



PORTABLE ELECTROCARDIOGRAPH FOR DETECTING DISEASES THAT TRIGGER SUDDEN DEATH, WITH MEDICAL DIAGNOSTIC SOFTWARE APPROXIMATE WIRELESS

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ABSTRACT

In this project, it was designed an electrocardiograph device has diagnostics for derivation DII, allowing a visualization of other derivations one at the time. Similarly, the electrocardiograph device, allows the electrocardiogram (ECG) test to be done wirelessly to facilitate the implementation of such test at any place or situation. The prototype is designed to facilitate the implementation of the ECG test in everyday circumstances and from the comfort of home, without losing the effectiveness in the test. It cannot be forgotten that the results of it, must be verified by qualified personnel. The application is developed in MATLAB; therefore, the PC must be licensed for its use. This software works directly with the hardware of the device doing it in real time. It was intuitively designed to facilitate its use. In this order of ideas, it is worth noting the role of diagnosing diseases that this application has. It is a great tool when it comes to analyze the information. The evidence is collected and stored digitally in a PDF format, in which the patient's personal data and the most relevant results of the ECG test in a digital file which can be directly printed. It is important to highlight that these files can be shared via email directly from the software designed. Without forgetting that the software has a database where the tests performed are stored

Keywords: diagnosis, derivation, electrocardiograph, ECG, hardware, Matlab, PC, prototype, software, wireless.

1. INTRODUCTION

The main concern of human beings in the course of the years has been their livelihood. Multiple wars, disease and climate change that has faced the human race have affected their chance of life; this result generates scientific efforts through various research and technological advances are aimed at the percentage of life increases with the passing of the years, and similarly the figure from disease and climatic disaster deaths decrease. According to the Global Status Report on Health of the World Health Organization (Gómez, 2011), cardiovascular diseases are responsible for most of the deaths in the world, therefore the analysis of electrocardiographic signals has taken preponderance today (Romero, 2015). The field of medicine and electronics have gone hand in hand in the study and design of new prototypes that help improve the quality of life of people through research and development of new techniques the possibility of studying a breakthrough in the area of prevention of diseases in humans (Sans, 2012). The importance of the study of the heart through devices such as electrocardiograph, facilitates the detection of cardiac deficiencies that prevent cases of sudden death (Montagud, 2015) are presented. The reason for this tool is very important as it is used for analyzing the electrical activity of the heart via electrodes that capture and extend the cardiac signal with the ability to detect possible alterations.

The reason why it is necessary to sharpen the usefulness of the electrocardiograph is its functionality as it is a device that will help a large number of people who are the ECG (Niggemeyer, 2008) exam practice among these is the population suffering from high blood pressure, high levels of blood sugar, overweight, high cholesterol, or possessing habits such as snuff or alcohol abuse. Also for

people with respiratory or heart, problems with population over 40 years, and athletes before starting a physical activity. (Cardiomenorca Medical Center, 2015).

The purpose of this project was to create a wireless device with XBEE broader technology compared to other technologies; with pc-user interface displayed on a computer system using MATLAB platform, which has a disease detection software developed under the collaboration and supervision of a health professional. That is why it is necessary to delve into the study of this device that is useful to society, contributing through field research to improve systems that sharpen their functionality. With the creation of a wireless electrocardiograph with medical diagnostic software approximate the expected impact on the population is achieved through this type of research.

2. METHODOLOGY

The prototype designed, provides a tool for the prevention of cases of sudden death, through the detection of heart disease resulting from ECG test, by implementing a wireless electrocardiograph and software developed in MATLAB. This set of components forming the system that has been called PECGI referring to prototype ECG Wireless, which offers six possible detection of heart disease, applying medical concepts for detection and thus contribute to the prevention of sudden death. The system block diagram shown in Figure-1.

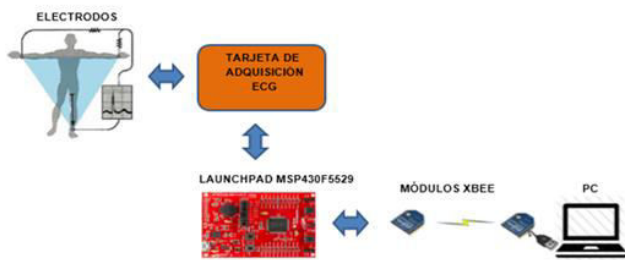


Figure-1. Schematic electrocardiography system.

2.1 Hardware

The prototype implemented electrocardiograph is illustrated in Figure 2, which, comprises: a plurality of electrodes, an acquisition card ECG, card development LAUNCHPAD MSP430F5529 two XBEE modules (transmitter and receiver) and a battery. Additional device such as a computer display means and diagnostic electrocardiography is used.



Figure-2. Electrocardiograph implemented.

2.2 Electrodes

CAH electrode (conductive adhesive hydrogel), or commonly called biopotential electrode is not more than a half cell complete the galvanic cell through other electrodes connected in the skin itself. That is why two electrodes to obtain an electronic reading required minimum, and at least three electrodes to obtain reasonable bioelectrical signal. The electrode is charged as if it were a capacitor (metal plate and dielectric gel skin) and gives off its load of electrons in the conductor cable and electric double layer.

ECG acquisition card. It corresponds to a card designed to acquire bioeléctricas heart signals and then are amplified and filtered by active filters Butterworth (Cabrera, 2016), according to frequency parameters usually implemented in electrocardiography, such as, 0.5 Hz for pass filter -high and 50 Hz for the low-pass filter.

The captured through the electrodes signal is received by the instrumentation amplifier INA2126, which was previously set with the external resistance for the gain control to 2k ohms, in order to obtain an amplification of 45 times the difference signal input as shown in equation (1).

$$G = 5 + \frac{80k\Omega}{RG} = 5 + \frac{80k\Omega}{2k\Omega} = 45 \quad (1)$$

The MSP430 is a family of microcontrollers manufactured by Texas Instruments. Built with a 16-bit CPU, the MSP430 is designed for low-cost embedded applications, wireless systems and / or ultra-low power consumption. This card performs the signal sampling, by a timer, configured to perform approximately 300 samples per second, then the samples are taken by the ADC12 module for analog to digital conversion in 12-bit resolution. The digital signal is passed to the UART card module for serial communication with the issuer XBEE module.

2.3 Modules Xbee

Xbee modules work with the communication protocol ZigBee, a wireless communications protocol based on the communication standard for wireless networks IEEE_802.15.4. Zigbee allows low-power electronic devices can perform their free wireless communications in the 2.4GHz band. Unlike Bluetooth, this protocol does not use FHSS (Frequency hopping), but performs communications via a single frequency, i.e. a channel. You can usually choose a channel from 16 possible. The extent depends on the transmission power of the device, as well as the type of antennas used (ceramics, dipoles, etc.) the normal range with online dipole antenna view is approximately 100m and 30m interiors. Speed data transmission network is a Zigbee up 256kbps. In the device, the XBEE transmitter transmits the XBEE receiver is connected to the PC, which will be held processing and signal storage module. The device has a 5 volt battery, which supplies about 2600mA / h, providing a range of approximately 40 hours at full load.

2.4 Computer

Used for receiving the signal from the device and where the processing and diagnostics software developed in MATLAB runs.

2.5 Software

The graphical interface called PECGI as an abbreviation for "Prototype electrocardiograph Wireless", was developed on MATLAB, as it is a software platform that provides a user friendly, without sacrificing the processing power. To access the software, you need to run the file "Guide_ECG.m" which opens the "Acquisition ECG" window. PECGI consists of three main windows for operation "ECG Acquisition", "Patient Data" and "Diagnosis".

2.6 Acquisition ECG

Manages the execution of the program and links to other windows that are part of the software. It electrocardiographic reading taken in real time by the device hardware is displayed. At the end of time estimated reading, it provides little information about the number of beats detected, the maximum amplitude voltage and the average distance (in time) between consecutive pulses. This window is shown in Figure-3.

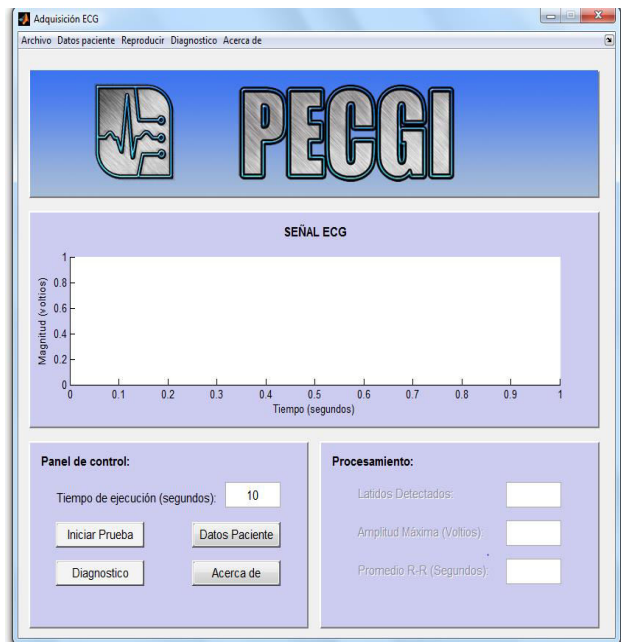


Figure-3. ECG acquisition window.

2.7 Personal data

Selecting the "Patient Data" in the main window, button accesses a new window called "Personal Data" as shown in Figure-4, which contains a form to fill out the user before starting the ECG test. If the document number supplied already created in the database automatically patient information will be reflected in the form. Otherwise, you must enter the information manually.

2.8 Diagnosis

Moreover, PECGI is in the ability to provide support a diagnosis medical personnel or the user. This is then generated from the analysis performed in software on essential variables such as amplitude, the absence of waves, time of occurrence and duration of the main waves to detect certain disease and heart disease in particular (American Heart Association, 2015). Diseases that the software is able to detect are: bradycardia (Thompson, 2014), atrial fibrillation, atrial hypertrophy, ischemia and tachycardia.

The software stores the readings and diagnoses performed want to keep, similarly allows the option to upload up to two readings for comparative analysis and evaluate the patient's progress. The prototype generates a report of all the information on the test performed, such as basic patient data, graphic signal, times and amplitudes of the waves, the possible diagnosis of heart disease, among others. This report is generated in PDF format.

Figure-4. Window "patient data".

It also has the ability to share this information by email directly from the application developed, which displays a popup window asking for input from the recipient email address.

3. RESULTS AND DISCUSSIONS

In developing the prototype ECG they were applied theoretical and practical concepts of electronics and biomedical engineering, in order to obtain satisfactory results and beneficial to improve the quality of life of people in general. In Figure-5, the ECG device developed and its position in the patient's body is observed. Through electrodes arranged in one of the twelve leads medically recognized (Yanowitz, 2016), the electrocardiograph collects bioelectric signals of the heart, in order to filter them and process them to be transmitted wirelessly to a computer which allows visualization and analysis.



Figure-5. Position of the device.

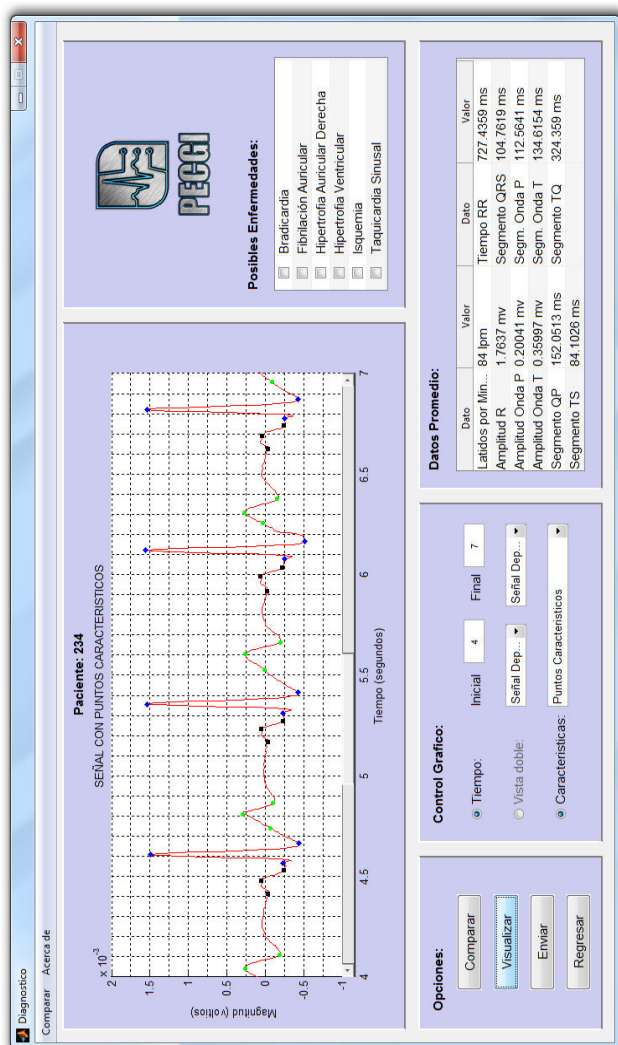


Figure-6. Window "Diagnosis".

PECGI, offers the user, obtain a comprehensive collection of information on the status and electrical behavior of the heart; You are selecting possible testing time thereof; It allows counting the heart beats; It recognizes an individual or group characteristics of the cardiac signal waves; supports the display of the original, refined signal filtered with the minutiae and detection of pulses.

3.1 Interface data visualization

Providing support a diagnosis of medical personnel or the user. This is then generated from the analysis performed in software on essential variables such as amplitude, the absence of waves, time of occurrence and duration of the main waves for detection of some particular disease. Diseases that the software is able to detect are: bradycardia, atrial fibrillation, atrial hypertrophy, ventricular hypertrophy, ischemia and sinus tachycardia. The disease will be diagnosed as positive if they appear in the box checked "possible diseases" in Figure-6.

3.2 Physical appearance hardware



Figure-7. Internal appearance of the device.

Preparing acquisition card ECG, visible in Figure-7, was performed on a motherboard single sided copper, with the measures shown in Table-1. The printing track was performed with the technique of ink transfer by heat. The box containing the device is constructed of transparent acrylic 3 mm gauge.

Table-1. Device measures.

Components	High (cm)	Wide (cm)	Deep (cm)
Prototype box	8,5	12,5	4,7
Launchpad MSP430F5529	5,5	7	0,2
Acquisition card	6,5	10	0,2
Xbee	3	2,5	0,2
Battery	9	2,5	2,5

3.3 Performance of the prototype

To analyze the performance of the prototype is necessary to calculate the precision (P) and sensitivity (S) that the device has to perform ECG tests through equations (2) and (3) respectively. To perform this analysis samples collected by volunteers at the fair on October 21, 2016 called Innovasoft in the University Surcolombiana be taken into account. The tests lasted one minute each.

In order to determine the accuracy and sensitivity of the software in the identification of P waves, T and QRS complex of the cardiac signal, a count of the number of correct points (PC), lost points (PP) and points in error is made (PE) for each of the waves. Tables II, III and IV contain statistics on detection of P waves, QRS complexes and T waves respectively.

After having these variables must be applied in the following equations.

$$P(\%) = \frac{PC}{PC + PE} \times 100 \quad (2)$$

$$S(\%) = \frac{PC}{PC + PP} \times 100 \quad (3)$$

**Table-2.** Statistics detection wave P.

Test Number	PC	PP	PE	Total
1	73	5	5	83
2	77	7	2	86
Total	150	12	7	169

By operating the values stored in Table II is obtained as a result in precise P (%) = 95.54% and sensitivity S (%) = 92.59% for the detection of the P wave.

Table-3. QRS complex detection statistics.

Test Number	PC	PP	PE	Total
1	79	5	0	84
2	77	7	3	87
Total	156	12	3	171

By operating the values stored in Table-3 is obtained as a result in precise P (%) = 98.11% and sensitivity S (%) = 92.85% for the detection of QRS complex.

Table-4. Statistics detection wave T.

Test Number	PC	PP	PE	Total
1	74	5	4	83
2	76	7	3	86
Total	150	12	7	169

By operating the values stored in Table IV is obtained as a result in precise P (%) = 95.54% and sensitivity S (%) = 92.59% for the detection of MT wave from the results obtained can be seen a high value of precision and sensitivity in the device for detecting the characteristic points of the signal.

4. CONCLUSIONS

Distortions and noise caused by the movements of the electrodes, muscle noise, errors in the placement of the electrodes, reuse of disposable adhesives are presented. This causes the appearance of artifacts which could not be eliminated by the filters implemented therefore might be mistaken for heart disease such as tachycardia.

The type used in digital signal processing Butterworth filter is due to the advantages it has to have a flat pass band that does not distort or offsets the processed signal.

Not using strategies and algorithms for error detection and correction generates communication problems electrocardiograph to the PC, it is why the software is designed not only to detect errors but also to correct them during the march, the test it is stopped if a read error occurs, but continues while the error is identified and discarded.

Although the software has an algorithm for the detection of heart disease, it is important to note that the results of this processing and subsequent diagnosis should be considered if it has the supervision of trained personnel for reading.

Uses cutting-edge devices ensure better energy efficiency, allowing the device to give greater autonomy and portability.

The cost of a device commonly only found in medical centers, to make it easily accessible to the public are reduced.

They presented many difficulties due to lack of support of the various medical facilities for conducting electrocardiographic certified testing equipment.

The ECG signal is obtained digitally, process that facilitates storage and allows you to be examined later.

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