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# Journal Applied Computing

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## Presentation of the Content

*In Issue 15* is presented an article *Website with thematic maps to consult agricultural production in Hidalgo State*, by HERNÁNDEZ-TAPIA, Zaila, ACOSTA-ACOSTA, Araceli, GARCÍA-GÓMEZ, Jose Francisco and HERNÁNDEZ-BAUTISTA, Emanuel, with adscription at Universidad Politécnica de Francisco I. Madero, in the next article *Computer security, one more reason to take care of yourself today*, by DOMINGUEZ-LUGO, Alma Jovita, CASTORENA-PEÑA, Jesús Abraham, CANTU-GONZALEZ, José Roberto and SALAZAR-GAITAN, Pablo Arturo, with adscription at Universidad Autónoma de Coahuila, in the next section *Systematic review of scrum harmonization and software process models*, by MEX-ALVAREZ, Diana Concepción & UC-RIOS, Carlos Eduardo, with adscription at Universidad Autónoma de Campeche and Universidad Internacional Iberoamericana, in the next section *Detection of the R wave using analogue multiplier*, by CÓRDOVA-MANZO, Jesús Fausto, CÓRDOVA ESCOBEDO, Jesús Fausto, MENDOZA-GONZÁLEZ, Felipe and GOMEZ-RODRIGUEZ, Cristian, with adscription at Universidad Veracruzana.

## Content

Article **Journal Applied Computing**
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# Website with thematic maps to consult agricultural production in Hidalgo State

# Sitio web con mapas temáticos para consultar la producción agrícola en el Estado de Hidalgo

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**Abstract**

In Hidalgo State, agriculture is one of the main economic activities. In order that, in a large part of the territorial extension different types of crops are sown, among them and according to the volume of production 7 stand out, mainly: Green Alfalfa, grain corn, green forage oats, grain barley, green forage corn, maguey pulquero and orange. (SIAP, 2020). However, there is a need to promote commercialization due to the facts that ignorance of productivity prompts there are no suppliers interested in acquiring the different products, which generates losses, sales at very low prices and impacts the income of farmers. Due to the notable demand to publish the products that are grown in Hidalgo, the main objective of this project is to develop a tool that allows showing the agricultural production of Hidalgo State, through a website and thematic maps. As a result, a website was developed where production by municipality can be consulted and visualized on thematic maps.

**Website, Thematic maps, Agriculture**

**Resumen**

En el Estado de Hidalgo una de las principales actividades económicas es la agricultura, por lo que en gran parte de la extensión territorial se siembran diferentes tipos de cultivos, entre los cuales de acuerdo al volumen de producción destacan 7 principalmente los cuales son: Alfalfa verde, maíz grano, avena forrajera en verde, cebada grano, Maíz forrajero en verde, maguey pulquero y naranja. (SIAP, 2020). Sin embargo, existe la necesidad de impulsar la comercialización ya que en ocasiones debido al desconocimiento de dicha productividad no existen proveedores interesados en la adquisición de los diferentes productos lo que genera pérdida, ventas a muy bajo precio e impacta en los ingresos de los agricultores. Debido a la notable necesidad de hacer difusión de los productos que se cultivan en Hidalgo, la creación de este proyecto tiene como principal objetivo crear una herramienta que permita mostrar la producción agrícola del estado de Hidalgo, a través de un sitio web y mapas temáticos. Como resultado se desarrolló un sitio web en donde se podrá consultar la producción por municipio y visualizarlo en mapas temáticos.

**Sitio web, Mapas temáticos, Agricultura**

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## Introduction

The purpose of this work is to develop a tool that serves as a means to consult the production volume of the main crops in Hidalgo State, as well as to show it on the thematic maps of the regions, in order to publish it.

The information that will be displayed on the website is consulted in the statistical data of the Agrifood and Fisheries Information Service SIAP (Servicio de Información Agroalimentaria y Pesquera) for the most recent year 2020.

The article has this structure: Section 2 presents the theoretical foundations. Section 3 describes the methodology. Section 4 shows the development, section 5 the results obtained represented in the thematic maps; and finally, in Section 6 conclusions.

## Theoretical fundament

Starting the development of this research, it is necessary to verify the statistical data of the agricultural production of 2020 of the main crops of Hidalgo State, according to the SIAP the first seven places are the following: Green alfalfa, grain corn, green forage oats, grain barley, green forage corn, maguey pulquero and orange.

Below, the statistical data is presented, which represent the 7 main crops considering the volume of production.

In oder to obtain the amount of total crop production, the Excel file of the most current year (SIAP, 2020) was downloaded and the information was processed, filtering first by state and crop type, below is an example of the information processing.

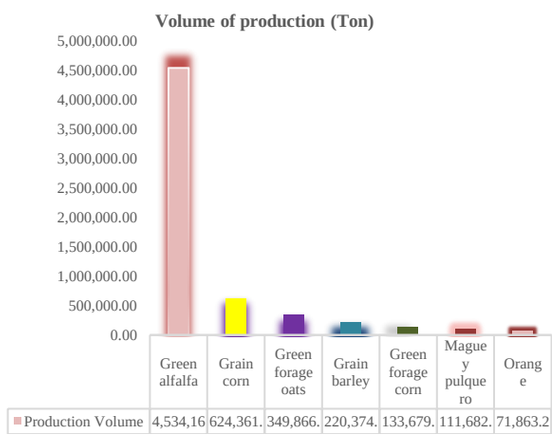
| Year | State ID | State | City | Crop | Production Volume |
|---|---|---|---|---|---|
| 2020 | 13 | Hidalgo | Ixmiquilpan | Green Alfalfa | 740110 |
| 2020 | 13 | Hidalgo | Alfajayucan | Green Alfalfa | 458338 |
| 2020 | 13 | Hidalgo | Mixquiahuala de Juárez | Green Alfalfa | 370220 |
| 2020 | 13 | Hidalgo | Tezontepec de Aldama | Green Alfalfa | 365170 |
| 2020 | 13 | Hidalgo | San Salvador | Green Alfalfa | 354120 |
| 2020 | 13 | Hidalgo | Tasquillo | Green Alfalfa | 264680 |
| 2020 | 13 | Hidalgo | Francisco I. Madero | Green Alfalfa | 261080 |
| 2020 | 13 | Hidalgo | Tula de Allende | Green Alfalfa | 231120 |
| 2020 | 13 | Hidalgo | Actopan | Green Alfalfa | 168896 |
| 2020 | 13 | Hidalgo | Santiago de Anaya | Green Alfalfa | 165528 |
| 2020 | 13 | Hidalgo | Tlaxcoapan | Green Alfalfa | 151410 |
| 2020 | 13 | Hidalgo | Progreso de Obregón | Green Alfalfa | 145808 |
| 2020 | 13 | Hidalgo | Tlahuelilpan | Green Alfalfa | 144560 |
| 2020 | 13 | Hidalgo | Atitalaquia | Green Alfalfa | 120190 |
| 2020 | 13 | Hidalgo | Ajacuba | Green Alfalfa | 106080 |
| 2020 | 13 | Hidalgo | Tecozautla | Green Alfalfa | 72115.3 |
| 2020 | 13 | Hidalgo | Tulancingo de Bravo | Green Alfalfa | 70189.6 |
| 2020 | 13 | Hidalgo | Atotonilco de Tula | Green Alfalfa | 68950 |
| 2020 | 13 | Hidalgo | Tepetitlán | Green Alfalfa | 67550 |

**Table 1** Filter by state and crops of Hidalgo State
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020*

Subsequently, the sum of the production volume column was made for each type of crop existing in Hidalgo State.

| Product | Production Volume |
|---|---|
| Green alfalfa | 4,534,168.82 |
| Grain corn | 624,361.92 |
| Green forage oats | 349,866.54 |
| Grain barley | 220,374.75 |
| Green forage corn | 133,679.04 |
| Maguey pulquero | 111,682.95 |
| Orange | 71,863.28 |

**Table 2** Seven main crops in Hidalgo State, according to the volume of production
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020*




**Graphic 1** Seven main crops in Hidalgo State, according to production volume
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020.*
*http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*

With a view to obtain the value of the total production (Thousands of pesos) of the Huasteca Hidalguense per crop, the sum of the value defined by each city was made.

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## Methodology to be developed

The methodology used for the construction of prototypes is appropriate since tests are applied during the design and development of the site, this allows deciding which is the most appropriate model, how to design the accesses and present operation progress, further it allows deliverables such as progress to be verified visually.

The methodology has the following stages:

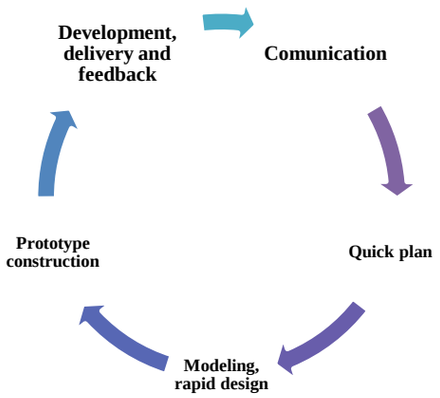


**Figure 1** Prototype construction methodology
*Source: Own elaboration*

a) Quick plan: A preliminary investigation of the problem is carried out and a general idea of the solution is proposed.

b) Modeling, rapid design: System requirements definition, the developer interacts with the user to determine needs.

c) Prototype construction: A technical design is achieved; the interface design is generated.

d) Development, delivery and feedback: Programming and testing, in this stage possible changes in the design are identified and proposed to ensure its correct functionality, this stage is performed as many times as necessary.

e) Communication: Development operation, ensuring that it meets the needs of the final user.

## Development

**Quick plan:** Statistical information collection on the SIAP site.

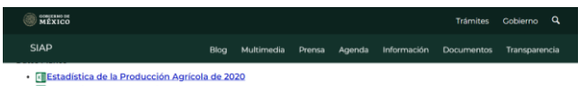


**Figure 2** Statistics of agricultural production for 2020.
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020*
*http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*

Example of the information that is downloaded to extract only the report of Hidalgo State.

| Year | State | City | Crop | Sown | Char vested | Sinister | Production volume |
|---|---|---|---|---|---|---|---|
| 2020 | Aguascalientes | Aguascalientes | Green forage oats | 1175 | 1175 | 0 | 32571 |
| 2020 | Aguascalientes | Aguascalientes | Broccoli | 15 | 15 | 0 | 295.6 |
| 2020 | Aguascalientes | Aguascalientes | Green forage oats | 160 | 160 | 0 | 4352 |
| 2020 | Aguascalientes | Aguascalientes | Broccoli | 20 | 20 | 0 | 306.6 |
| 2020 | Aguascalientes | Aguascalientes | Green chili | 6.48 | 6.48 | 0 | 313.5 |
| 2020 | Aguascalientes | Aguascalientes | Strawberry | 5 | 5 | 0 | 230 |
| 2020 | Aguascalientes | Aguascalientes | Green forage corn | 3000 | 3000 | 0 | 193950 |
| 2020 | Aguascalientes | Aguascalientes | Grain corn | 620 | 620 | 0 | 4675 |
| 2020 | Aguascalientes | Aguascalientes | Green forage sorghum | 147 | 147 | 0 | 8264.34 |
| 2020 | Aguascalientes | Aguascalientes | Red tomato (jitomate) | 18 | 18 | 0 | 2471 |
| 2020 | Aguascalientes | Aguascalientes | Green tomato | 27 | 27 | 0 | 511 |
| 2020 | Aguascalientes | Aguascalientes | Carrot | 3 | 3 | 0 | 85.6 |
| 2020 | Aguascalientes | Aguascalientes | Green forage oats | 235 | 235 | 0 | 1997.5 |
| 2020 | Aguascalientes | Aguascalientes | Bean | 490 | 490 | 0 | 191.1 |
| 2020 | Aguascalientes | Aguascalientes | Green forage corn | 13120 | 13120 | 0 | 136448 |
| 2020 | Aguascalientes | Aguascalientes | Grain corn | 5105 | 5105 | 0 | 2654.6 |
| 2020 | Aguascalientes | Aguascalientes | Green forage sorghum | 120 | 120 | 0 | 1242 |
| 2020 | Aguascalientes | Aguascalientes | Green alfalfa | 1339 | 1339 | 0 | 129900.8 |
| 2020 | Aguascalientes | Aguascalientes | Peach | 12.5 | 10 | 0 | 166.3 |

**Table 3** Statistics of agricultural production for 2020
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020*
*http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*

**Modeling and rapid design:** Analysis and design of the database and interface system.

| Crop | Production volume |
|---|---|
| Green alfalfa | 4,534,168.82 |
| Grain corn | 624,361.92 |
| Green forage oats | 349,866.54 |
| Barley grain | 220,374.75 |
| Green forage corn | 133,679.04 |
| Maguey pulquero | 111,682.95 |
| Orange | 71,863.28 |
| Red Tomato (jitomate) | 53,690.22 |
| zucchini | 32,847.74 |
| Cherry coffee | 31,422.55 |
| Corn | 18,075.70 |
| Cauliflower | 17,533.72 |
| Green tomato | 17,503.48 |
| Bean | 15,414.18 |
| Tuna | 14,483.88 |
| Green chile | 12,266.73 |
| Rose | 7,662.80 |
| Nopal | 6,265.76 |
| Wheat grain | 3,870.25 |
| Avocado | 3,558.15 |
| Cucumber | 3,328.51 |
| Nut | 3,178.34 |
| Apple | 3,073.89 |
| Oatmeal | 2,941.65 |
| Lettuce | 2,388.85 |
| Peach | 2,168.33 |
| Lemon | 1,845.98 |

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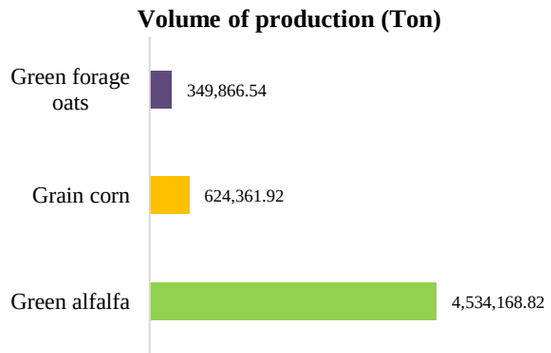
| | |
|---|---|
| Onion | 1,705.26 |
| Grenade | 1,501.36 |
| Zempoalxochitl | 1,217.91 |
| Dried chili | 1,037.00 |
| Garlic | 673.27 |
| Brocoli | 651.20 |
| Mango | 510.08 |
| Potato | 405.20 |
| Grain sorghum | 393.98 |
| Guava | 350.45 |
| Pineapple | 290.60 |
| Tangerine | 250.30 |
| Pear | 202.91 |
| Banana | 56.00 |
| Asparagus | 22.00 |
| Chickpea grain | 16.38 |
| Blackberry | 2.30 |
| **Total** | **6,308,804.21** |

**Table 4** Production volume per crop
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020. http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*




**Graphic 2** Three main crops in Hidalgo State, according to production volume
*Source: Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020. http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*

## Database design

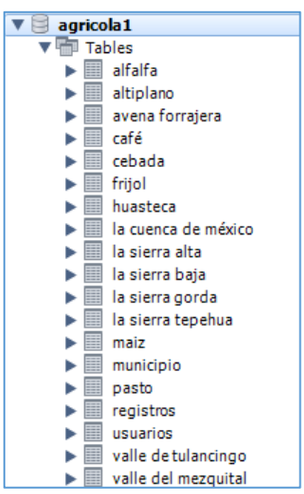



**Figure 3** Database
*Source: Own elaboration*

## Interface, definition of colors


**Figure 4** Interface design
*Source: Own elaboration*

**Prototype construction:** The prototype design was accomplished.

Website landing page

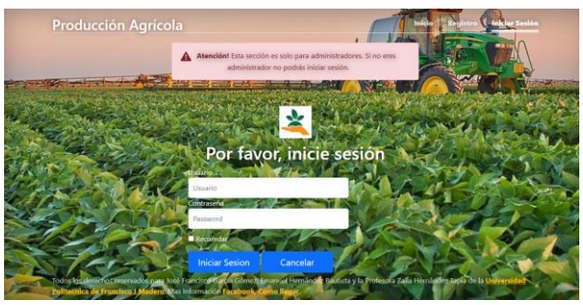



**Figure 5** Login page
*Source: Own elaboration*

It is recommended the register form, for users who wish to access the site, in order to have the number of people interested in the information.

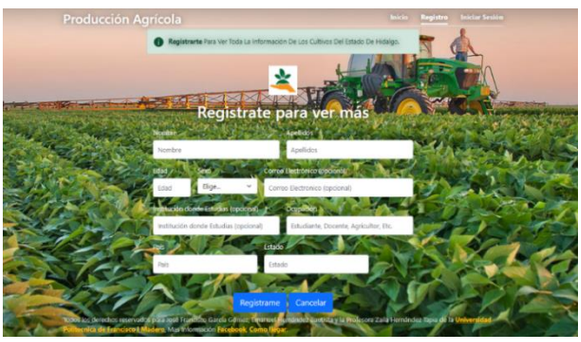



**Figure 6** Registration page
*Source: Own elaboration*

Example of how the query of a crop will be displayed within the website through the thematic map.

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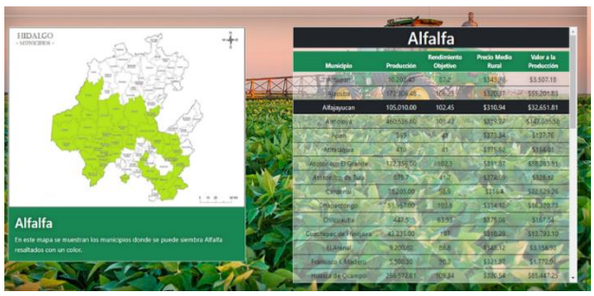


**Figure 7** Alfalfa production
*Source: Design-Own elaboration*
*Source: Data- Servicio de Información Agroalimentaria y Pesquera (SIAP), year 2020*
*http://infosiap.siap.gob.mx/gobmx/datosAbiertos_a.php*

**Development, delivery and feedback:** The functionality of the website and the presentation of the information are verified.

## Results

The website was developed in an effort to show the production volume of the main crops of Hidalgo State, to publicize it.

## Conclusions

Using different tools such as: Xampp, PhpMyAdmin, MySQL Workbench and Atom, the development of the website was possible and it will allow to know the main crops of Hidalgo State, likewise, it will be possible to consult the production volume of each city or region. In future, more information will be attached in the research such as: Sown area, harvested area, rural price average, production value, among other data.

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# Computer security, one more reason to take care of yourself today

# Seguridad informática, una razón más para cuidarse hoy en día

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**Abstract**

The pandemic did not come alone, it came with the increase in cybercrime and the world turned into chaos, because with so many technological changes in the way of carrying out activities, the opportunities for cybercriminals have been increased. Online shopping rose sharply, and they are here to stay even and after this contingency, people realized that this way to go shopping is very simple and its transactions can be easily done by young and even older people. Even these days, incredibly many of the users do not have adequate precautions to maintain the security of each movement, it has even reached high reliability since the devices have generally open sessions, some for purchases, banks, networks social, etc. There are various software packages that in the hands of malicious people, very probably could be useful to access to passwords, images and files from any computer or electronic device, thus leaving the safety of users affected.

**Pandemic, Cybercrime, Computer Forensics, Security**

**Resumen**

La pandemia no llegó sola, llegó con el incremento de delitos informáticos y el mundo se volvió un caos, pues con tantos cambios tecnológicos en la manera de realizar las actividades se han incrementado las oportunidades de los ciberdelincuentes. Las compras en línea se elevaron en gran medida, y llegaron para quedarse aun y después de esta contingencia, las personas se dieron cuenta que esta forma de ir de compras es muy sencilla y además sus transacciones pueden ser realizadas tanto por jóvenes e inclusive por personas mayores. Aun en estos días, increíblemente muchos de los usuarios no tienen las precauciones adecuadas para mantener la seguridad de cada movimiento, se ha llegado incluso a la alta confiablidad desde el momento en que los dispositivos tienen generalmente abiertas las sesiones algunas para compras, bancos, redes sociales, etc. Existen diversos softwares que, en manos de personas mal intencionadas, muy probablemente podrían ser útiles para acceder a contraseñas, imágenes y archivos de cualquier computadora o dispositivo electrónico, quedando así la seguridad de los usuarios afectada.

**Pandemia, Delitos informáticos, informática forense, seguridad**

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## Introduction

With the presence of information technologies in the world, “the intelligent society” has become present, depending on three fundamental technological elements: connectivity, smart devices and software, as well as all the principles associated with sustainable development. (Ngary Njeru, 2017) When we say intelligent society, we are talking about the use of technologies, where society interacts daily with smartphones and computers, used for working, studying, socializing and shopping online.

Based on the increase in work at home, but especially the use of the internet as a consequence of the physical isolation measures imposed by the coronavirus pandemic, the digital vulnerabilities of professionals and individuals increased and revealed.

With the emergence of the telephone, during the 1960s, different computer programmers or systems specialists tried to boycott government financing of the Vietnam War through the free use of the service.

The phreakers (neologism from the English words: "freak", of rarity; "phone", of telephone; and "free", free) used blue boxes or blue boxes that reproduced ringtones similar to those used by the Bell Corporation, and the ATT established free long distance communications. The first misconduct or illegal conduct related to computers began to be reflected during the 70s, from some resounding cases portrayed by period newspapers.

The first computer crimes were of an economic nature, among which computer espionage, software “piracy”, sabotage of digitized databases and extortion stood out. In relation to espionage, these were carried out by removing hard drives from computers, stealing floppy disks or direct copying of information from devices, as well as the absorption of electromagnetic emissions that every computer radiates for capture. of data.

The espionage was commercial or industrial, as it is often called, its main objectives being computer programs, research data in the defense area, accounting information of companies and the address book of corporate clients.

Cases of computer sabotage and extortion, which means deleting, suppressing or modifying without authorization computer functions or data with the intention of obstructing the normal functioning of the system, were the crimes that most concerned organizations due to the high concentration of data stored in format digital. (ERREIUS, 2018) Before like today, when a cyber attack of any kind is suffered, it is necessary to gather the necessary information to determine the damage suffered, its consequences, try to reach the source and discover who is responsible. This work corresponds to computer forensics, which has seen a significant increase, with the automation of processes and the rise of the internet of things applied to vehicles, homes and others.

Overall, eight out of ten social media users are concerned about advertisers and businesses accessing the data they share on social media platforms. However, they use video calling platforms and applications on a daily basis that barely meet minimum standards or reasonable security practices, leaving them open to spying or cyberattacks. (Jara, 2020).

*Computer forensics*

This is responsible for acquiring, preserving and protecting data processed electronically and stored on a physical medium. Information systems are periodically investigated to detect any small vulnerabilities that could endanger the enormous amount of data that is processed and stored every second. (Technology, 2020)

Computer forensics is characterized by its preventive approach, so that through various techniques, it proves that the security systems implemented are adequate. In addition, it is also in charge of developing security policies and defining which systems are suitable for each case.

Computer forensics is an indispensable science for all companies, as it ensures that the confidential information and data of everyone who interacts with the company is properly protected and out of the reach of network criminals. (Secron, 2018).

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**Developing**

During the first half of 2020, there were 450 security threats per minute around the world. (Anton, 2021)

To support the clarification and prevention of these computer crimes, forensic computer science arises, which with its phases allows us to decipher:

*ID*

It refers to the collection of information necessary to work on the data source presented by the server administrator (forensic request).

*Preservation and Acquisition of the Elements*

To ensure that both the processes and the tools to be used are the most suitable, it must have suitable personnel who can be assigned to lead the forensic process, for this the security team must be trained and thoroughly understand the methodology.

*Identify the evidence*

It is important to identify the evidence presented at our "crime" scene, which will be subject to all the necessary processes for the presentation of final results, the evidence will be classified according to the type of device and storage mode.

*Investigation of Acquired Items*

At this stage, the following is analyzed: What happened? For what purpose did it enter? and Can you detect who has been responsible?

*Documentation and presentation of evidence*

It consists of documenting the investigation and presenting the results

**Computer forensics tools**

Almost every day we find that there are leaks of private or company data to the Internet, either due to a bad network configuration and computer systems, or because a cybercriminal has managed to circumvent the security measures implemented and has done with a lot of information that has subsequently ended up on the internet.

There are free tools for computer forensics useful for when a security incident occurs to be able to identify: Where did it come from? What has happened? And how to act so that it never happens again?

*Autopsy and The Sleuth Kit*

The Autopsy tool is one of the most used and recommended, it allows you to locate many of the open source programs and plugins, it is like a Unix library and Windows-based utilities, which greatly facilitates the forensic analysis of computer systems.

Autopsy is a graphical user interface that displays forensic search results. This tool is widely used by the police, the military and companies when they want to investigate what has happened to a computer.

One of the most interesting aspects is that it is extensible, this means that users can add new plugins easily and quickly. It incorporates some tools by default such as PhotoRec to recover files, and it even allows extracting EXIF information from images and videos.

As for The Sleuth Kit, it is a collection of online command tools for investigating and analyzing the volume and file systems used in digital forensic investigations. With its modular design, the correct data and evidence can be obtained. Also, it is compatible and works on Linux and runs on Windows and Unix platforms. (Cortez Castilla, 2017)

*Name Search Tool Analysis*

The File Name Search module can be used to perform a basic search by entering a search string and a location. For example, the search for "file" will match "file.txt", "test.file", or "MyFile.doc"; even to perform more advanced searches which can be selected from the preset options to quickly locate certain types of files, some examples of preset searches are the following:

- Images + Face-detect Al
- Images + Ilicit-detect Al
- Photo taken with iPhone

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- Office Documents
- Video Files
- E-mail Files
- Virtual Machine Files, among others.

We will define the first two in more detail:

Images + Face-detect

When trying to locate all images in a system or directory that contains faces; results are displayed and highlighted in green based on a percentage score.

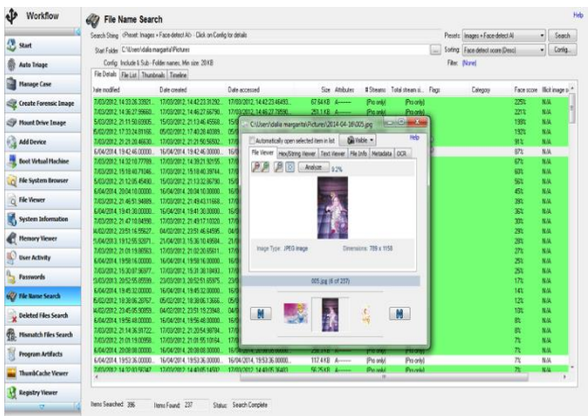

**Figure 1** Image Face-Detect

*Images + Ilicit-detect*

This feature tries to locate any image that contains nudity or pornography; results are displayed and highlighted in red based on a percentage score.

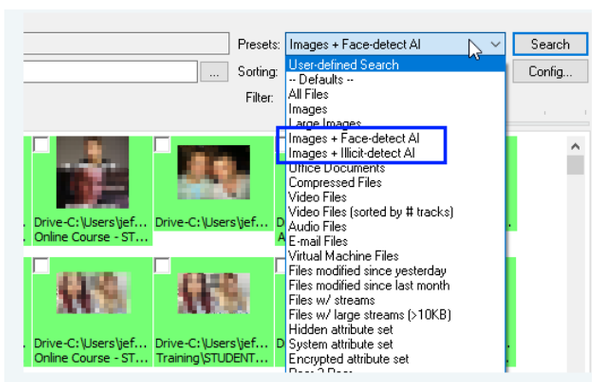


**Figure 2** Image Ilicit-Detect

*User Activity*

The User Activity module scans the system for evidence of recent activity, such as accessed websites, USB drives, wireless networks, recent downloads, website logins, and website passwords. This is especially useful for identifying user trends and patterns, and any recently accessed materials or accounts.

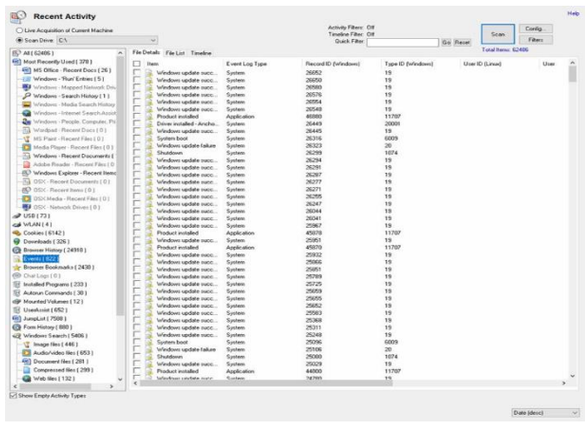

**Figure 3** User Activity

Next, we will see some information that this scan would show us:

Web browser activity

Shows users' web browser activity such as browsing history, cookies, and stored user names from web browsers. The following table shows what items can be retrieved from commonly used web browsers using this module.

Connected USB devices

Displays the details of the USB devices that have recently been connected to the computer, providing information about the last connection date and device information such as the manufacturer's name, product identification, and serial number.

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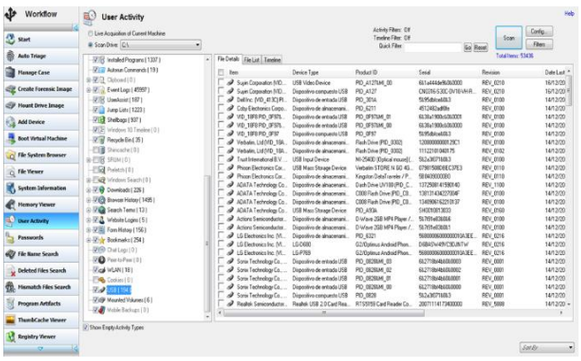

**Figure 4** USB devices that have been connected

*Wireless network connections*

Lists the WIFI access points that the machine has connected to in the past, including the date and time it was accessed.

Downloads: shows all document or file downloads made by users.

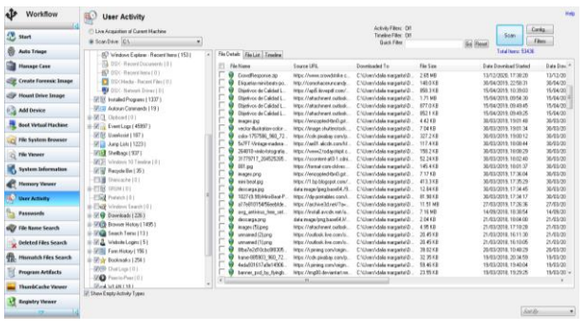

**Figure 5** Used wireless network connections

*Event log*

Scans Windows logs for system activity, such as the following events:

- Security log events, such as account login attempts, logoffs, and password changes.
- System log events such as Windows update attempts, system boot / shutdown, and driver installations.
- Application log events, such as application installation attempts.

*Password*

Recovers passwords and product keys that have been stored by various applications and web browsers on the system.

**Figure 6** Recovers stored passwords and keys

## Recommendations

- It is recommended to use passwords that are not so easy to deduce, in addition to including second levels of authentication or two-step verification, which would make it more difficult to violate the entry.
- Avoid using the same password in several applications, such as accessing email, banking applications, social networks, and any other internet resource that requires some validation to enter with the same password.
- You should also think about having a secure connection and trying to avoid public wireless networks, since anyone can access our data if the connection is not encrypted and most who connect do so for convenience without thinking about what this is. may cause.
- Having antivirus, protection with updated equipment, will allow greater security.
- Do not open emails or files that come from unknown or unexpected senders.
- Keep all types of connections disabled when not in use, for example "Bluetooth".
- Do not install unknown programs.
- Use all the filters and security services offered by the different Internet tools and systems.

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## Conclusion

In order to have a broader information on what society lives in a matter of cybercrimes, an instrument of 5 questions was developed, giving the following results:

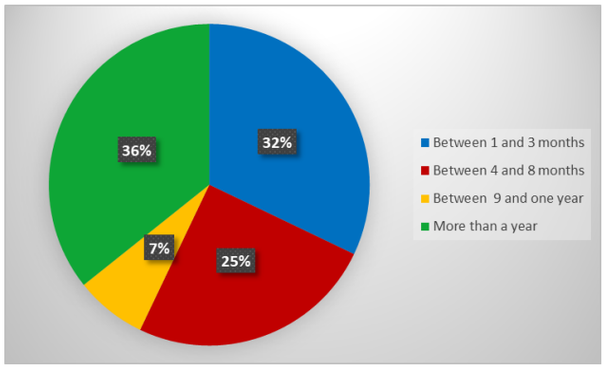


**Figure 7** When was the last time you changed your password?

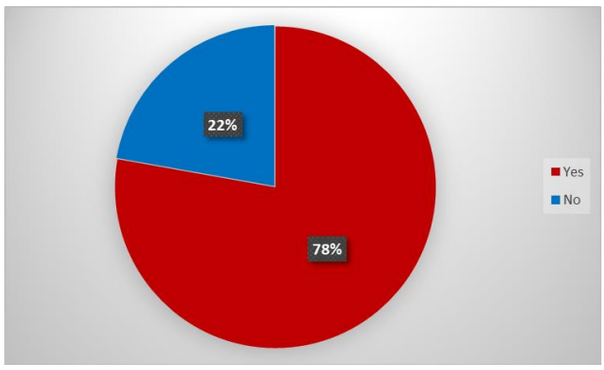


**Figure 8** Do you know what to do in case of a computer crime?

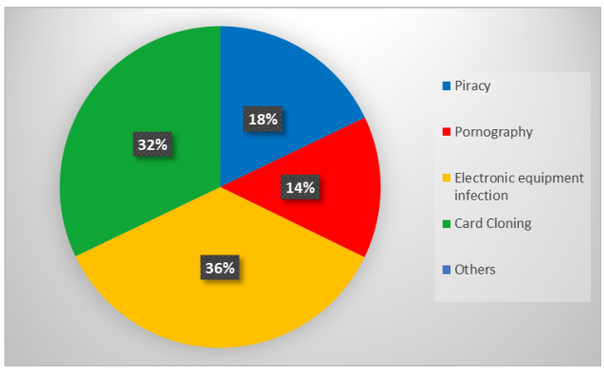


**Figure 9** What do you consider to be the most common computer crime?

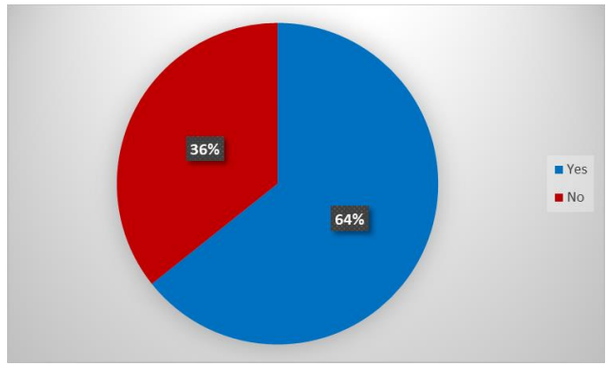


**Figure 10** Do you know what a computer crime is?

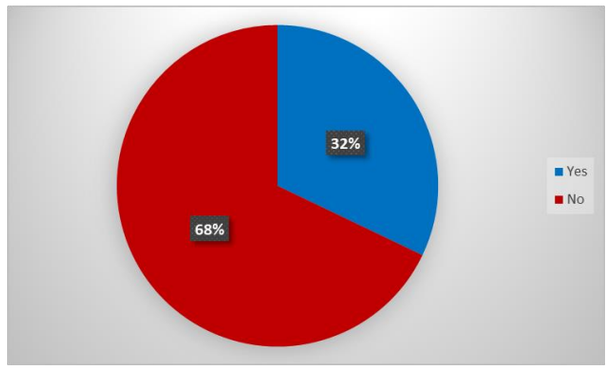


**Figure 11** Have you been a victim of cybercrime?

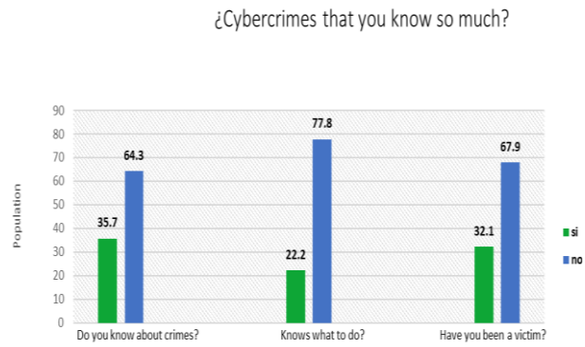


**Figure 12** How much does society know about cybercrime?

Based on the results obtained from the survey, it is presented that the majority do not know about the subject, but nevertheless they will not know what to do in the event of a cybercrime.

Likewise, it is shown that a third part of society has been a victim.

Therefore, it is concluded that it is important to keep your devices and computer equipment safe to prevent them from being victims of a cybercriminal.

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And if it is about companies, as a preventive measure to detect any vulnerability in it; it is highly recommended to constantly use computer forensic software such as OSForensics since it helps to carry out the case from the beginning, the creation of images and clones of the units to be investigated, the analysis and incorporation of evidence, protection of evidence with hash code, creation automatic log of the investigation carried out and final report.

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# Systematic review of scrum harmonization and software process models

# Revisión sistemática de la armonización de scrum con los modelos de procesos de software

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**Abstract**

Agile methodologies such as Scrum are being used in most of the current projects, due to their flexibility and speed in the processes and because it offers a great increase in productivity, quality and efficiency, as well as promotes teamwork.

However, in different situations companies need more than one model to improve their competitiveness in the software development industry and achieve the organization's goals, so many organizations that implement a software process model seek to harmonize them with agile methodologies such as scrum.

This paper, through the methodology known as systematic review, analyzes multiple studies from national and international sources in order to provide a broad overview of the harmonization of scrum with software process models and identify strengths, weaknesses and areas of opportunity in order to contribute to the improvement of software processes for future research.

**Scrum, Process Model, Software Engineering**

**Resumen**

Las metodologías ágiles como Scrum están siendo empleadas en gran parte de los proyectos actuales, esto debido a su flexibilidad y rapidez en los procesos y porque nos ofrece un gran aumento en productividad, calidad y eficiencia, así como también promueve el trabajo en equipo.

Sin embargo, en distintas situaciones las empresas necesitan más de un modelo para mejorar su competitividad en la industria de desarrollo de software y lograr los objetivos de la organización, por ello que muchas organizaciones que implementan algún modelo de procesos de software buscan armonizarlos con metodologías ágiles como scrum.

El presente trabajo, a través de la metodología conocida como revisión sistemática, se analizan múltiples estudios de fuentes nacionales e internacionales con la finalidad ofrecer un amplio panorama sobre la armonización de scrum con los modelos de procesos de software e identificar fortalezas, debilidades y áreas de oportunidad con el fin de contribuir a la mejora de los procesos de software para futuras investigaciones.

**Scrum, Modelo de Procesos, Ingeniería de Software**

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## Introduction

Scrum is one of the most popular agile methodologies for software development project management. It is based on the definition of the rules for the joint use of the elements listed below:

Three roles: Product Owner, Developers and Scrum Master.

Three artifacts: Product Backlog, Sprint Backlog, and Increment.

Five events: Sprint, Sprint Planning, Daily Scrum, Sprint Review, and Sprint Retrospective.

The importance of process models in the software industry lies, as described by Oud (2005), in the capacity they have to improve the competitiveness of organizations, fundamentally with an abstract description of the activities for which the software is developed. Providing benefits when evaluating and institutionalizing new or improved processes, becoming more competitive and producing high quality products.

On the other hand, software development organizations face the challenge of needing more than one model to support and achieve the strategic objectives of the organization, seeking the resolution of structural differences, terminology or homogenization, comparing elements and combining or integrating the practices agile with reference models. (O. Salo and P. Abrahamsson, 2005)

However, there is a lack of proposals to harmonization problems between different standards, models and methodologies, so it is not an easy task for organizations to carry out the implementation and management of the different events that must be considered to harmonize more than two approaches or models as references for the improvement of software processes. (C. Jesús and P. Calvache, 2012)

According to various studies in the last 5 years the software engineering community has shown increasing interest in harmonizing multiple models. (Pardo, 2012)

In the software development industry, various models and standards have been implemented that serve as a reference for different objectives and needs (De la Villa et al, 2004).

The software process is made up of several activities focused on the creation of a software product, essentially: Specification, Design and implementation, validation and evolution. (Sommerville, 2009)

Wang (2008) defines it as a set of sequential practices that are functionally coherent, repeatable and reusable for the organization, development and administration of software engineering.

According to Sommerville (2009) a software process model is a simple definition of a software process that presents a vision of that process.

Four software process models are usually presented: Cascade development, step-by-step refinement, incremental development and releases, military and industrial standards, and capacity models. (Buede, 2011)

The main agile methodologies most used in the software development industry are: Agile Modeling, Extreme Programming, Pragmatic Programming and Scrum (Abrahamsson et al., 2002)

Scrum provides a framework for project management, while the other methodologies mentioned above focus on describing practices, activities, and work product techniques related to software development. (Pino et al. ,, 2010)

Because Scrum is a methodology in which several processes and techniques can be used and it is not a process or a technique to create products (Schwaber & Sutherland, 2020) and also has the ability to complement other existing methods and processes (From the new et al., 2011) allows harmonization with various process models.

In order to obtain better quality in software development companies, the need arises to make compatible the use of Agile Scrum-type methodologies and good practice standards. (Pasini et al ,. 2013)

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However, the effort that is needed to implement the models can be unfavorable for companies since there is a difficulty in relating them to the business need. (Suárez & León, 2019)

Two approaches assiduously used in companies for the use of software process models are presented, the conventional approach that uses reference models, such as CMMI-DEV v1.2 and MoProSoft, and the agile approach that uses agile methodologies, such as Extreme Programming (XP, Extreme Programming) and Scrum. (Garcia, 2014)

Using the systematic review, it will be possible to identify, evaluate, interpret and synthesize a set of existing and relevant research in order to know the trends of the research carried out on the harmonization of scrum with the software process models. The results obtained will allow us to provide a broad overview of the main aspects involved, strengths, weaknesses and areas of opportunity in order to contribute to the improvement of future research software processes. (Biolchini et al., 2005)

This work is organized in such a way that the methodology to develop the systematic review of the harmonization of scrum with the software process models is presented, describing the application of the systematic review protocol, the extraction of the information and the summary of the results.

**Methodology to be developed**

The systematic review (SR) according to Biolchini et al. (2005) "is used to refer to a specific research methodology, developed in order to collect and evaluate the available evidence pertaining to a focused topic" which is detailed below:

A. Protocol development: rigorous and iterative phase. Covers the general plan for the systematic review of the literature.

    1. Question formulation: section where important research questions that must be answered during the SR are identified. In this section the objectives of the investigation should be clearly defined.

    2. Identification and selection of sources: section whose objective is to identify and select the sources where the search for primary studies will be carried out. It is made up of the following sections: definition of the criteria for the selection of sources, language of the studies, identification of sources, selection of sources after evaluation, verification of sources.

    3. Selection of studies: section that aims to identify primary and secondary studies. Studies are selected after application of the inclusion and exclusion criteria.

B. Information extraction: phase in which the search for studies is carried out in the defined sources, the studies found are evaluated with the defined criteria.

    1. Definition of the information inclusion criteria (ICinf) and information exclusion (ECinf), which aims to define the criteria with which the information will be evaluated.

    2. Templates for information extraction: section that aims to register the primary studies derived from the selection process.

    3. Execution of the extraction: section in which the evaluation of the studies is carried out using the defined criteria.

**Systematic review of the harmonization of Scrum with the Software Process Models**

**A. Development of the Protocol**

**Formulation of the question**

**a) Focus of the question**

Many organizations that implement a software process model seek to harmonize them with agile methodologies such as scrum, through this research process models that have enough methods to achieve complete harmonization with scrum and those that lack it will be identified.

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**b) Breadth and quality of the question.**

**(1) Problem**

Companies need more than one model to improve their competitiveness in the software development industry and achieve the objectives of the organization.

It is essential to identify process models that do not yet have sufficient methods to achieve full alignment with Scrum or that lack it.

**(2) Question**

What are the process models that have or lack sufficient harmonization methods with Scrum?

**(3) Keywords and synonyms**

**The following definitions were used:**

Process Model, Scrum, Process Improvement, Harmonization, Implementation, Integration, Fusion, Adaptation, Process Reference Model, Software Engineering, Process Model, Process Improvement, Harmonization, Implementation, Fusion, Adaptation, Integration, Process Reference Model Software Engineering.

**(4) Intervention**

Aspects involved in software process models and their ability to harmonize with scrum.

**(5) Effect**

Studies that allow identifying the main trends in the harmonization of software and scrum process models.

**(6) Population**

Publications related to the harmonization of software and scrum process models, experiences, use cases and lessons learned.

**(7) Application**

Organizations dedicated to the software industry.

**Selection and identification of sources**

**a) Definition of source selection criteria:**

– Keyword search mechanisms.

– Posts suggested by other authors.

– Publications available on websites.

**b) Language of studies:**

– Spanish.

– English.

**c) Identification of sources**

**(1) Source search methods**

The systematic review has been carried out using web search engines.

**(2) Search strings**

Logical connectors “AND”, “OR” and “NOT” were used in combination with the list of keywords identified in both Spanish (Table 1) and English (Table 2) and general basic search strings were obtained.

| Keywords with logical operators |
|---|
| (“Process Model” OR “Process Improvement”) AND (“Harmonization” OR “Combination” OR “Integration”) AND (“Scrum”) |

**Table 1** Search string in Spanish
*Source: Own elaboration*

| Keywords with logical operators in English |
|---|
| (“Process Models” OR “Process Improvement”) AND (“Harmonization” OR “Combination” OR “Integration”) AND ("Scrum") |

**Table 2** Search string in English
*Source: Own elaboration*

**(3) List of sources**

– DIALNET.

– Google Scholar.

– SciELO.

– Redalyc.

– Research Gate.

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**d) Source selection after criteria evaluation.**

A verification of the sources was carried out and they conform to the previously defined criteria, and the list of sources was established, shown in Table 4.

| Number | Sources |
|---|---|
| 1 | DIALNET |
| 2 | Google Scholar |
| 3 | SciELO |
| 4 | Redalyc |
| 5 | Research Gate |

**Table 3** Sources used
*Source: Own elaboration*

**Verification of sources**

All sources were verified and approved.

**Selection of studies**

**a) Definition of studies**

**(1) Definition of inclusion criteria (IC) of studies and exclusion (CE) of studies.**

Four studies (CI) and two study exclusion criteria (CE) were identified, as shown in Table 5.

| Criterion | Description |
|---|---|
| CI1 | Includes publications whose titles are related to Scrum and Software Process Models. |
| CI2 | Includes posts that contain keywords that match those defined in the search string. |
| CI3 | Includes publications whose abstract is related to the selected topic. |
| CI4 | Includes posts that have been partially or fully read. |
| CE1 | Exclude publications that do not match the previous inclusion criteria. |
| CE2 | Exclude all duplicate posts. |
| CE3 | It excludes all publications that comprise other agile methodologies in harmonization. |

**Table 4** Inclusion and exclusion criteria
*Source: Own elaboration*

**(2) Definition of types of studies:**

Studies related to the harmonization of Scrum and Software Process Models in organizations from various countries were analyzed.

**(3) Procedure for selecting studies:**

The criteria considered were: the title of the publication, the summary of each one and in some cases it was required to review the complete content.

**b) Execution of the selection:**

The searches were carried out, adapting the chains to the engines of each search engine, to determine the quality of the studies, the inclusion and exclusion criteria were applied.

**B. Information Extraction.**

**1.Definition of the criteria for inclusion of information (CIinf) and exclusion of information (CEinf).**

Two information inclusion criteria (CIinf) and one exclusion (CEinf) were identified. Table 6 shows a description of these criteria.

| Criterion | Description |
|---|---|
| CI1inf | Collect information on the harmonization of Scrum and Software Process Models. |
| CI2inf | Identify the main trends in the harmonization of software and scrum process models |
| CE1inf | Exclude information that is not related to the inclusion criteria defined above |

**Table 5** Information inclusion and exclusion criteria
*Source: Own elaboration*

**2.- Templates for Information Extraction.**

To record the identification data of the study, the template detailed below was implemented.

| | |
|---|---|
| **Qualification** | |
| **Year** | |
| **Authors** | |
| **Summary** | |

**Table 6** Information extraction
*Source: Own elaboration*

**3.- Execution of Extraction**

The records obtained were placed in the templates for the extraction of the information. The evaluation was carried out through observations of the main ideas, using the information inclusion and exclusion criteria.

The information of the primary publications was stored in the templates as shown in tables 8, 9 and 10.

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| | |
|---|---|
| **Title** | Implementation of ISO / IEC 15504 and ISO / IEC 12207 with agile methods and SCRUM |
| **Year** | 2019 |
| **Authors** | García, M & Garzás J. |
| **Abstract** | A study is presented on the degree of coverage between the processes of ISO / IEC 15504 - ISO / IEC 12207: 2008 and SCRUM. |

**Table 7** Example of information extraction
*Source: Own elaboration*

| | |
|---|---|
| **Title** | Systematic Mapping of the Harmonization of SCRUM and ISO 9001. |
| **Year** | 2021 |
| **Authors** | Burbano-Delgado, D. L., Pardo-Calvache, C. J., & Orozco-Garcés, C. E. |
| **Abstract** | It presents a systematic mapping in order to identify related studies between Scrum and ISO 9001. |

**Table 8** Example of information extraction
*Source: Own elaboration*

| | |
|---|---|
| **Title** | Integration of frameworks for software development: Scrum, PSP and ISO 25000. |
| **Year** | 2015. |
| **Authors** | Barrera, J. A. H. |
| **Abstract** | A study that contains the definition of a software development process in an SME through the integration of various frameworks (Scrum, PSP and ISO 25000). |

**Table 9** Example of information extraction
*Source: Own elaboration*

## C. Summary of Results

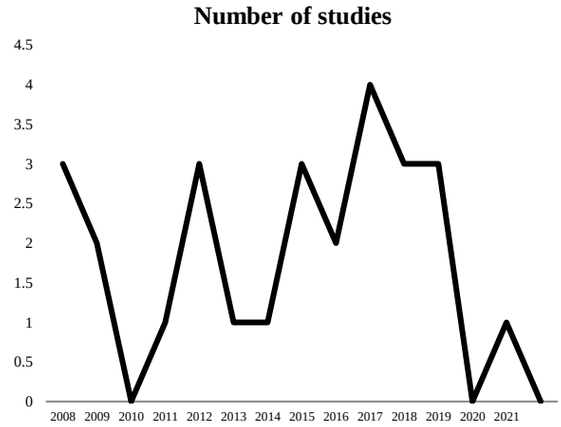
### Results

A statistical analysis was carried out on the specific studies to which the information extraction was applied, analyzing different perspectives, among them: Study trends covering publications by year, models used, type of research carried out, countries and languages of the studies.

### 1.- Study trend

### Publications per year

In graph 1 it can be seen that between 2017 and 2019 were the years that more studies were published related to a harmonization of Scrum with other models. Being in 2017 the year with the highest amount and the years 2010 and 2020 in which no related studies were found.




**Graphic 1** Studies related to the harmonisation of Scrum and other models, published by year
*Source: Own elaboration*

### Models used

It is important to highlight the different models in the studies involved in the harmonisation with Scrum, as shown in Table 10 and Graphic 2, the most used models in the harmonisation with Scrum are CMMI (54.55%) and ISO/IEC 15504 (9.09%), followed by ISO 9001, ISO/IEC 12207 and MOPROSOFT with 6.06% in each model. ISO/IEC 29110, ISO 25000, ISO 9000, COMPETISOFT, PSP and TMMI with 3.03% each.

| Model | Total | Percentage |
|---|---|---|
| CMMI | 18 | 54.55% |
| ISO/IEC 15504 | 3 | 9.09% |
| ISO 9001 | 2 | 6.06% |
| ISO/IEC 12207 | 2 | 6.06% |
| MOPROSOFT | 2 | 6.06% |
| ISO/IEC 29110 | 1 | 3.03% |
| ISO 25000 | 1 | 3.03% |
| ISO 9000 | 1 | 3.03% |
| COMPETISOFT | 1 | 3.03% |
| PSP | 1 | 3.03% |
| TMMI | 1 | 3.03% |

**Table 10** Models used in harmonization with scrum
*Source: Own elaboration*

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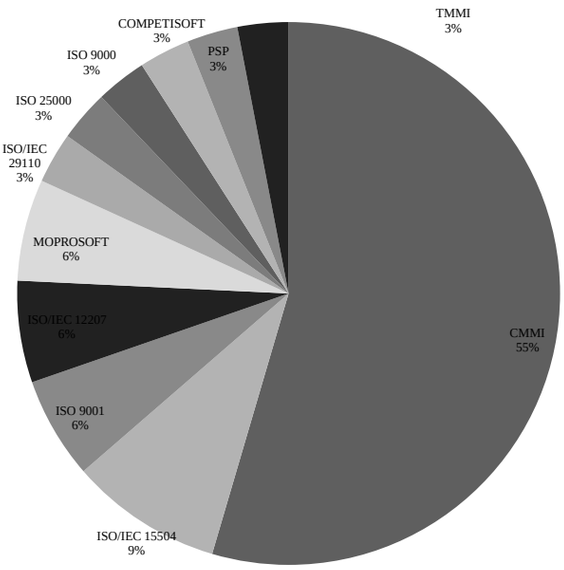


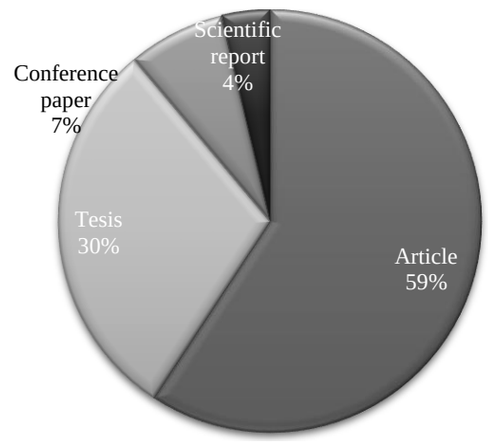

**Graphic 2** Percentage of models used
*Source: Own elaboration*

## Types of studies carried out.

The studies found come from different types of research (Table 11) such as articles, thesis, conference papers, and scientific reports. Graphic 3 shows the percentages of the types of studies found.

| Type of study | Number |
|---|---|
| Article | 16 |
| Thesis | 8 |
| Conference paper | 2 |
| Scientific report | 1 |

**Table 11** Types of studies carried out
*Source: Own elaboration*




**Graphic 3** Percentage of types of studies carried out
*Source: Own elaboration*

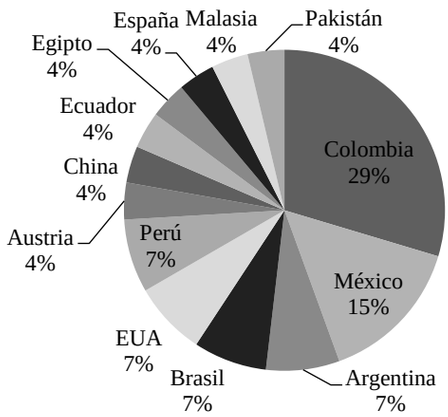
## Study countries

In the analysis of the publishing countries, the countries where the research of the selected studies was carried out was identified.

Table 12 shows the number of studies carried out by country. Similarly, Graphic 4 shows the percentage of studies in each country. The country with the highest number of studies is Colombia (29.6%), followed by Mexico (14.8%), Argentina, Brazil, USA, Peru with 7.4% each and Austria, China, Ecuador, Egypt, Spain, Malaysia and Pakistan.

| Country | Number of studies |
|---|---|
| Colombia | 8 |
| Mexico | 4 |
| Argentina | 2 |
| Brazil | 2 |
| USA | 2 |
| Peru | 2 |
| Austria | 1 |
| China | 1 |
| Ecuador | 1 |
| Egypt | 1 |
| Spain | 1 |
| Malaysia | 1 |
| Pakistan | 1 |

**Table 12** Countries where the studies have been carried out
*Source: Own elaboration*




**Graphic 4** Percentage of countries in the studies carried out
*Source: Own elaboration*

## Languages of the studies carried out.

Most of the studies found with the search strings were in the Spanish language (Table 13). with 55.6% while in English 44.4% (Graphic 5).

| Idiom | Number of studies |
|---|---|
| Spanish | 15 |
| English | 12 |

**Table 13** Languages of studies carried out
*Source: Own elaboration*

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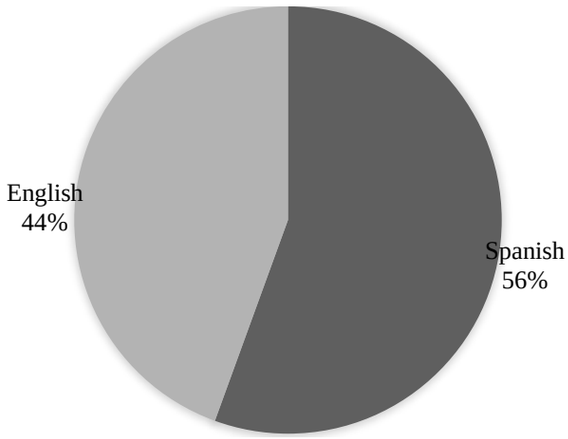


**Graphic 5** Percentage of languages of the studies carried out
*Source: Own elaboration*

**Acknowledgments**

The authors thank the Autonomous University of Campeche and the International Ibero-American University for the facilities granted to carry out and disseminate this work.

**Conclusions**

The studies found were published between 2008 and 2019. With 2017 being the year in which more studies were published. In 2010 and 2020, no related studies were found. The most used model is the CMMI (54.55%) and ISO / IEC 15504 (9.09%)

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# Detection of the R wave using analogue multiplier

# Detección de la onda R empleando multiplicador analógico

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**Abstract**

In the present work, a novel methodology is proposed for the detection of the R wave of the electrocardiogram (ECG) making use of the analog multiplier AD633 and function in the methodology of the detection algorithm of the Pan-Tompkins R wave. With the proposed methodology, different ECG leads were simulated, achieving favorable results in respect of the R wave detection. The circuits present in this work were simulated in Proteus. The contribution of this work is to design a novel way to perform R wave detection with analog elements.

**Resumen**

En el presente trabajo se propone una innovadora metodología para la detección de la onda R del electrocardiograma (ECG) haciendo uso del multiplicador analógico AD633 basándose en la metodología del algoritmo de detección de la onda R Pan-Tompkins. Con la metodología propuesta, se simularon diferentes derivaciones del ECG logrando resultados favorables en la detección de la onda R. Los circuitos presentes en este trabajo fueron simulados en Proteus. La contribución de este trabajo es diseñar una novedosa forma de realizar la detección de la onda R con elementos analógicos.

**Analog multiplier, R wave, electrocardiogram**

**Multiplicador Analógico, Onda R, electrocardiograma**

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## Introduction

An electrocardiogram (ECG) is a test in charge of recording the electrical signals of the heart; It is used to detect heart problems and evaluate the health of the heart.

The electrical activity is recorded from the patient's body surface and is drawn on a paper by means of a graphic representation, where different waves are observed that represent the electrical stimuli of the atria and ventricles. The medical equipment with which the electrocardiogram is obtained is called an electrocardiograph.


**Figure 1** Lead II electrocardiogram showing premature ventricular contraction (PVC).
*Source: https://es.dreamstime.com/ image213247971*

For the acquisition of electrical activity by the electrocardiograph, electrodes placed on the patient's skin are needed. These electrodes will be attached to the electrocardiograph by cables. With 10 electrodes, 12 leads are obtained.

This results in 12 traces of the heart's electrical impulses from different points in the body. There is the possibility of adding extra leads by adding more electrodes to the body surface, however, the basic electrocardiogram consists of a minimum of 12 leads.

The electrocardiogram of a healthy person has a characteristic tracing. Due to this very particular morphology of the signal, there are changes in said tracing and the specialist can determine if there is a problem with the heart.

The ECG is useful for measuring the heart rhythm, the size and position of the atria and ventricles, any damage to the heart, and the effects that certain drugs or devices implanted on the heart may have.

The alterations shown in the trace are essential for the detection and analysis of cardiac arrhythmias. It is very useful in acute episodes of coronary disease, such as myocardial infarction.

It is a simple, available, fast test that does not cause any discomfort and there is no risk for the patient since no type of current is sent, it only detects the electrical activity that is generated in the heart itself.

## ECG waves

(My EKG, 2021)

The electrocardiogram records the electrical activity of the heart in line tracings on paper. The peaks and valleys traced are called waves.

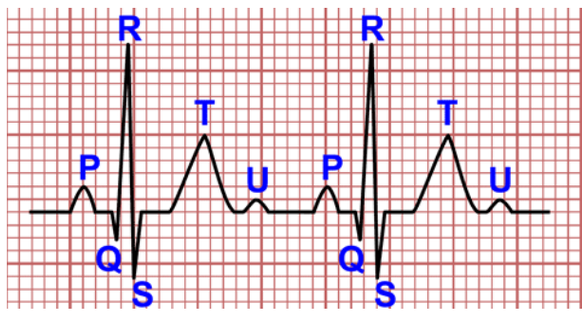


**Figure 2** ECG waves. P, Q, S, R and T, different types of waves that the electrocardiogram produces
*Source: MyEKG.com*

The P wave is the first wave of the cardiac cycle, it records electrical activity through the atria (upper chambers of the heart). It is composed of the superposition of the electrical activity of both atria. The initial part corresponds to the depolarization of the right atrium and its final part to that of the left atrium

The T wave represents the moment when the lower chambers of the heart are electrically restored and ready for the next muscle contraction.

The U wave is positive of low amplitude, it appears immediately behind the T wave. It signifies the repolarization of the papillary muscles in precordial leads.

## QRS complex

Group of waves that result from the depolarization of the ventricles. Its duration ranges from 0.06 s to 0.10 s. Depending on the derivation, it takes different morphologies.

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Q wave: Represents the first wave of the QRS complex and is negative.

R wave: it is the first positive wave of the QRS complex, sometimes preceded by a negative wave (Q wave). If there is another positive wave in the QRS complex, it is called R '.

S wave: it is the negative wave that appears after the R wave.

QS wave: when a complex is completely negative, without the presence of a positive wave, it is called a QS complex. It is usually a sign of necrosis.

R 'and S' waves: when there is more than one R wave or more than one S wave, they are called R 'and S'.

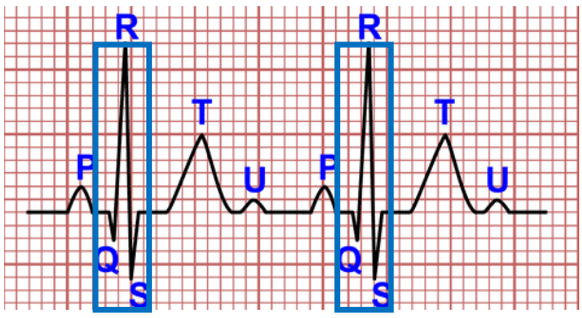


**Figure 3** ECG signal where the QRS complex stands out
*Source: MyEKG.com*

**Analog multipliers**
(Cancino de Greiff, 2021)

An analog multiplier is a circuit with 2 inputs, which generates a voltage output (V) represented by the following formula.

$$v_o = kv_x v_y \quad (1)$$

Where:

$v_o$ is the exit $[V]$

$v_x, v_y$ they are entrance $[V]$

$k$ is a constant with $[V^{-1}]$

The polarity of the multiplier inputs are classified as:

- Four-quadrant multiplier: Both inputs can be bipolar.
- Two-quadrant multiplier: One input is unipolar and the other bipolar.
- One-quadrant multiplier: The two inputs are unipolar.

The characteristics of a multiplier are described in terms of its precision and its linearity.

- The precision of a multiplier represents the maximum deviation of the ideal multiplier output from the ideal transfer function.
- The linearity of a multiplier is measured as the maximum output deviation, relative to the line that best approximates the multiplier output curve with respect to one of the inputs, when the other is kept constant at its maximum value.

To process these analog signals, the circuit is often required to take two analog inputs to produce an output proportional to that of your product. When multiplying these two analog signals, the following elements that make up these signals must be taken into account:

1. The magnitude, 2. The frequency and 3. The phase.

An integrated circuit capable of performing the aforementioned operation is the AD633.

**AD633**
(CALDAS, 2021)

The AD633 is an analog signal multiplier integrated circuit, capable of performing operations in all 4 quadrants, with a 1 MHz bandwidth. It does not require external components and extensive calibration, with an error of 2% at full scale. Generate 0V with a buried Zener (Texas Instruments, 2015).

The following expression represents the output:

$$\boxed{W = \frac{(X1-X2)(Y1-Y2)}{10\,V} + Z} \quad (2)$$

Where:

$W$ is the output of AD633

$X1, X2, Y1, Y2$ are input signals

$Z$ is the OFFSET voltage

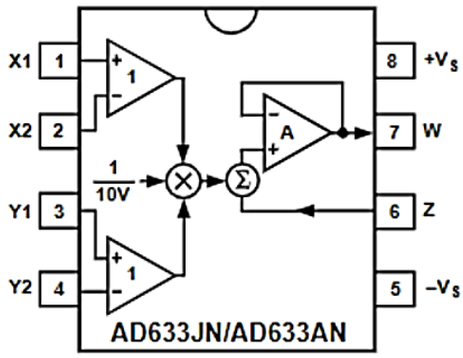


**Figure 4** AD633 Block Diagram
*Source: Datasheet AD633*

## Highlights

1. The AD633 is inexpensive. It is offered in 8-lead plastic packages.

2. It is stable and reliable due to its monolithic construction and laser calibration.

3. It allows high resistance values in MΩ, making the signal source load negligible.

4. The power supply voltages range from ± 8 V to ± 18 V. The internal scale voltage is generated by a stable Zener diode; multiplier precision is essentially supply insensitive.

## Applications involving R wave detection

The pacemaker is an electronic device whose purpose is to make the heart beat, using electric shocks that replace the cardiac conduction system itself and guarantee a synchronous and efficient beat. Pacemaker placement depends on the presence or absence of significant symptoms or signs attributable to bradycardia. (Carrasco & Villeda, 2000)

Pacemakers use algorithms that allow detecting the time between each R wave. If the time that exists between each R wave corresponds to tachycardia, then electrical shocks are sent to reestablish normal heart rhythm.

Similarly, in the case of tachycardias, the defibrillator is available. Defibrillation is based on applying an electrical current abruptly and briefly to reverse rapid cardiac arrhythmias; situations in which the number of heartbeats increases excessively or there is disorganized electrical activity. As can be concluded, like pacemakers, defibrillators must be able to determine in a correct way that the patient is in tachycardia and for this they rely on algorithms for detecting the R wave to determine the heart rhythm and verify if it is in effect. have an arrhythmia or not.

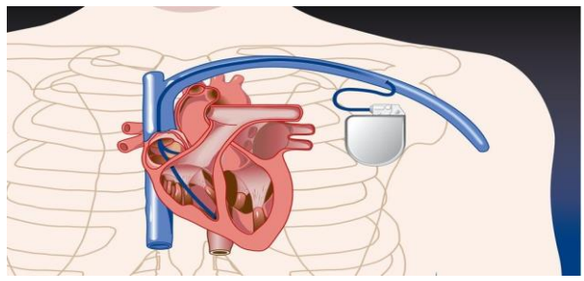

**Figure 5** Schematic of an implantable pacemaker
*Source: http://www.insuficiencia-cardiaca.com*

## Methodology

The study was divided into 5 phases: the first is the Database, where the vector of values from a real ECG study was collected. Additionally, a signal treatment was carried out to adapt it to admissible values for pulse width modulation (PWM).

The second stage is the Deployment of the data whereby means of the analog writing that the microcontroller performs using PWM and a second order RC low-pass filter we obtain the ECG signal.

The last three phases were the description and implementation of the Variant of the Pan-Tompkins algorithm where the band-pass filter was designed to clean the signal; ECG signal squared and voltage level assigned to achieve R wave detection.

## Phase 1.- Database

The vector of ECG lead I values was obtained from the Physionet online database. A 10 second study was downloaded with a 2 millisecond sample time, this study contains too much data (5000 items).

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Therefore, it was decided to reduce the number of samples to 100. This was achieved considering only the first 2 seconds of the study, which correspond to 1000 data. Of these 1000 pieces of data, one element out of ten was assigned to a new vector that finally has 100 pieces of data.

It is important to mention that the values of the vector that generates the pulse width modulation (PWM) in the Arduino microcontroller, are integers that go from 0 to 255.

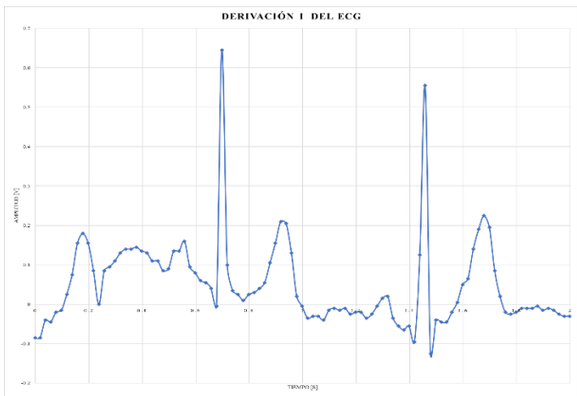


**Figure 6** ECG lead I vector
*Source: Own elaboration*

This vector consists of decimal values that are both positive and negative, so a conditioning of the vector had to be performed to display the data on the scale from 0 to 255.

An OFFSET was applied to the entire signal, thus avoiding possible negative components that could not be displayed by the Arduino's PWM. For this, the most negative value was found and it was subtracted from the entire vector, resulting in the graph shown in figure 7.

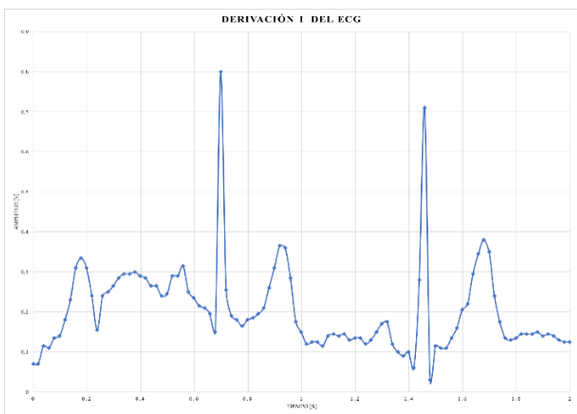


**Figure 7** ECG Lead I without negative values
*Source: Own elaboration*

The maximum amplitude of the signal was made unitary, as can be seen in figure 8.

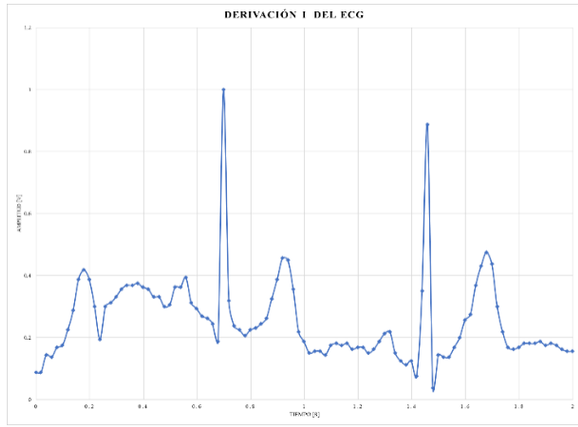


**Figure 8** ECG vector with maximum amplitude of 1
*Source: Own elaboration*

Finally, this entire vector was multiplied by 255, with rounding to obtain whole numbers. It is this last vector, the one that can be declared in the Arduino board program, since it complies with the admissible values for the PWM, as shown in figure 9.

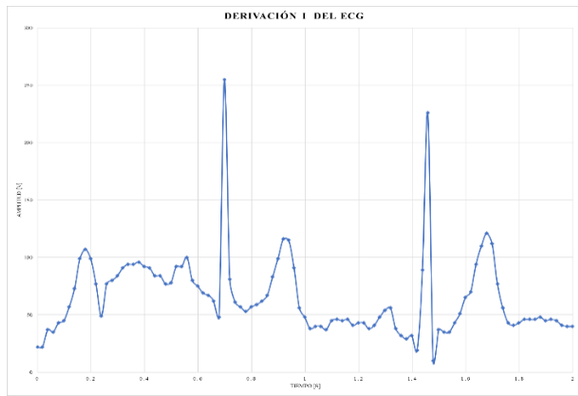


**Figure 9** Lead I of the ECG with acceptable values for PWM (Integers ranging from 0 to 255)
*Source: Own elaboration*

## Phase 2.- Deployment of the data

To display the data, the microcontroller's analog write with a timeout was used. The calculation of this wait was determined as follows:

$$delay = \frac{2000ms}{100\ datos} = 20\ ms/datos \qquad (3)$$

For the signal period to be 2 seconds, there must be a wait between each of the 100 20-millisecond data.

To visualize lead I, we have to fit a second order RC low-pass filter since the PWM alone is nothing more than square waves.

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The cutoff frequency will be, the number of cycles of the signal between the total period of the signal in seconds).

$$f_c = \frac{2\ ciclos}{2\ s} = 1\ Hz \quad (4)$$

For practical purposes a higher cutoff frequency will be used without affecting the integrity of the signal.

This frequency is determined by the values of capacitors and resistors with which the filter was built.

With 6.8 kΩ resistors and 1 μF capacitors, the corresponding cutoff frequency is:

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(6.8\ k\Omega)(1\mu F)} = 23.4051\ Hz \quad (5)$$

In this way, the ECG lead I signal can be recovered in the simulation..

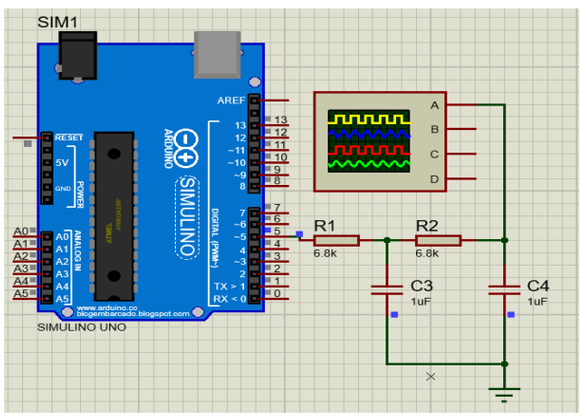


**Figure 10** ECG lead I signal generator. It consists of the Arduino that generates the signal and a second-order RC low-pass filter
*Source: Own elaboration*

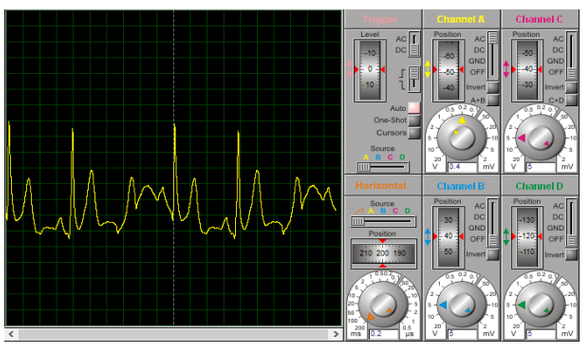


**Figure 11** ECG lead I signal displayed on the oscilloscope
*Source: Own elaboration*

**Phase 3.- Variant of the Pan-Tompkins algorithm**

The Pan-Tompkins algorithm is a sequential process that allows us to detect the R wave of the ECG. This sequence of steps is: Step 1.- The band-pass filter eliminates any unwanted noise. Step 2.- A derivative is made to emphasize those parts of the signal where there are sudden changes in slopes. Step 3.- A squared elevation is performed to make all the components of the signal positive and further accentuate the results of the derivative (Tompkins, 1992).

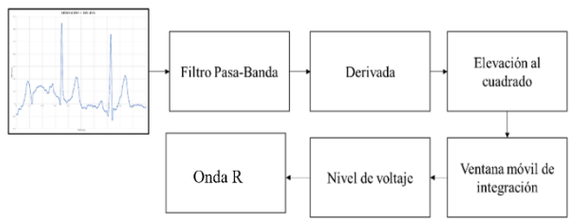


**Figure 12** Pan-Tompkins algorithm
*Source: Own elaboration*

It is based on the accentuation of sudden changes in slope, emphasizing them thanks to the derivative and the squared elevation, giving the R wave a high amplitude with which it is easier to detect said wave. Although the derivative and the mobile integration window could be implemented, in the present methodology it was decided to omit these stages, in such a way that the variant of the Pan-Tompkins algorithm for the detection of the R wave is shown in figure 13.

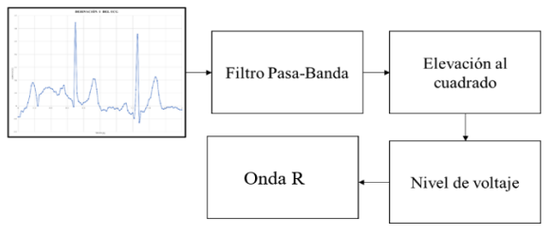


**Figure 13** Variant of the Pan-Tompkins algorithm
*Source: Own elaboration*

**Phase 4.- Implementation of the variant of the Pan-Tompkins algorithm: Design of a band-pass filter from 0.5 to 150 Hz.**

To eliminate possible undesirable noise and clean the signal, a band-pass filter composed of the response of a high-pass filter in series with an active second-order low-pass filter MFB with cutoff frequencies $\omega_1 = 0.5$ Hz and $\omega_2$ was used. = 150 Hz respectively (Webster, 2010).

These frequencies are at which an electrocardiogram operates (Webster, 2010).

**Design of the active second-order high-pass filter MFB**

Considering that we want to implement an approximation of the Butterworth type, whose quality factor Q = 0.7071, whose constant k = 1, a unity gain of the filter (| A | = 1.1), with a cut-off frequency $f_c$ = 0.5 Hz and setting the value of the capacitors at C = 1 μF, we proceed to calculate the real values of the remaining elements:

Calculating the constant $m$

$$m = \frac{1+\sqrt{1+8Q^2(A-1)}}{4Q} \quad (6)$$

$$m = \frac{1+\sqrt{1+8(0.7071)^2((1.1)-1)}}{4(0.7071)} = 0.7719$$

For resistance $R_1$

$$R_1 = \frac{m}{2\pi k f_c C} \quad (7)$$

$$R_1 = \frac{0.7719}{2\pi(1)(0.5\,Hz)(1\times10^{-6}F)}$$

$$\boldsymbol{R_1} = 2.457\times10^5\Omega = 245.7\times10^3\Omega = \boldsymbol{245.7k\Omega}$$

For resistance $R_2$

$$R_2 = \frac{R_1}{m^2} \quad (8)$$

$$\boldsymbol{R_2} = \frac{245.7k\Omega}{(0.7719)^2} = \boldsymbol{412.37k\Omega}$$

For resistance $R_a$

$$R_a = \frac{AR_2}{A-1} \quad (9)$$

$$\boldsymbol{R_a} = \frac{(1.1)(412.37k\Omega)}{(1.1)-1} = \boldsymbol{4536.07k\Omega}$$

For resistance $R_b$

$$R_b = AR_2 \quad (10)$$

$$\boldsymbol{R_b} = 1.1(412.37k\Omega) = \boldsymbol{453.61k\Omega}$$

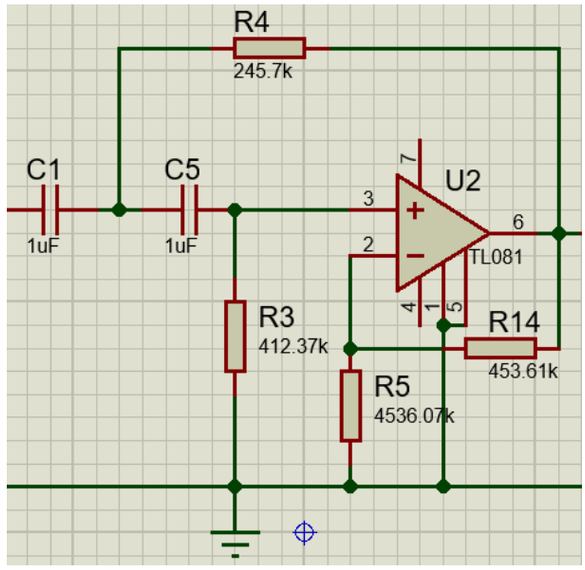


**Figure 14** Sallen Key 2nd order active high-pass filter with cutoff frequency at 0.5 Hz and 1.1 gain
*Source: Own elaboration*

**MFB second-order active low-pass filter design**

Considering that it is desired to implement an approximation of the Butterworth type, whose quality factor Q = 0.7071, whose constant k = 1, a unity gain of the filter (| A | = 1), with a cut-off frequency $f_c$ = 150 Hz and setting the capacitor value at $C_1$ = 1 μF, we proceed to calculate the real values of the remaining elements:

For resistance $R_3$

$$R_3 = \frac{Q(A+1)}{\pi k f_c C_1} \quad (11)$$

$$R_3 = \frac{0.7071(1+1)}{\pi(1)(150\,Hz)(1\times10^{-6}F)}$$

$$\boldsymbol{R_3} = 3.001\times10^3\Omega = 3.001k\Omega = \boldsymbol{3k\Omega}$$

For the capacitor $C_2$

$$C_2 = \frac{1}{4\pi k f_c Q R_3} \quad (12)$$

$$C_2 = \frac{1}{4\pi(1)(150\,Hz)(0.7071)(3\times10^3\Omega)}$$

$$\boldsymbol{C_2} = 2.5009\times10^{-7}F = 250.09\times10^{-9}F = \boldsymbol{250\,nF}$$

For resistance $R_1$

$$R_1 = \frac{R_3}{A} \quad (13)$$

$$\boldsymbol{R_1 = \frac{3k\Omega}{(1)} = 3k\Omega}$$

For resistance $R_2$

$$R_2 = \frac{R_3}{A+1} \quad (14)$$

$$\boldsymbol{R_2 = \frac{3k\Omega}{(1)+1} = \frac{3k\Omega}{2} = 1.5k\Omega}$$

For resistance $R_4$

$$R_4 = 2R_2 \quad (15)$$

$$\boldsymbol{R_4 = 2(1.5k\Omega) = 3k\Omega}$$

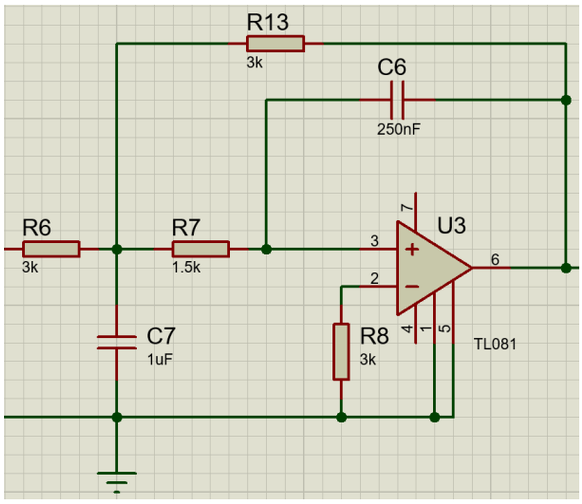


**Figure 15** Active low-pass filter of 2nd order type MFB with cut-off frequency at 150 Hz and unity gain
*Source: Own elaboration*

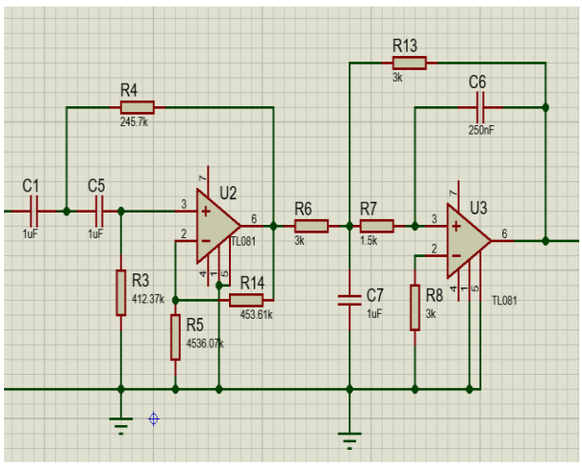


**Figure 16** Band-pass filter composed of a cut-off frequency 0.5 Hz high-pass filter and a 150 Hz low-pass filter.
*Source: Own elaboration*

**Phase 5.- Implementation of the variant of the Pan-Tompkins algorithm: Elevation squared and Voltage level**

Once the filters that will have the desired band-pass filter behavior have been designed, it remains to square the signal and assign a voltage level to achieve the detection of the R wave.

Due to the transfer function of the low-pass filter, the ECG signal is inverted. However, since the next step in the variant of the Pan-Tompkins algorithm involves squaring the signal, it is well possible to proceed with the output of the filters without inverting it. In this case the signal is inverted as shown in the following figure.

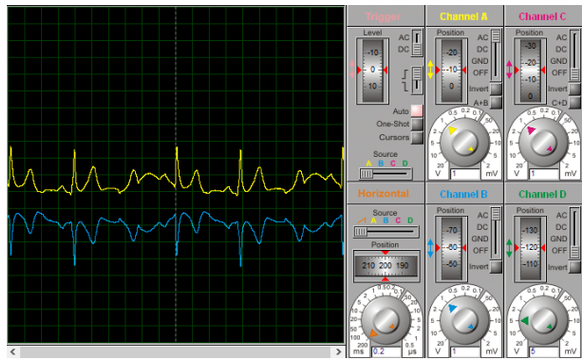

**Figure 17** ECG lead I signal displayed on the oscilloscope (yellow) and signal resulting from applying the band-pass filter (blue).
*Source: Own elaboration*

To square the signal, use was made of the AD633 analog multiplier, whose output voltage equation is given by:

$$W = \frac{(X1-X2)(Y1-Y2)}{10\,V} + Z \quad (16)$$

Where:

W is the output of the AD633

X1, X2, Y1, Y2 are input signals

Z is the OFFSET voltage

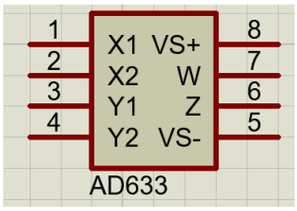


**Figure 18** AD633 in Proteus
*Source: Own elaboration*

Since we want to square the signal, inputs X1 and Y1 will be the same, while X2, Y2 and Z will go to ground.

$$W = \frac{(X1)(Y1)}{10\,V} = \frac{(X1)(X1)}{10\,V} = \frac{X1^2}{10\,V} \quad (17)$$

According to the AD633 data sheet to polarize the AD633, it is necessary to supply with +12 V for $V_{S+}$ and -12 V for $V_{S-}$. Both sources must go in series with a 10 µF capacitor.

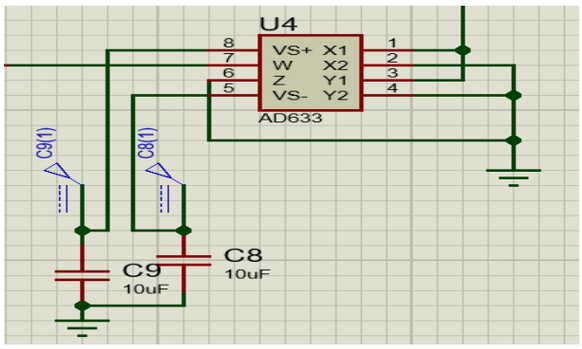


**Figure 19** AD633 setup to square the signal.
*Source: Own elaboration*

One option to simulate the AD633 is to select SIMPLE instead of AD633 (by default). This option guarantees accuracy and precision in simulation tests.

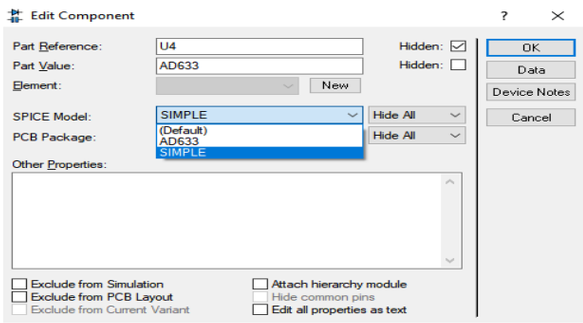


**Figure 20** AD633 SPICE Model configuration
*Source: Own elaboration*

With these considerations, it was possible to obtain the squared ECG signal at the output. However, as seen earlier in the AD633's output voltage equation, the product is being divided by 10, so it is necessary to amplify the signal 10 times to compensate for this factor.

An op amp in non-inverting configuration or a pair of op amps can be used as inverters, in this case a pair of op amps was used as inverters.

**Design of operational amplifiers in inverter configuration**

The voltage gain is given by

$$G = -\frac{R_f}{R_i} \quad (18)$$

The gain of the first OpAmp in inverter configuration is -5, if R_i = 1kΩ, then:

$$\boldsymbol{R_f = 5R_i = 5(1k\Omega) = 5k\Omega}$$

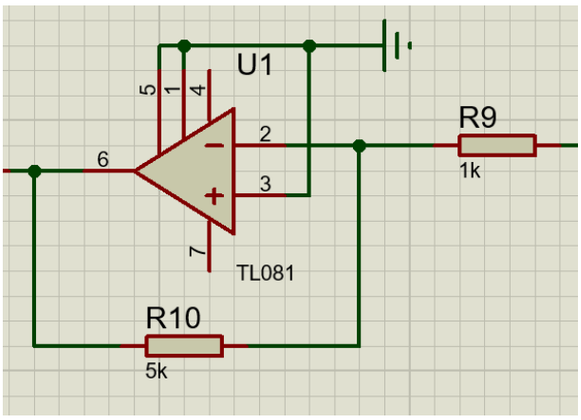


**Figure 21** OpAmp in inverter configuration and -5 gain
*Source: Own elaboration*

The gain of the second OpAmp in inverter configuration is -2, if

$R_i$ = 1kΩ, then we proceed to calculate $R_f$:

$$\boldsymbol{R_f = 2R_i = 2(1k\Omega) = 2k\Omega}$$

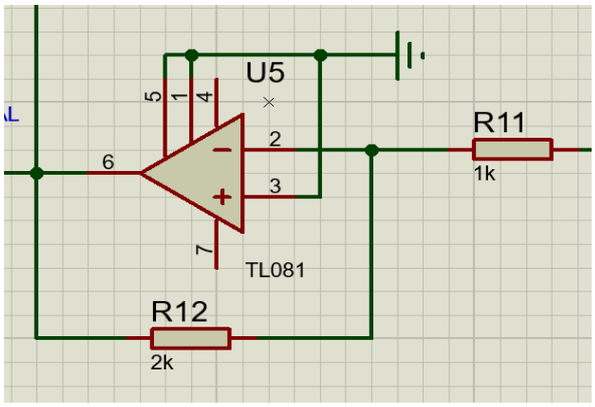


**Figure 22** OpAmp in inverter configuration and gain of -2
*Source: Own elaboration*

The joint action of both operational amplifiers, in inverting configuration, results in an amplified signal 10 times, which compensates the factor of the output equation of the AD633.

The results of squaring the ECG signal are shown below in Figures 23 and 24:

**Figure 23** ECG lead I signal displayed on the oscilloscope (yellow) and ECG signal after filtering squared (magenta)
*Source: Own elaboration*

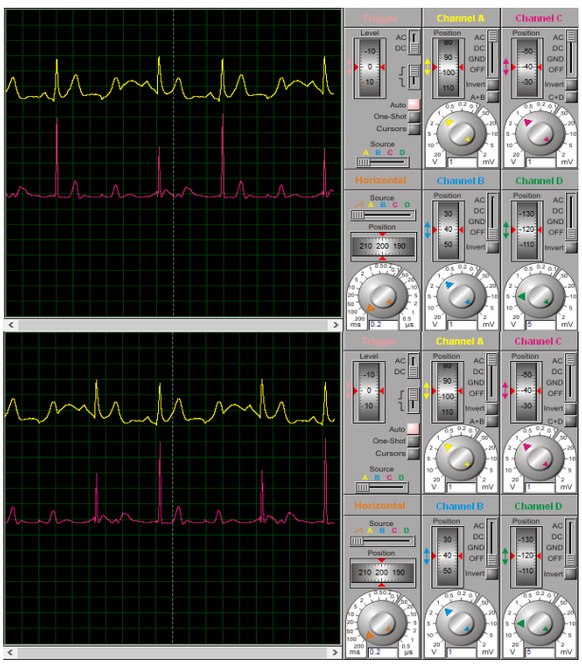

**Figure 24** ECG lead I signal displayed on oscilloscope (yellow) and ECG signal after filtering squared (magenta)
*Source: Own elaboration*

As the last step of the variant of the implemented algorithm, a voltage threshold is assigned such that it is able to discriminate those peaks that are not of our interest and to identify only the one corresponding to the R wave. To achieve this purpose, an operational amplifier was used in comparator configuration. With this setup, you are constantly comparing the value of the squared ECG signal against a reference voltage. As a consequence, the OpAmp will output positive saturation in those parts of the signal where the threshold is exceeded (as expected from the R wave) and will return negative saturation to the output in those parts of the signal where the voltage of reference is higher.

The voltage being compared against can be varied with a potentiometer to achieve different results. The results of having considered our reference voltage of 9 Volts are the following: (see figure 25)

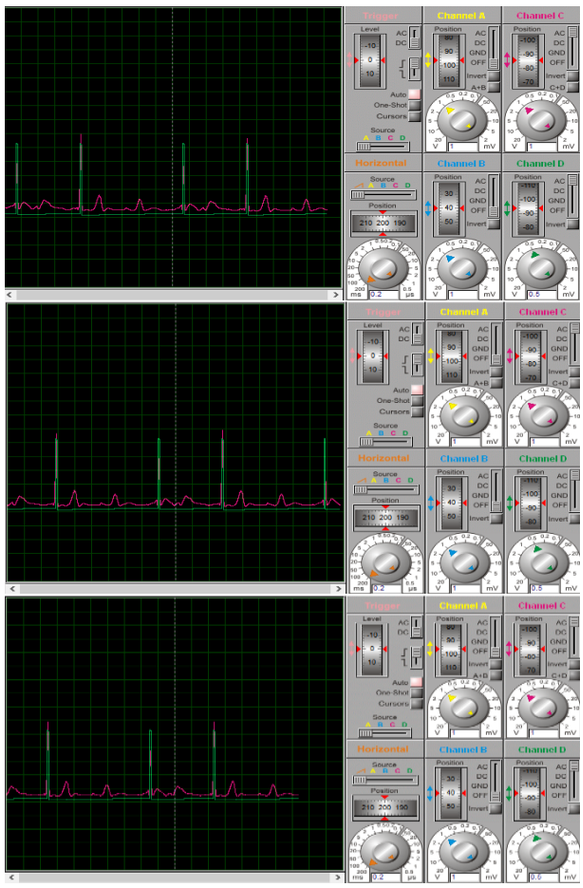

**Figure 25** ECG signal after filtering squared (magenta) and comparator output (green). Oscilloscope at 0.2 seconds per division.
*Source: Own elaboration*

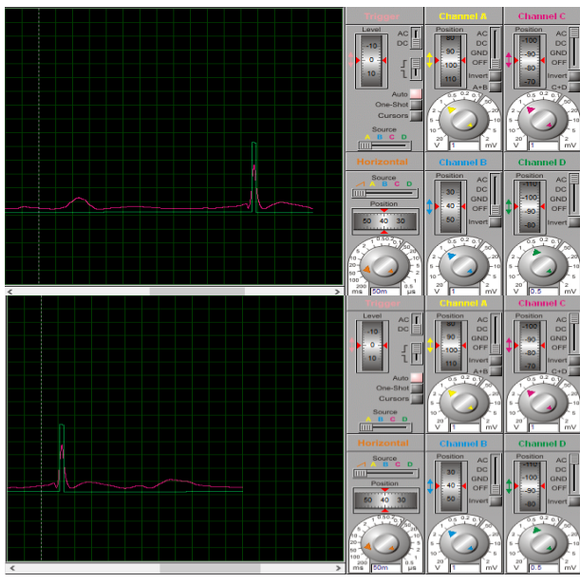

**Figure 26** ECG signal after filtering squared (magenta) and comparator output (green). Oscilloscope at 50 milliseconds per division
*Source: Own elaboration*

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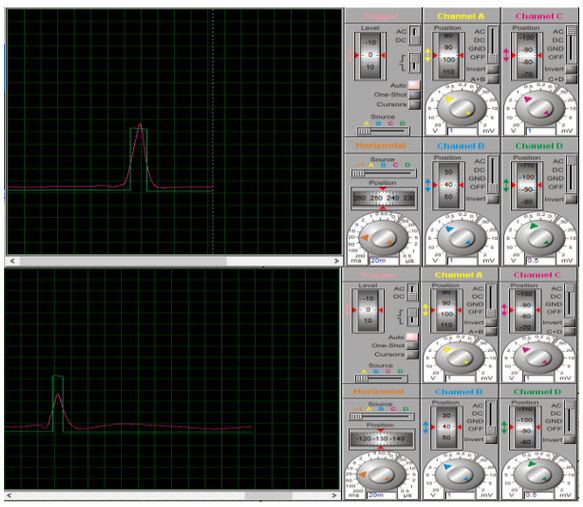

**Figure 27** ECG signal after filtering squared (magenta) and comparator output (green). Oscilloscope at 20 milliseconds per division.
*Source: Own elaboration*

## R wave detection

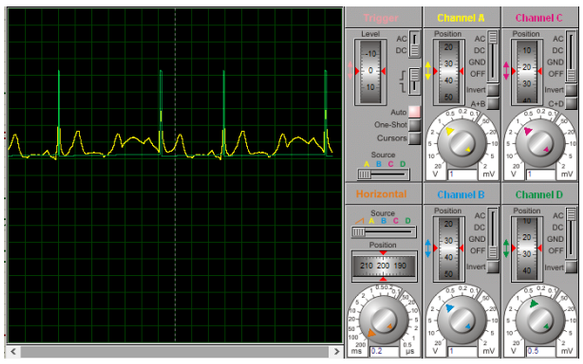

**Figure 28** Results displayed on the oscilloscope, where the detection is made by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

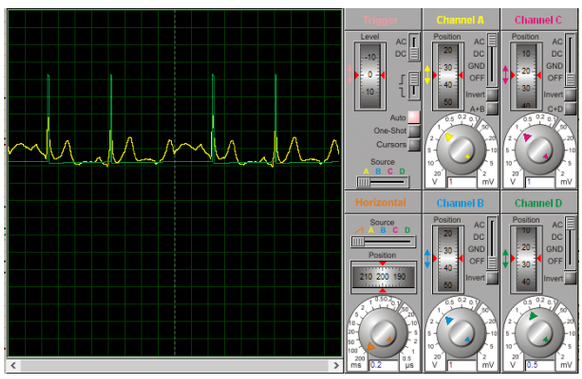

**Figure 29** Results displayed on the oscilloscope, where the detection is made by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

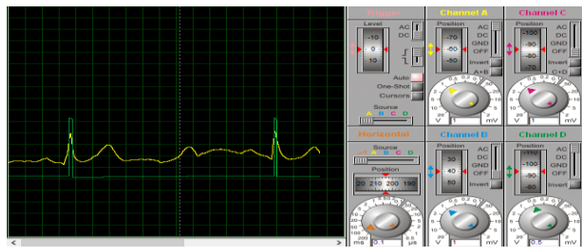

**Figure 30** Results displayed on the oscilloscope, where the detection is made by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

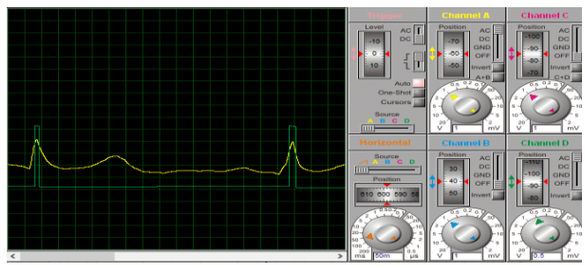

**Figure 31** Results displayed on the oscilloscope, where the detection is made by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

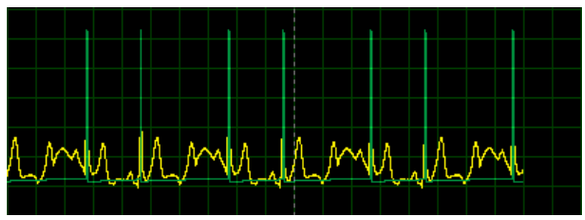

**Figure 32** Results displayed on the oscilloscope, where the detection is made by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

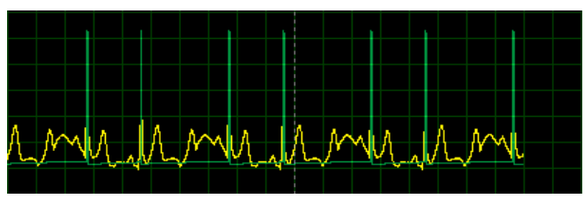

**Figure 33** Results displayed on the oscilloscope, where detection is carried out by the comparator amplifier (green), which "encloses" the R wave of lead I of the ECG (yellow)
*Source: Own elaboration*

## Results

The results of the simulations are correct and coincide with what was expected. The oscilloscope of the simulator shows how it is possible to detect the R wave of the lead I signal of the ECG.

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With regard to the detection of the R wave in a real ECG study for lead I, this methodology can be physically implemented with the previously described analog elements, obtaining results in accordance with expectations and therefore, a correct functioning of the detector.

## Conclusions

Taking as a basis the Pan-Tompkins algorithm for the detection of the R wave was a very useful tool since it is a methodology that has been developed previously, achieving favorable results in the multiple studies that have implemented it.

A poor implementation of the R wave detector, at the simulation level, does not represent any risk. However, physically the detector may lack precision and miss that the patient is suffering from an arrhythmia, which leads to more serious complications such as fainting, cardiac arrest and eventually death.

The results obtained with the simulations show a correct behavior and an ideal operation of the R wave detector for lead I.

Developing this work for multiple derivations and verifying that the obtained corresponds to what is expected, allows the general validation of the Pan-Tompkins algorithm. that presents good results regardless of the derivation with which it is being treated, but it is worth corroborating this variant of the algorithm implemented with analog elements in different derivations to verify its effectiveness, precision and accuracy.

It is feasible in the future, the inclusion of analog elements to achieve the detection of the R wave and thus estimate the heart rate of the heart. The determination of the heart rhythm has applications for example in the pacemaker or in equipment such as the defibrillator.

The inclusion of detectors built with analog elements would achieve a possible reduction in the price of these medical devices, since the use of microcontrollers for heart rhythm determination tasks would be neglected.

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# [Title in Times New Roman and Bold No. 14 in English and Spanish]

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* Correspondence to Author (example@example.org)
† Researcher contributing as first author.

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Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

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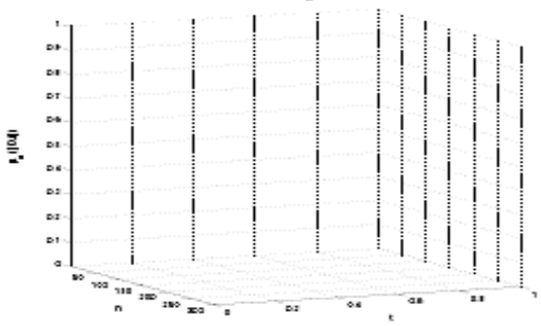

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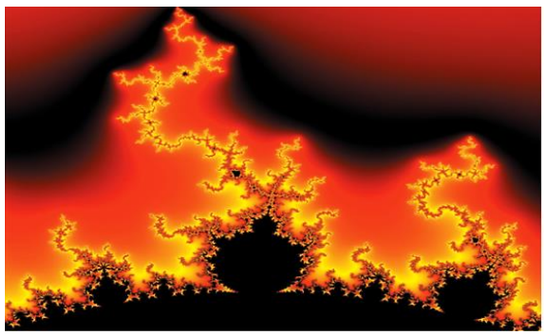

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Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

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