International Journal of Engineering Trends and Technology
ISSN: 2231–5381 / https://doi.org/10.14445/22315381/IJETT-V71I10P231

Volume 71 Issue 10, 346-354, October 2023

Original Article

Mobile Application: Heart Attack Monitoring and Control Using a Frequency and Pulse Sensor

Alejandro Boza-Chua[1], Laberiano Andrade-Arenas[2]

[1,2]*Faculty of Sciences and Engineering, Universidad de Ciencias y Humanidades, Lima, Perú.*

[2]*Corresponding Author : landrade@uch.edu.pe*

Received: 18 July 2023 Revised: 11 September 2023 Accepted: 18 September 2023 Published: 03 October 2023

Abstract *- Currently, in much of Latin America, heart attack is one of the main problems of society, especially in rural areas of Peru; is one of the main reasons why heart attacks are part of the highest percentage mortality rate due to the little technological development for the support and monitoring of those prone to heart attacks. Above all, a lack of governmental support. For this reason, the present research work is generated, which aims to provide benefits for controlling and monitoring the population prone to heart attacks. Therefore, it was proposed a system of frequency and pulses linked to a mobile application, with high accessibility to people with low resources, such as the majority of people in rural areas. For this purpose, a form was filled out and sent to cardiology students and teachers, together with 5 doctors from Northern Lima, Peru, to collect the main requirements for the project's development. In addition, the scrum methodology was used, as it is the most appropriate for a changing project like this one. Finally, it was concluded that this project will provide different adequate and viable benefits for the control and monitoring of this social problem.*

Keywords *- Heart attack, Mobile application, Scrum methodology, Sensory system, Social health.*

1. Introduction

Heart attacks are produced due to the obstruction of blood flow to the heart; plaque rupture causes these obstructions. Although much of the world society does not take the importance that really corresponds to it, these heart attacks are the main killers of the population. That is why, for the last decade, heart disease has been one of the leading causes of death worldwide [1]; among these problems, the main reason is heart attacks, which have a 75% probability of causing the death of a person through a cardiac infarction.

In Latin America, one of the countries most affected by this type of disease due to the lack of technological support and scientific development is Peru, where more than 4,000 citizens suffer heart attacks every year [2][3] caused by obesity, hypertension and stress, becoming one of the main problems affecting Peruvian society [4]. Recent medical events worldwide have highlighted the precariousness of the Peruvian health system, both in terms of technology and the lack of truly trained and dedicated human resources for the primary care of society [5].

Due to the lack of funding focused on the health area. However, what is most tragic is the lack of information that people have about this type of disease that can cause large numbers of deaths annually [6]. While it is true that there are many ways to prevent heart attacks caused by heart attacks in time, a large part of the population is not alert to the symptoms of heart attacks [7] or events that this disease can provoke [7].

The main and most recurrent warning symptoms of a heart attack are severe pain in the chest, upper body, or arms [8]. In addition, it may cause nausea, fainting, or shortness of breath.

Therefore, it is really necessary to emphasize how important it is to implement and establish an integrated system that can support the prevention of heart attacks through the control of heart attacks attended in time and constantly monitored. For this reason, this research is focused on developing a mobile application that monitors and controls people prone to contracting a heart attack through a pulse and heart rate sensor. Different sections establish the present research work. Section 2 shows the literature review. Likewise, section 3 establishes the methodological phase-oriented to the project's development. Section 4 shows the results and discussion of the research work. Finally, Section 5 presents the conclusion and future work.

2. Literature Review

For the literature review phase, a study was made of 5 projects based on the contribution and improvement of infarct control. The aim was to provide feedback and observe the difficulties of each of these projects, together with their limitations, to develop a project based on improvement

through the knowledge gathered. On the other hand, it focused on studying the tools that bring the greatest benefit to the project when applied.

2.1. First Project: Projects Studied

2.1.1. First Project

The developers of this first work built a smartphone mobile application focused on locating people affected after cardiac arrest. This application generates alerts directed to paramedics or firefighters, and the mobile application contains an unusual, complex, and not very understandable interface for users. In addition, it is designed in a basic way, obtaining different limitations for its use, allowing late attention to the patient [9].

2.1.2. Second Project

The authors developed a mobile application focused on out-of-hospital care of traumatic cardiac arrest in this second research work. This application had the purpose of sending notifications in response to events occurring in nearby public places detected according to an accident related to a heart attack. Its main limitation is its functionality, which is only to notify events after cardiac arrest and not during, or at least preventively [10].

2.1.3. Third Project

An advanced usability application was developed for the user, with an understandable and adaptable interface focused on recording and notifying cases of people who suffer cardiac arrest. This application compares and records how many people were attended in time, how many cases were responded to, and information on what to do in certain cases. Although it is not highly reliable as it is only a registration application, it does not detect instantly, so it lacks direct interaction with the patient for immediate detection [11].

2.1.4. Fourth Project

In this fourth study, we analyzed an application that was developed with the purpose of acting as an intermediary between the doctor and the patient. This application performs real-time monitoring of the patient's condition to reduce patient care delays. In addition, it is oriented to patients with cardiac problems; although the main idea is very consistent with the established problem, it does not provide great effectiveness in supporting these patients, with a precarious and unsafe design for the information and health status of the user, since the response time is late [12].

2.1.5. Fifth Project

In the last study, we analyzed an application interconnected in a sensory way to a device, which, through continuous cardiac monitoring, focuses on performing periodic medical checkups. Likewise, through a clinic or hospital, the cases issued by this interconnection are received and attended. However, the application's design is not very innovative and very basic for the usability of the user; although it covers much of the needs of the problem, it is not enough to meet the requirements [13].

Finally, after having carried out the literature review, it was possible to know different methods regarding the use of established technologies to cover one of the main needs of society, in this case, oriented to controlling heart attacks and reducing deaths due to heart attacks. However, these established projects are not entirely adequate to cover this problem. That is why this research work will focus on improving and establishing a project with a better structure based on the limitations and shortcomings of the previous projects.

2.2. Development Tools

A study was conducted for the implementation and usability of development and design tools for this research work. This study was carried out to obtain the main tools for the present project oriented to the proportion of best benefits to be implemented. This analysis and follow-up were focused on adaptability and ease of development, mainly for user usability.

2.2.1. C programming Language

It is one of the most used programming languages nowadays due to the fact that it works under a simple data structure directly interconnected to the machine, generating an adequate performance [14, 15]. In addition, compared to other programming languages, C is generally useful for technological development to obtain a more functional development for different fields [16] mainly because this programming language provides flexibility to carry out different projects by not having complexity in its usability and being an efficient language [17].

2.2.2. Java programming Language

Like the C programming language, Java is another of the most widely used programming languages in recent years [18, 19]. Its main benefits are focused on the creation of modules and reusable code. In addition, it stands out for its structuring, being a simple language with multiple components, making it highly adaptable to any type of project [20, 21]. In general, the learning path for this programming language is short because it is an interpreted programming language.

2.2.3. Android Studio

This tool is a development environment (IDE), which, compared to others, has a fast emulator integration, which allows testing the functionalities of the developed mobile application by simulating the area environment [22, 23]. One of the main advantages of implementing Android Studio in a project is its frequent updates [24]. It also uses the guard tool, which optimizes and reduces the project codeo to export an apk for devices with a limited range [25].

2.2.4. Arduino Nano Pinout

This tool is a small microcontroller board and one of the most outstanding, with compatibility, flexibility, and ease of use [26]. Due to the size and structure of the breadboard, this tool is a suitable option for most of the applications where the size of the components is of great importance due to the convenience of the user [27]. Its main benefit is that it does not require a separate loader to execute and save the program since this microcontroller board already contains a built-in internal boot loader [28].

2.2.5. Bluetooth Module HC - 06

This tool is a device that supports different wireless connections through the Bluetooth protocol, giving the possibility to interconnect the Arduino development with a cell phone or smartphone [29], which allows for speeding up the reception of sound waves emitted through different devices. In addition, it provides the facility to know the connection status through an LED anchored to this module, which develops its functionalities through AT commands [30].

3. Methodology

For the present research work, the extreme programming methodology was implemented, which is focused on agility and flexibility in project management. Its main benefit is the centralized development in creating an exact product based on the requirements established at the beginning of the project [31].

Likewise, this methodology is highly adaptable to the development of different projects as it is composed of 4 phases that cover the main needs of any type of development, as shown in Fig. 1.

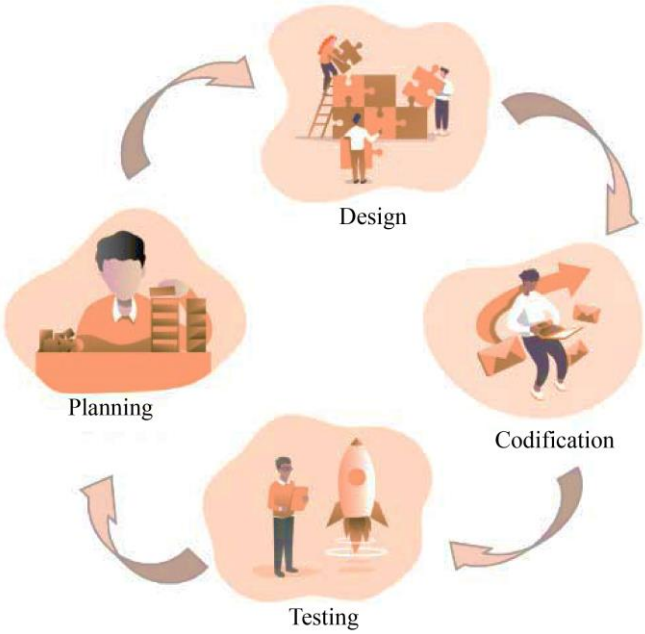

Fig. 1 Phases of the XP methodology

As shown in Fig. 1, the XP methodology is structured in 4 phases. Its first phase focuses on interpreting and identifying the project needs and generating user stories. The second phase is focused on developing prototypes and structuring the project through creating story sketches [32, 33]. Phase 3 of this methodology focuses on coding user stories through the developed sketches through compliance with programming standards. Finally, there is phase 4; in this stage, functionality tests are performed and developed, validating that the requirements established in the first phase were met.

3.1. Planning

As the first stage of the XP methodology, planning is established. For this project, a questionnaire was sent to cardiology students and teachers, together with 5 doctors from Lima Norte, Peru. With the purpose of focusing the development of the project on the needs of the society in front of this problem, it was finally obtaining the user stories that can be visualized in Table 1.

Table 1. Requirements

Nº	User Stories
1	As a user, I would like the heart rate monitor to be small so I can wear it without it being too visible.
2	As a user, I would like the heart rate monitor to be linked to a mobile application to manage its functionalities.
3	As a user, I would like the mobile application to activate an alert to my family and medical center to control a post-heart attack.
4	As an administrator, I would like the mobile application to be intuitive to use and easy for the user to understand.
5	As a user, I would like the mobile application to have a history of the user's cardiac variations for further medical study.
6	As a user, I would like the mobile application to share my location for medical or family assistance in case of emergencies.

3.2. Design

In the design phase, three initial processes were established for the present research project. These processes were focused on the interaction structure of the cardiac pulse sensor. They also focused on the software architecture of the mobile application and, finally, the functionality of the project.

3.2.1. Cardiac Pulse Sensor

The process starts in the Arduino microcontroller, configuring the variables and the way of conversion. Because the sensor picks up the amount of light difference in its receiver, it also has an infrared receiver and an infrared emitter. After this, it sends the infrared light that bounces back and evidences whether the blood is circulating or not. All this is done by the Arduino analogically, through its converter

transforming all pulses into digital values (zeros and ones). Then, having the information in the microcontroller, it is expressed through the LEDs, where one LED indicates the pulse by turning on and off every time a sensor detects the bounce of the infrared light. On the other hand, the other LED indicates when there is an anomaly, in this case, 80 beats per minute, detecting a heart attack. Then, when linking the Bluetooth, the reception is sent to the mobile device through serial communication, capturing the signal within the mobile application (See Fig. 2).

3.2.2. Multilayer Software Architecture

The stable and appropriate software architecture for this project is the multilayer structured architecture. This type of architecture has the benefit of standardizing all processes within the mobile application in four essential and viable phases for its functionality, as shown in Fig. 3. Another benefit is eliminating dependencies between the different layers, limiting them to work only between adjacent layers. The first layer is focused on establishing the interaction between the system and the reception of the data sent through the functionalities provided by the system. Likewise, this layer works in conjunction with layer 2, which consumes the data through an API. On the other hand, there is layer 3, which, as a result of the two previous layers, stores the business logic, locating the verifications and tests of the system. Finally, layer 4, which contains the relational database, is based on the organizational relationship, in this case, in the medical entity or family members.

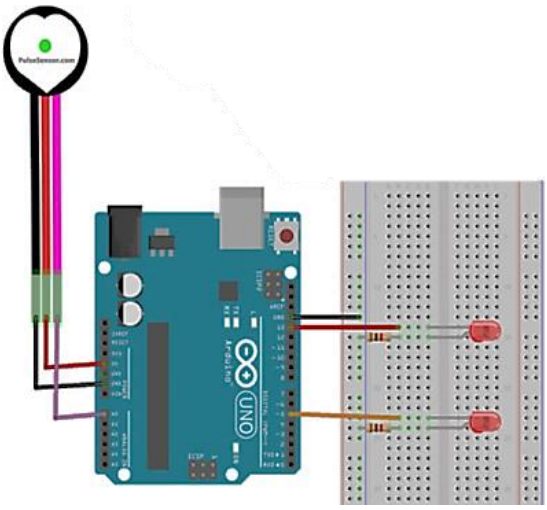

Fig. 2 Cardiac pulse sensor prototype

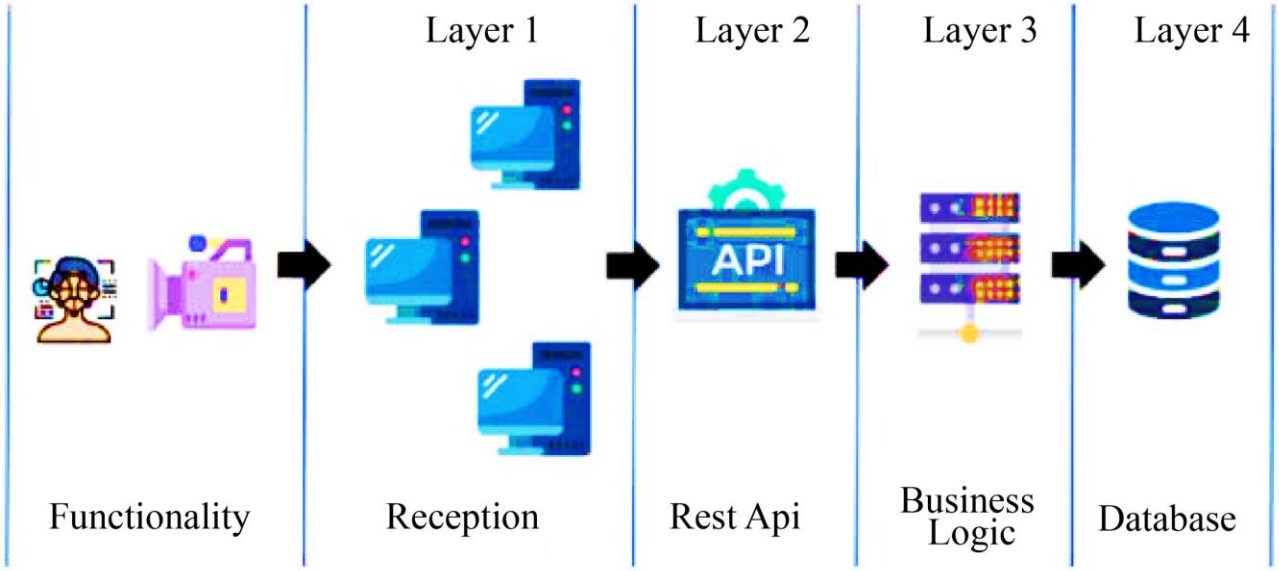

Fig. 3 Multilayer software architecture

3.2.3. Project Functionality

The present design was established for the sequential structuring of the functionality of the project from start to finish, as shown in Fig. 4. The first stage is the photoelectric sensor, which sends pulses performing the sensory communication within the Arduino to subsequently process the information received, according to whether cardiac anomalies have been captured in analog pulses, represented by zeros and ones. Then, this information is sent via Bluetooth connection, which interprets the signal by plotting the heart rate in time according to the number of pulses received. Finally, this is received by the mobile application, which gives the result through a cardiac status; in case the results are recorded as anomalies, it emits alerts to the nearest medical units and contacts previously established to receive signals and locations of the user at risk.

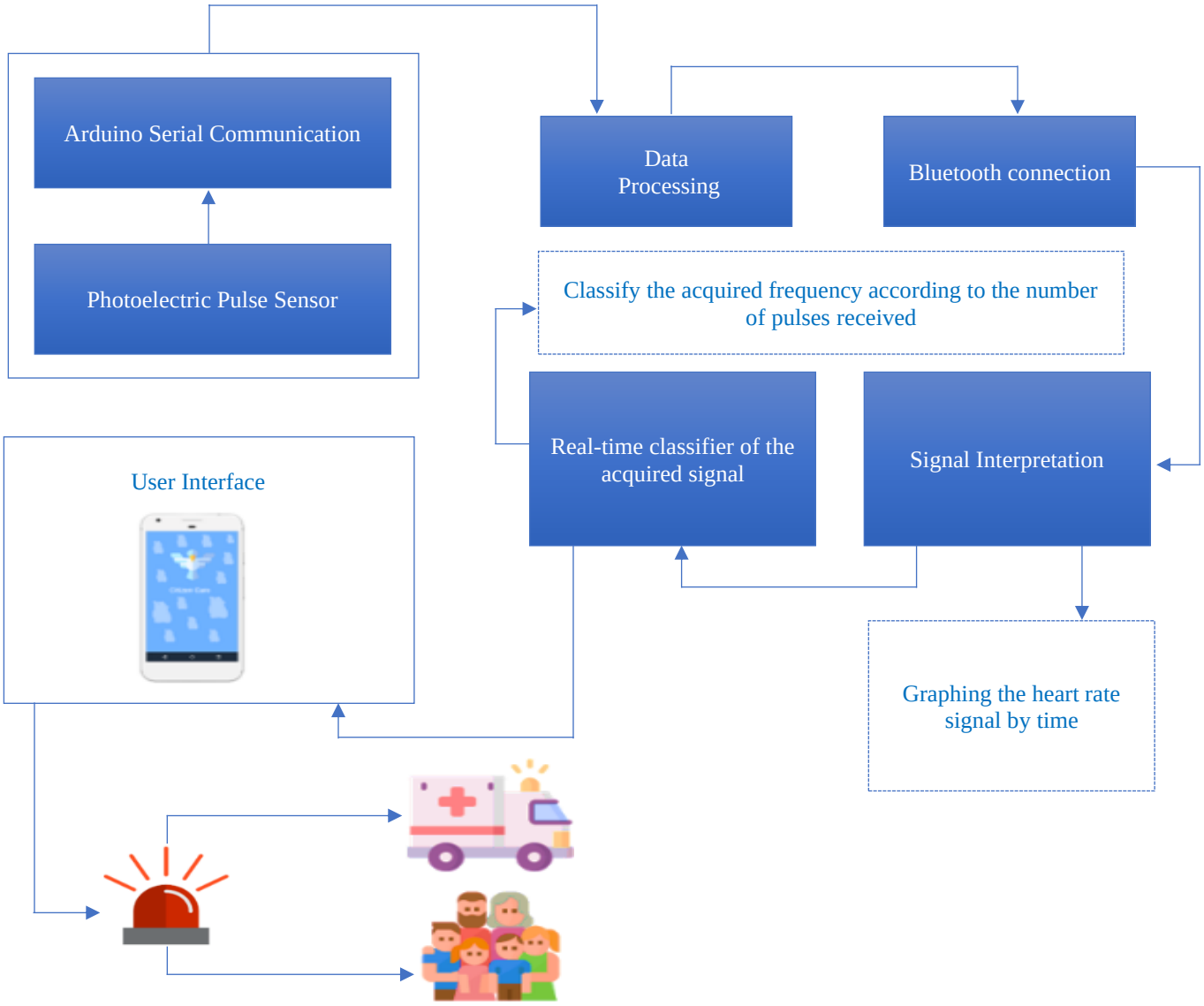

Fig. 4 Project functionality

3.3. Coding

The coding implemented for the present research project was divided into 2 processes. These processes were focused on the recognition of cardiac pulses and Bluetooth interaction. These processes have subprocesses for better interaction between the user and the application.

3.3.1. Recognition of Cardiac Pulses

The code entered in these processes is focused on recognizing the cardiac variations according to the established limit of change.

If the amount of variation is exceeded, it will emit and establish a connection with the second coding process. The cardiac pulse process is established in three sub-processes: variable assignment, buzzer connection and recording of the changing pulse, as shown in Fig. 5.

```
START CAPTURING CARDIAC PULSE
1   assign variable_connector_buzzer=11;
2   assign pulse_variable=0;
3   assign pulse_limit_count_variable = 550;
4
5   connect_buzzer function(){
6   pinMode(variable_connector_buzzer,Output)
7   serial.begin(9600);
8   }
9
10  function loop(){
11
12  variable_pulso = analog(A0);
13  serial.print(<<*>>);
14    serial.println(pulse_variable);
15      if(pulse_variable > pulse_count_limit_variable){
16      digitalWrite(variable_connector_buzzer,HIGH);
17      }else{
18      digitalWrite(variable_connector_buzzer,LOW);
19      }
20    delay(35);
21  }
END OF CARDIAC PULSE CAPTURE
```

Fig. 5 Cardiac pulse recognition

```
START BLUETOOTH CONNECTION
1 Include SoftwareSerial BT1(4,2) library;
2 Funcion Configuracion(){
3 Serial.begin(9600);
4 Serial.printl("Enter commands:")
5 }
6
7 funcion bucle()
8 {
9   if(BT1.availability())
10  {
11  Serial.write(BT1.read())
12  }
13  if(Serial.available())
14  {
15  assign s = GetLine();
16  BT1.print(S);
17  Serial.println("--->" + S);
18  }
19
20 }
21
22  Function get_line()
23  {
24  assign S = "";
25   if(Serial.available())
26   {
27   assign c = Serial.read();
28   do while ( c != '\n')
29         {
30          assign S = S + c;
31          delay(25);
32          c = Serial.read();
33         }
34        return(S + '\n');
35   }
36  }
END OF BLUETOOTH CONNECTION
```

Fig. 6 Bluetooth configuration

3.3.2. Bluetooth Configuration

The present coding process was established in the Bluetooth connection with the Arduino Nano. This later allowed the interaction with the mobile application focused on sending location and attention to the user. The coding of the Bluetooth configuration was established in 4 sub-processes, including the software serial library, the configuration of the HC-06 serial module, the reader of the connection availability, and the assignment and reader of the serial location, as shown in Fig. 6.

4. Results and Discussions

The results to be presented in this phase of the methodology are structured in two approaches. As a first approach, the functionality of the project was established, focused on a study of compliance with the optimal functionality of the project. Likewise, the second approach is related to the acceptance of the development of this research project through an evaluation of different characteristics.

4.1. Tests

After the design was completed based on the structure of the heart rate sensor, we proceeded to build the hardware for testing and confirm its functionality, as shown in Fig. 7. After the construction of the hardware, the linkage with the developed mobile application was made, linked by means of the Bluetooth sensor. Checking its functionality according to the responses obtained and reflected in the mobile application as shown in Fig. 8. The final functionality of the project is standardized in establishing the hardware in a portable use for the user, being located on the arm and extended to the index finger, as shown in Fig. 9. This project manages to reduce the price and development time being accessible to the low-income population.

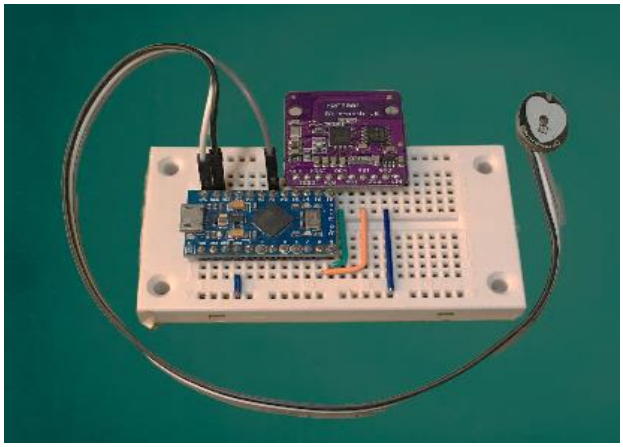

Fig. 7 Heart pulse rate sensor

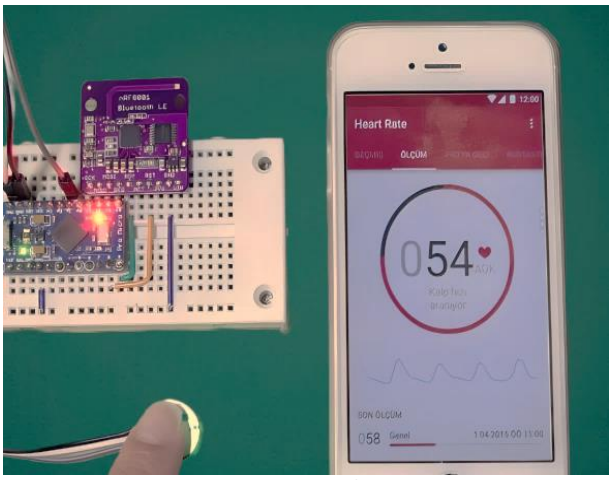

Fig. 8 Hardware and software testing

Fig. 9 Project standardization

Table 2. Evaluation criteria

Criterion	Excellent (4)	Well (3)	Regular (2)	Deficient (1)
Design	17	20	1	0
Support Services	19	17	2	0
Software	27	11	0	0
Hardware	5	27	6	0
System Response	25	13	0	0

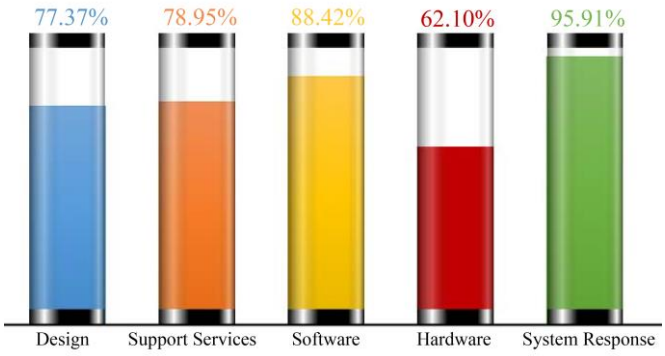

Fig. 10 Satisfaction evaluation

4.2. Satisfaction

To evaluate the degree of satisfaction obtained with the project based on the monitoring and control of heart attacks, a survey was conducted among the people who helped to obtain the requirements for this project, including cardiology students and teachers, together with 5 physicians from northern Lima, Peru. The purpose of the survey is to benefit future work that could be done by collecting information and providing feedback. The results shown in Table 2 were obtained through the questionnaire, which was categorized into 5 levels of evaluation and 4 levels of qualification. The information located in Table 2 focuses on the data collection of all the people evaluated. Through the collection of information, a percentage study of the project rating was carried out, which can be seen in Fig. 10.

4.2.1. Criteria Evaluated

As the first criterion, the design quality was evaluated, focused on the evaluation oriented to the strategy and design model; this qualification will help to make an improved version, avoiding design and control nonconformity. As a second criterion, the quality of the support service was evaluated. This evaluates the internal and external reference of the project, focused on whether the application is really related to the initial purpose for which it was implemented. As a third evaluation criterion, the Quality of the software was analyzed; in this criterion, the effectiveness of the application was evaluated in relation to the needs established in the first phases of the project to know if what has been developed is relevant. As a last criterion, the quality of the hardware was evaluated, in which the environment, adaptability, and integrity of the system in interaction with the user were evaluated, prioritizing comfort and quality of development. Efficiency in the response of the support system: comparative evaluation with other projects focused on the same problem, evaluating development time, benefits, and interaction of software and hardware between the user and the problem.

Likewise, the graph in Fig. 10 shows the final study on the feasibility of the project. It was analyzed that the design obtained a 77.37% approval, allowing us to know that the project's strategy, structure, and model are adequate for the user. In the same way, the software obtained 88.42% approval, determining that it is highly efficient and focused on the established needs. It was also possible to verify that the project has achieved its initial purpose and is focused on supporting the central problem through the qualification of 78.95% in quality of support service and 95.91% in the efficiency of the system's response. Finally, it is known that there is room for improvement in the evaluation of the environment due to the 62.10% obtained for hardware and user comfort.

5. Conclusion and Future Work

Finally, a system was developed and implemented to support and help meet the objectives based on the project requirements and problems through collaborative work with the people involved in the questionnaires to obtain requirements and evaluate project approval. Likewise, this development will be able to provide better control of heart attacks to all those people prone to suffer from this disease. Likewise, this project will bring different benefits to the medical environment and its development, especially in rural areas with low economic resources and little medical support, as is evident in much of Latin America. Accordingly, in future work, we want to implement different improvements regarding the results obtained to improve the interaction with the user. On the other hand, this study should be the beginning of improving citizen life in rural environments with little governmental support, encouraging a better contribution and technological development oriented to this population, not only in Peru but worldwide.

References

[1] Meng Wang, Xinghua Yao, and Yixiang Chen, "An Imbalanced-Data Processing Algorithm for the Prediction of Heart Attack in Stroke Patients," *IEEE Access*, vol. 9, pp. 25394–25404, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[2] J.C. Van Hooser et al., "Knowledge of Heart Attack and Stroke Symptoms among Us Native American Adults: A Cross-Sectional Population-Based Study Analyzing a Multi-Year BRFSS Database," *BMC Public Health*, vol. 20, no. 1, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[3] V. Tapia et al., "Time-Series Analysis of Ambient $PM_{2.5}$ and Cardiorespiratory Emergency Room Visits in Lima, Peru," *Journal of Exposure Science & Environmental Epidemiology*, vol. 30, no. 4, pp. 680–688, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[4] Catalina Pineda Molina, "Regulation of Tissue Engineered Devices in some Latin American Countries: Development and External Influences," *Universitas Odontologica*, vol. 37, no. 79, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[5] Aldo Alvarez-Risco, Shyla Del-Aguila-Arcentales, and Jaime A. Yáñez, "Telemedicine in Peru as a Result of the COVID-19 Pandemic: Perspective from a Country with Limited Internet Access," *American Journal of Tropical Medicine and Hygiene*, vol. 105, no. 1, pp. 6–11, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[6] Meneses-Claudio Brian et al., "Advances and Uses of ICT in Public Health of Peru," *Proceedings of the 2018 IEEE Sciences and Humanities International Research Conference*, pp. 1-5, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[7] Rosa Perez-Siguas, Eduardo Matta-Solis, and Hernan Matta-Solis, "Design of a Portable Electrocardiogram (ECG) for the Prevention of Cardiac Anomalies in Health Campaigns in Peru," *International Journal of Emerging Technology and Advanced Engineering*, vol. 11, no. 10, pp. 131–136, 2021. [CrossRef] [Publisher Link]

[8] Paulo Abreu, Fernando Carneiro, and Maria Teresa Restivo, "Screening System for Cardiac Problems through Non-Invasive Identification of Blood Pressure Waveform," *Information*, vol. 11, pp. 1-7, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[9] R. Stroop et al., "Smartphone-basierte First-Responder-Alarmierung 'Mobile Retter': Implementierung Eines Qualifizierten Ersthelfer-Systems," *Notarzt*, vol. 31, no. 5, pp. 239–245, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[10] Geoffrey S. Kelly, and Drew Clare, "Improving Out-of-Hospital Notification in Traumatic Cardiac Arrests with Novel Usage of Smartphone Application," *Journal of the American College of Emergency Physicians Open*, vol. 1, no. 4, pp. 618–623, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[11] Wei Ming Ng et al., "myResponder Smartphone Application to Crowdsource Basic Life Support for Out-of-Hospital Cardiac Arrest: The Singapore Experience," *Prehospital Emergency Care*, vol. 25, no. 3, pp. 388-396, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[12] Ummi Namirah Hashim et al., "The Design and Implementation of Mobile Heart Monitoring Applications Using Wearable Heart Rate Sensor," *International Journal of Advanced Computer Science and Applications*, vol. 12, no. 1, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[13] Pietro Cinaglia et al., "Design and Implementation of a Telecardiology System for Mobile Devices," *Interdisciplinary Sciences: Computational Life Sciences*, vol. 7, no. 3, pp. 266–274, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[14] V. Haroon Omar, and A. Farah begam, "Integrated Health Care System Management Using Mobile Application," *SSRG International Journal of Mobile Computing and Application*, vol. 1, no. 1, pp. 12-15, 2014. [CrossRef] [Publisher Link]

[15] Sabah A. Abdulkareem, and Ali J. Abboud, "Evaluating Python, C++, JavaScript and Java Programming Languages Based on Software Complexity Calculator (Halstead Metrics)," *IOP Conference Series: Materials Science and Engineering*, vol. 1076, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[16] Liudmyla Hlynchuk, Tetiana Hryshanovych, and Andrii Stupin, "Implementation of the Des Symmetrical Encryption Standard Using C Programming Language and Comparison of Its Working Time with Known Utilities," *Cybersecurity: Education, Science, Technique*, vol. 2, no. 14, pp. 118–130, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[17] Lihong Wang, Xue Han, and Yunhui Gao, "Research of Construction and Practice of Blended 'Golden Course' Teaching based on C Language Programming," *2021 2nd International Conference on Big Data and Informatization Education (ICBDIE)*, pp. 587–590, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[18] Leon Christopher, and Alexander Waworuntu, "Java Programming Language Learning Application Based on Octalysis Gamification Framework," *International Journal of New Media Technology*, vol. 8, no. 1, pp. 65–69, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[19] Zainatul Yushaniza Mohamed Yusoff, Mohamad Khairi Ishak, and Lukman A.B. Rahim, "A Java Servlet-based Transaction Broker for Internet of Things Edge Device Communications," *Bulletin of Electrical Engineering and Informatics*, vol. 11, no. 1, pp. 488–497, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[20] Wen Yandong, "Research on the Fragmented Learning of 'Java Language Programming' in the Internet + Era," *IEEE 16th International Conference on Computer Science and Education*, pp. 375-378, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[21] Hadion Wijoyo et al., "Design of Information System Buddhist Identity Card in Riau Province Using Java Programming Language," *Proceedings of the 2nd Annual Conference on Education and Social Science (ACCESS 2020)*, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[22] S.H. Aji et al., "Development of Physics Mobile Learning Media in Optical Instruments for Senior High School Student Using Android Studio," *Journal of Physics: Conference Series*, vol. 1440, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[23] Andi Ainun Najib, Rendy Munadi, and Nyoman Bogi Aditya Karna, "Security System with RFID Control Using E-KTP and Internet of Things," *Bulletin of Electrical Engineering and Informatics*, vol. 10, no. 3, pp. 1436–1445, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[24] Sufyan bin Uzayr, *Getting Started with Android Studio*, 1st ed., Mastering Android Studio, CRC Press, pp. 33–84, 2022. [Google Scholar] [Publisher Link]

[25] Aaron Don M. Africa et al., "A Comprehensive Study on Application Development Software Systems," *International Journal of Emerging Trends in Engineering Research*, vol. 7, no. 8, pp. 99–103, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[26] Thomas Bräunl, "Arduino," *Embedded Robotics*, Springer Singapore, pp. 53–65, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[27] Md. Monirul Islam, Mohammod Abul Kashem, and Jia Uddin, "An Internet of Things Framework for Real-Time Aquatic Environment Monitoring Using an Arduino and Sensors," *International Journal of Electrical and Computer Engineering*, vol. 12, no. 1, pp. 826–833, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[28] Miguel Tupac-Yupanqui et al., "Exploiting Arduino Features to Develop Programming Competencies," *IEEE Access*, vol. 10, pp. 20602–20615, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[29] Veronica Montserrat Castro Arrieta, Teresa González Bautista, and Luis Rodolfo Coello Galindo, "Voice Recognition System to Control a Prototype of a Wheelchair for Children with Lower Extremity Problems," *INVESTIGIUM Scientific Bulletin of the Higher School of Tizayuca*, vol. 3, no. 6, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[30] Leslie Heluit De La Portilla Medina, and Luis Rodolfo Coello Galindo, "Development of Two Prototypes of Educational Toys to Work on Sensory Integration Therapy in Children with Asperger's Syndrome," *INVESTIGIUM Scientific Bulletin of the Higher School of Tizayuca*, vol. 4, no. 7, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[31] Osama Sohaib et al., "Integrating Design Thinking into Extreme Programming," *Journal of Ambient Intelligence and Humanized Computing Volume*, vol. 10, pp. 2485–2492, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[32] Oluwaseun Alexander Dada, and Ismaila Temitayo Sanusi, "The Adoption of Software Engineering Practices in a Scrum Environment," *African Journal of Science, Technology, Innovation and Development*, vol. 14, no. 6, pp. 1429-1446, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[33] Hasanain Abdalridha Abed Alshadoodee et al., "The Role of Artificial Intelligence in Enhancing Administrative Decision Support Systems by Depend on Knowledge Management," *Bulletin of Electrical Engineering and Informatics*, vol. 11, no. 6, pp. 3577–3589, 2022. [CrossRef] [Google Scholar] [Publisher Link]