to be fully connected at any time and thus be able to offer a better power of benefits for people. Therefore, I develop an intelligent IoT system that is IoT systems based on ehHealth so that it can predict the personalized heart attack, in addition it will be able to combine some components of detection and communication.

According to the author [12]. According to information from the World Health Organization, it was estimated that around 51 million people died in 2008 from any type of communicable and non-communicable diseases. In addition, mortality among cardiovascular diseases with 17.3 million deaths in 2008 alone, which represents 30% of global deaths. Also, there are more diseases that are related to the heart with fractions that can be a meaning of death, such as hypertensive heart disease and inflammatory heart disease, because more people die from cardiac dysfunction than from AIDS. So that they can solve, it is important to use cell phones for diseases and health conditions in order to begin the study of applications for diseases and health conditions. 710 applications were found that are relevant to the play store and the app store, although it is very noticeable that the applications are for both stores.

III. METHODOLOGY

3.1. Scrum Methodology

Scrum is one of the agile methodologies that aims to create cycles to be able to execute, taking into account that iterations are better known in the scrum rubric "sprint".

First, one of the general forms is defined as characteristics of the products that can be assigned in a team for development. Then, the layout will have to be made with the information that was obtained and the limits that will be developed in the product can be defined.

Consequently, the products will be able to add the functionalities of speculations, also the team will review everything that was built and will check that the objective is the desired one and to finalize the agreed date of a version of the product that was desired.[12].

1) Phases

Next, we are going to show the 4 Phases and Activities of the methodology that will be developed in the project processes

A. Sprint planning

In this phase, the first meeting will have to be held with the team where the aspects of the functionalities, objectives that must be met, risks that may occur during the course of the project, delivery deadlines and other priorities must be defined. For this reason, a meeting must be held between the team members and the boss so that they can explain how each point to be executed should be developed and also the changes, improvements and decision-making will be evaluated. [13].

B. Sprint development work

When the sprint is being developed, it should be taken into consideration that changes should not be made that affect the sprint objectives and the quality objectives should not be reduced. In addition, when one of the sprints is very long, the definition of what is built has to change and the complexity increases, also increasing the risks. The sprints allow to guarantee the inspections and adaptations that the progress towards a goal has.[14].

C. Sprint Review.

To make the revisions, everything must be modeled and implemented by the team, therefore, a review of the process or evaluation of the work group must be carried out.

In addition, it is important that you know that constructive opinions and viable solutions must have an important sum.[15].

D. Retrospective

The results expected in the project can be delivered in order to receive feedback not only from those who are part of the team, but also from the people who can be used directly on what must be accomplished. Scrum methodologies are used in all possible cases when developing a project. For this, it is used that the company has one of the resources that they have to have available, so that they can ensure the first steps [13].

Next, the phases of the scrum methodology that you need to be able to develop a project will be shown, as shown in Figure 1.

Figure 1: Scrum Methodology Stage

3.2. Prototyping tools.

Balsamiq is a tool that can create web page prototypes, Balsamiq, a tool that can quickly create prototypes because its design is simple. In addition, Balsamiq can allow you to choose endless functions and objects [16].

3.3. Development tools

Next, the tools that will be needed to develop the project will be shown.

A. NoSQL

For the execution of the project, the NoSQL database will be used, which will allow storing all the information that is necessary for those situations in which the database can be related and cannot cause certain performance problems in the database and that users have many queries daily. The advantage of using it is that the machines use few resources and large amounts of data can be handled so as not to be able to generate a bottleneck[16].

B. Android Studio

Android Studio is a development environment for creating Android apps and is based on IntelliJ. As well as having a good code editor and tools for IntelliJ developers. In addition, it has a fast and feature-rich emulator and can also have a GitHub link and code templates to help run apps that are common. [17].

C. Kotlin

Kotlin is a programming language that was created to be used with Java and Android virtual machines. Also, it can be compiled as JavaScript source code. In addition, it can be characterized as having a good combination of being function-oriented during programming and being able to focus on safety and clarity. [18].

D. Arduino

Arduino is a tool that can be used to develop some elements, or can also be connected to other devices to develop programs such as hardware and software. In addition, it is used to control an element, which has a motor that goes up and down based on the light that has a sensor connected to Arduino[19].

E. Pulse Sensor Amped

The pulse sensor is a sensor that can give the heart rate that by simply connecting to Arduino it is already being used. Also, it is essential that a simple sensor can be combined with amplified heart rate and noise cancellation circuitry making readings reliable, easy and fast to obtain. Only 4 mA of current is needed at 5 volts and it connects to the earlobe or fingertip[20].

IV. CASE STUDY

In this section, the meter will be developed with Arduino and the pulse sensor to be able to calculate the rhythm, in addition, it will be explained in detail how it is carried out in the prototype, with the SCRUM methodology, due to the fact that all the execution in a way that is accepted in the requirements.

4.1 Pulse Sensor with Arduino

The heart rate sensor is essential for a photoplethysmography, which is a medical device that is known to be able to use and monitor heart rates in a non-invasive way. The pulse signal that comes out will be an analog voltage fluctuation and will have a predictable wave. The pulse sensor will amplify the pulse sensor signals above and normalized to a v/2 depending on the light intensity. One of the objectives is to find the moment that is successive of the heartbeat and to be able to measure the time that is passing, called inter beat [21].

As the heart pumps blood through the body, with each beat there is a pulse wave that may be traveling along the arteries to the extremities of the tissue as shown in Figure 2.

The sensor will be connected to the +5v power supply between the red (+5v) and orange wires and from the brown wire an analog output will have to come out that can be contacted to the first analog input of any board that is the Arduino and for terminate must be entered on binary output pin 11 [21].
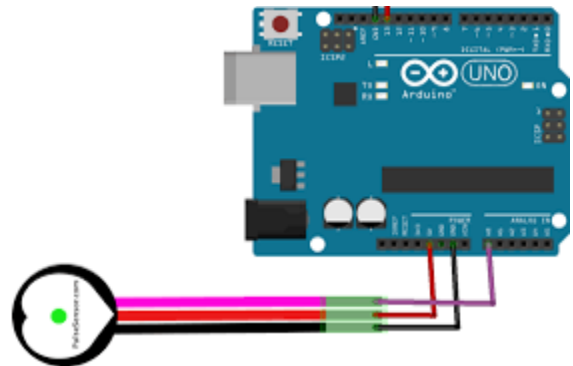

Figure 2: Arduino architecture with pulse sensor

In figure 3, it will show how the pulse sensor will connect with the application in order to send the collected information
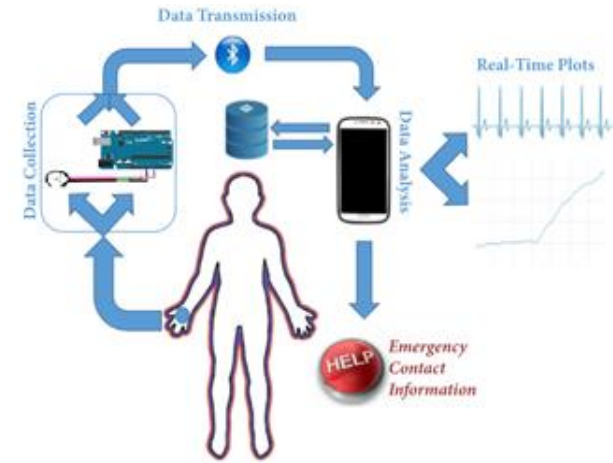

Figure 3: project architecture

4.2 Sprint Planning

In order to start, we must create the requirements that are needed by the client to be able to execute it.

❖ As a user I want the bracelet to receive the data of the symptoms so that it can inform me exactly to have control with my pulses

❖ As a user I want the application to receive data that was obtained by the sensors to have exact information

❖ As a user, I want the application to be able to notify me when a possible stoppage may occur to take into account and take action

❖ As a user I want to enter the application through a login to have my data registered

❖ As a user I want the application to have control of the activities I carry out in order to have control of my daily activities.

4.3 Development stage.

A. Time Estimation

For the development of all the sprints, approximately 38 days will be used, as shown in table 1.

Tabla 1:
Duración de los Sprint

SPRINT	HISTORY	DURATION	PRIORITY
sprint 1	Conduct research on symptoms of cardiac arrest	3 days	high
	The system must allow recording the symptoms that the client has	1 days	high
	Verify the set of data and rules needed for stop detection	2 days	half
sprint 2	Carry out the programming of the Arduino to know the information of the pulse	2 days	high
	Program the sending of pulses that are obtained by the sensors	3 days	half
	develop the application that has the data obtained from the sensors	2 days	half
	Implement an algorithm to stop cardiac arrest	6 days	high
sprint 3	The system must calculate the customer's steps	4 days	half
	The application must have a login	2 days	short
	The system must allow entering the amount of water filled	5 days	half
sprint 4	The Application must allow to register the values of weight, frequency, blood pressure and glucose levels	4 days	high
	The Application Will Allow Sending an Emergency Message To People Who Were Trusted Registered	5 days	high

B. Product Scope

It is the estimate of the time in which the team will take to have the points of the user story, therefore, all the estimates of the scope of the team will be noted in Figure 4.
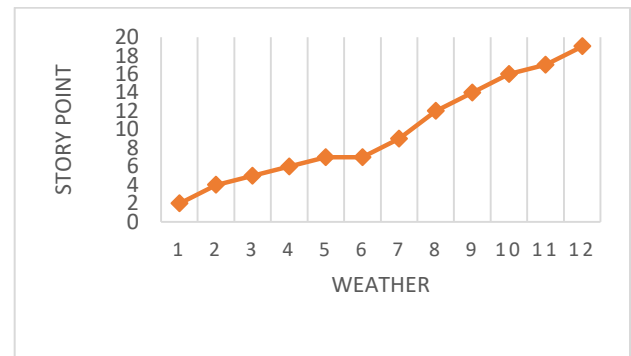

Figure 4: Product scope.

A. Mobile Application Prototypes

In this stage we will show the creation of the mobile application design that we will carry out and we will detail the functions that each of the modules will have as we can see in Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, Figure 15 and Figure 16.
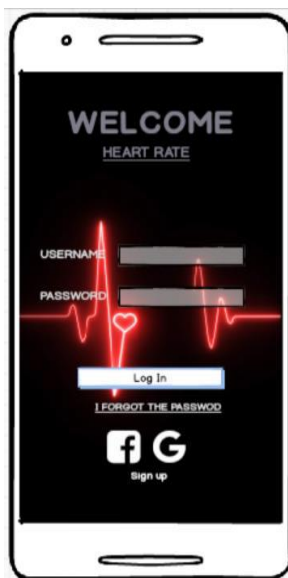

Figure 9: Symptom Log   **Figure 10: Bluetooth Sync to Arduino**

Figure 5: Login Module   **Figure 6: Symptom Calendar**
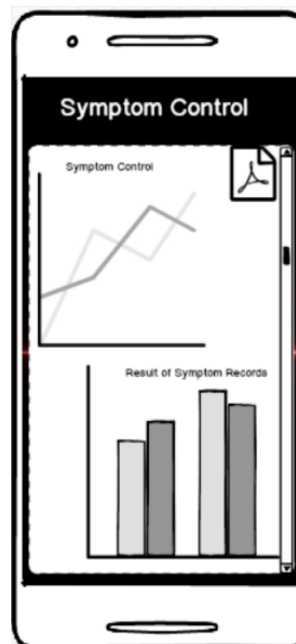
Figure 11: Symptom Control   **Figure 12: pulse check**
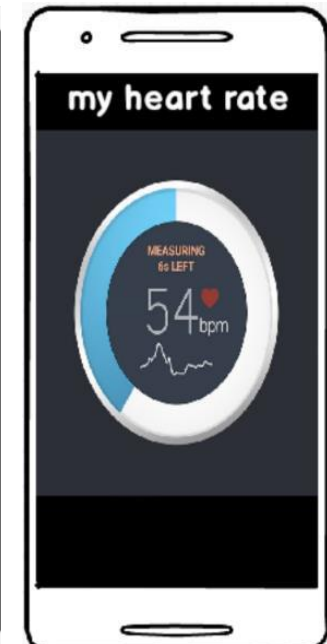
Figure 7: Symptom Log   **Figure 8: Symptom Log**
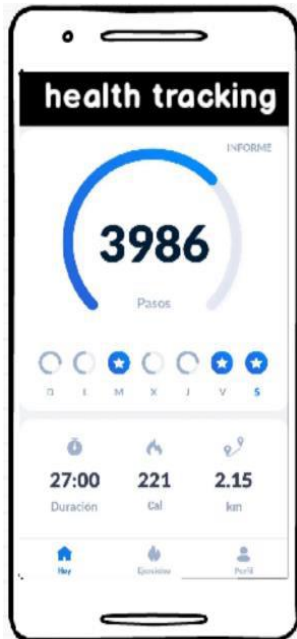
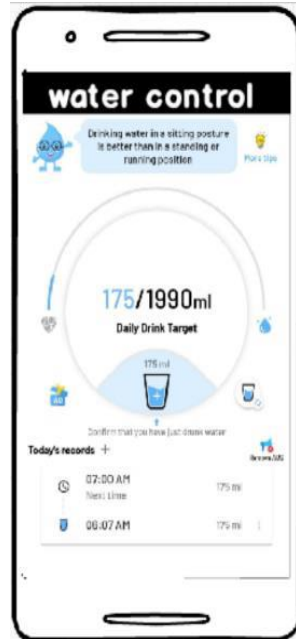**Figure 13: Step Control**
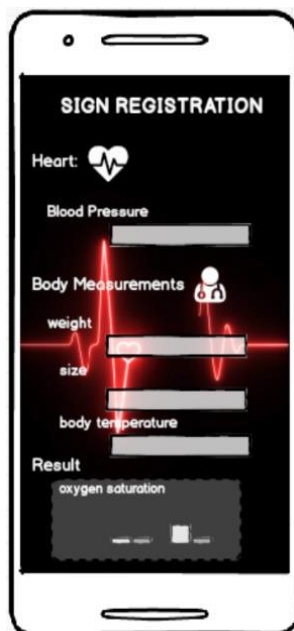

Figure 14: Water monitoring

Figure 15: Heald Record

Figure 16: Heald alert

A. Increase of the modules of the mobile application

Next, each function of the modules and their relationship with each elaborated prototype will be described.

Increment 1: Login Module.

In this increment it shows a login, you must register your credentials to be able to enter, as shown in Figure 5. At this point, you must already be previously registered so that you can access.

Increment 2: Symptom Records Module.

In this module you can enter the calendar as shown in Figure 6 and you can add the date that you are feeling bad so that you can have a follow-up. In addition, there is a module that will ask you how you feel, with what symptoms you are frequently feeling, since those symptoms are the most common as shown in Figure 7, Figure 8 and Figure 9.

Increment 3: Connection Module.

This increase allows linking the mobile device with the Arduino meter as shown in Figure 10, to be able to obtain the reading data.

Increment 4: Data Module.

The Data Module allows you to change some of your personal information, such as your password, as shown in Figure 9.

Increment 5: Reports Module

In this increment you will be able to view the reports of your physical activity and symptoms as shown in figure 11 and you will be able to download it in PDF so that you can show it to your doctor.

Increment 6: Control Module.

In this module you can have control of your heartbeat, but first you must put your finger on the sensor that is connected to the Arduino so that later it can be synchronized and the application will show you the result as shown in figure 12.

In order for you to have a healthy activity, as recommended by doctors, the application will allow you to show the number of steps you take and the amount of water you should drink as shown in Figure 13 and Figure 14.

In addition, you can record your weight, height, body temperature to show you the result of oxygen saturation.

Increment 7: Alert Module

In this module you will be able to register 4 people as trusted contacts so that they can show you the place where a heart attack is possibly going to take place. Since, when the application sees that the control of the pulses is automatically decreasing, it will send the message and also to the nearest hospital as shown in Figure 16.

4.4 Sprint Review

When all the Sprints are finished, they will have to be reviewed by all the members of the team, having the inspection time of two to three hours. One of the team members will have to evaluate each task developed and it must be determined if any changes are needed to correct it. In addition, the members of the development team will explain each process and the solutions that must be implemented when having problems when the Sprint is being developed.

4.5 Sprint feedback.

The team members will have to evaluate each process and technique that was implemented during the development of the Sprints. For example, the use of the Kotlin programming language, the SQLite database manager or the Balsamiq tool for the development of prototypes. New ideas or methods can be suggested for the gradual improvement of each Sprint, as well as adding new tools for the execution of the scrum method for a better organization.

V. RESULTS AND DISCUSSION

A. About the case study

Next, the expected results will be shown when carrying out the investigation of the article within the case study and the scrum methodology, where the proposals that were being implemented and the development of the control system were taken into account, in order to later be able to carry out an analysis that will make a comparison with other investigations that are within the subject, for which similarities or inequalities are presented with respect to the development of the chosen methodology, taking into account that the phases that are involved and in their form of development of the execution.

Next, it is known that when a person suffers from some discomfort in the heart, they go directly to the clinic or hospital and the corresponding tests are carried out. In addition, once the results are obtained, the necessary treatments are assigned to carry out better control and supervision. But other people with heart problems give up their control for economics or other reasons, endangering their lives because they can have a heart attack at any time. Afterwards, an analysis of the results of the indicators was made: that is, the percentage of alerts that there are of a possible cardiac arrest. It was concluded that the percentage of alerts that were correct was 61% and with the budget method it is 74%. So that comparisons can be made, 100% of the result obtained from the measurements with the current method is taken as one of the references. When performed, the comparisons show that the percentage and correct alerts can be obtained with the budget method for early detections that there was an increase of 13% with respect to the current methods of the doctor of cardiology as shown in Figure 17 and Table 2[10].

Table 2:
Sprint Duration

Method	P	%
Current	61%	100%
Budget	74%	121.31%
Increase	13%	21.31%
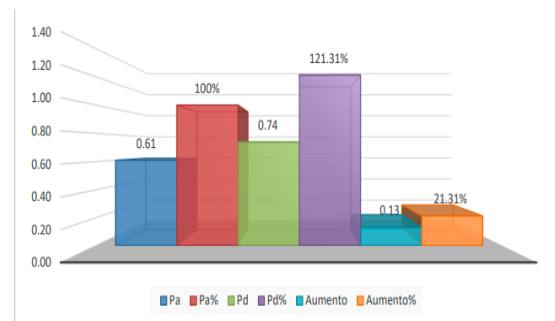
Figure 17: Percentage of correct alerts of a possible cardiac arrest

There is an analysis of a total of 1,609 cases of AMI, obtained from 34 hospitals and some clinics in Lima, Callao and the provinces, in which descriptive analyzes were carried out through relative frequencies for the cases of category variables and summary mean for the uses of variables. As a result, it was obtained from the 1,609 cases of acute myocardial infarction, 1,172 being male, which is 72.8%, and 437 females, which is 27.2%, of which 1,345 came from Lima (83.6%). and 264 from provinces (16.4%). In Lima, 27 institutions participated, of which Social Security provided 886 cases (55.1%), MINSA Hospitals 227 cases (14.1%), clinics 134 cases (8.3%) and the Armed Forces 98 cases (6.1%).[6].

Currently, there are many apps created for cardiology, such as the Appteca project. That it is a project that was born from Spanish society and helps the people who are involved to have a diagnosis, treatment and follow-up of patients with cardiovascular problems and that is how they start. Help for cardiovascular risk, practical ECG, arterial hypertension, echocardioscopy and heart failure. They are free applications and they have the objective of targeting the finances of the fameindustry to be able to resolve some conflicts [22].

B. About the methodology

There are too many methodologies to be able to develop a project, but the scrum methodology was chosen because it is considered one of the methodology where you can try and do, err, try and do an iterative process because you can work by tasks and time periods called Sprint, since it allows a fluid, fast and flexible development. In addition, to improve the response for a project, it can be accommodated to the needs obtaining a better result.[23]. It is also more focused on the management of a project taking into account the life cycle [10].

Unlike other RUP methodologies, which aims to ensure the production of high and higher quality software in order to meet all the needs of users who have compliance at the end of one of the limits and has the advantage of having a improvement in the productivity of the team, allowing the team member to specify the same knowledge base as the other members[24]. In addition, traditional methodologies have a predictive approach where it will be possible to achieve a predictive approach, where it will follow a one-way sequential process and the estimates are requirements that are only used once[25].

Next, the differences between traditional Methodology and Scrum Methodology will be shown, as presented in Table 3.

Table 3:
Difference between Traditional Methodology and Agile Methodology.

Traditional Methodology	Scrum Methodology
The client can only act when the development team is in meetings.	The client is part of the development members
Proposes resistance to change. Proposes resistance to change.	There is a process to determine the changes of the development of the project
It is based on artifact numbers	Contains few artifacts
There is a predefined contract	There is no fixed contract
Applies to projects of large or small sizes	It is more oriented to small projects

VI. CONCLUSIONS AND FUTURE WORK

Within the study, it can be affirmed that the great diversity of applications that are available worldwide, either by parameters that are going to be able to be monitored or the functions that they provide and to be able to result if it is necessary to establish alignments in terms of the characteristics that are possessed.

The prototype that was proposed will help patients feel safer, since they will be able to check their heart rate graphically, in addition to being careful with the activities they perform to have better control with the monitoring that is needed. It will also help the doctor because he will have to record the symptoms that occurred during the week, so he will have a better reminder of what happened.

Consequently, it should be noted that the interface was friendly and simple so that you have a better interaction with the application in a transparent way, in addition to having a good prediction of a heart attack, since it will send the location to your relatives and a nearby hospital.

For future work, it is recommended to make a chat box connected with doctors who are specialists in cardiology, for better control and that it be personalized for consultations.

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