

ECG Self – Diagnosis System at P- R Interval

Pedro R. Gomes

Universidade Lusitana, Famalicão, Portugal

Filomena O. Soares & J. H. Correia

Universidade do Minho, Guimarães, Portugal

ABSTRACT: This paper presents a data-acquisition system for monitoring the heart electrical activity in detail with self-diagnosis at P-R interval and application in atrial fibrillation (AF). The hardware acquisition system is based on a custom printed-circuit board with pre-amplifier, filters and interface for short term Ag/AgCl electrodes. The electrodes position follows the vector cardiogram distribution (left and right arms and left and right legs). A MATLAB algorithm was developed for self-diagnosis. A regular signal-acquisition board for personal computer is used as the control of the acquisition. AF is the most common cardiac arrhythmia in clinical practice and has in recent years received considerable research interest since the mechanisms causing its initiation and maintenance are not sufficiently well understood. The main goal of this work is to develop a low-cost electrocardiogram (ECG) system with help-diagnosis functionality.

1 INTRODUCTION

The electrical potentials generated by the heart appear throughout the body and on its surface. The potential differentials are determined by placing electrodes on the surface of the body and measuring the voltage between them.

The ECG records and compares the electrical activity detected in the different electrodes and the result obtained is called “lead”. For example, the electrical events detected by the electrodes connected to the left and right arms called “lead I” (Neuman, 1992) (Figure 1).

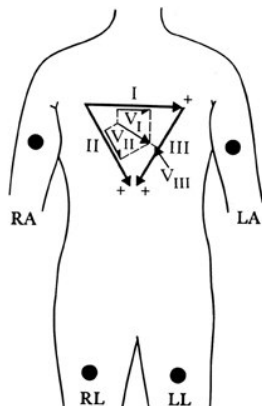


Figure 1. Vectocardiogram leads.

The ECG signal is characterized by six peaks and valleys labeled with different characters: P, Q, R, S, T and U (Stein, 2000) (Figure 2).

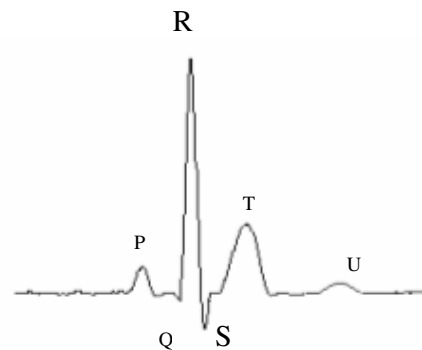


Figure 2. Form of ECG signal.

The conventional ECG systems record changes in electrical activity by drawing a trace on a moving paper strip (Berbari, 2000). However, these charts must be interpreted by the physicians.

Nowadays, ECG systems for self-diagnosis are very primitive, expensive and not reliable. Therefore, the proposed system is a step further in the ECG analysis, as it allows self-diagnosis in the complete ECG signal and it is a low-cost system.

2 ECG DATA-ACQUISITION SYSTEM

Figure 3 shows a block diagram of the system. The hardware consists of a printed circuit board (PCB), including signal conditioning, filtering and amplification. The electrical activity of the heart is filtered, amplified and converted in a digital signal. A data-acquisition board, NI 6014, set in differential mode is used to control the acquisition hardware and A/D conversion.

The software for acquisition and monitoring was developed in MATLAB. Also, it was developed a database (DB) for storing the signals for future analysis. The signal acquisition can be repeated and recorded with a different identification. For each acquired signal, a new file is created in the DB with all obligatory parameters filled in.

The mandatory parameters are the date of acquisition, the name, age and sex of the patient. The data (voltage magnitude and time) is saved in two

arrays. Two Butterworth filters are used, for reducing the 50 Hz noise and for eliminating the DC component of the signal. After, the signal is analyzed in the frequency domain by the Fourier Fast Transformer (FFT). After the selection of the signal it is used a digital filter to achieve the peaks P, Q, R, S, and T without noise and their correspondent position in the array. The basic period is calculated to obtain the length of the array. Each point of the array is got using the basic MATLAB functions to set the positions of the relevant peaks. A “time-window” is setup in order to go through the whole signal acquired and to find possible differences and record them for a later analysis.

Figure 4 shows the experimental setup with the developed ECG data-acquisition PCB system, the patient with the electrodes and the signal displayed in the PC monitor.

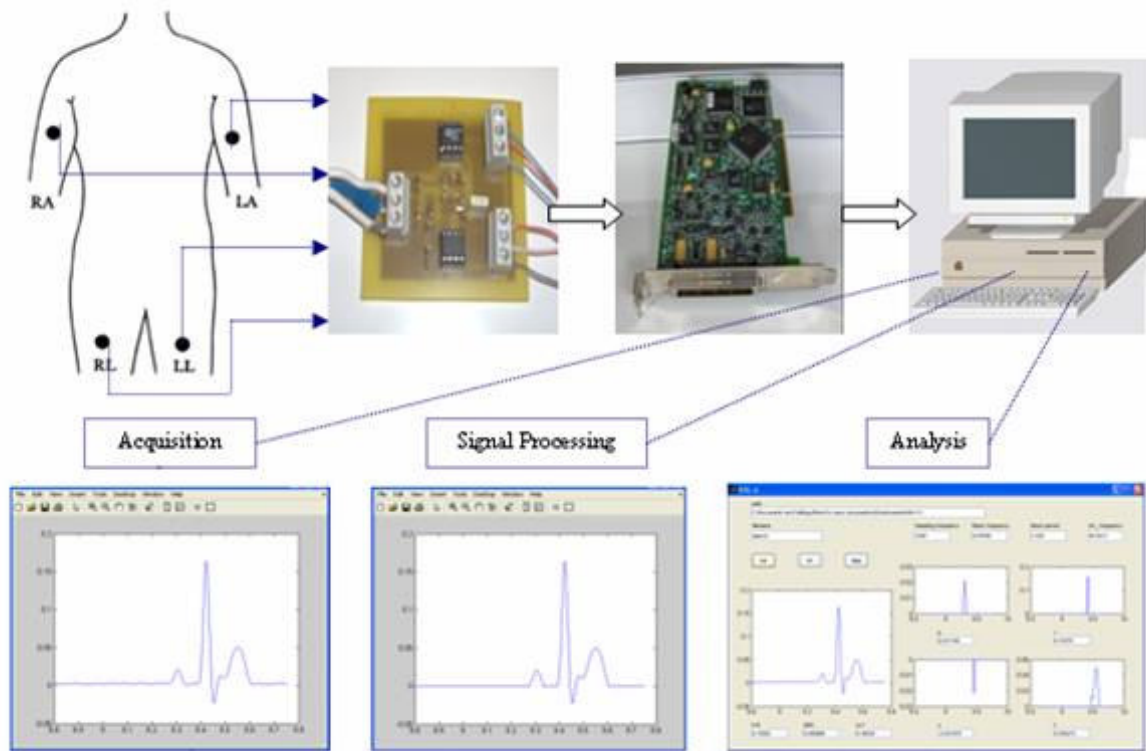


Figure 3. Block diagram of the system.

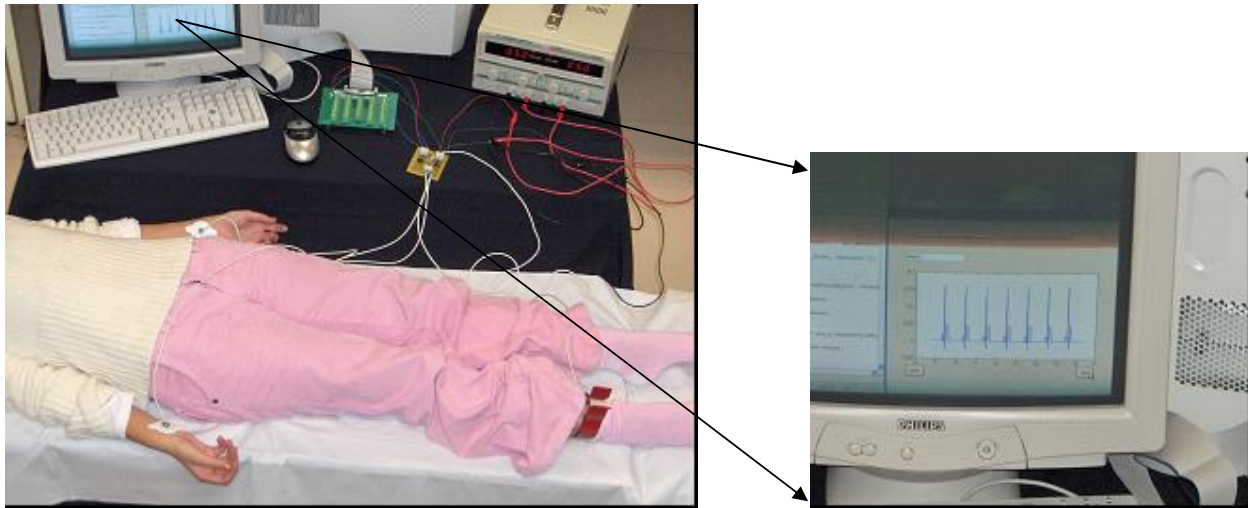


Figure 4. Experimental set-up.

3 ANALYSIS AND SELF-DIAGNOSIS

The software developed in MATLAB processes each acquired signal. This processing consists of verifying the period, the sampling frequency and calculating the SA node frequency (sinus rhythm). The software also calculates the intervals P-R, QRS and Q-T, presenting the peaks P, Q, R, S and T.

The user can select an interval, e.g., the P-R, and to obtain information about its contents (Figure 5).

The first goal of this work was the development of the application of the ECG self-diagnosis system to the P-R interval. During atrial fibrillation (AF),

the P-R interval and hence, the ventricular rate, is commonly observed as irregular. However, ventricular activity of this sort is present not only in AF but also in a variety of other arrhythmias, including multifocal atrial tachycardia and atrial flutter with variable atrioventricular (AV) block (Figure 6). Abnormal cardiac rhythms in P-R interval can be detected using these developed algorithms, as the expansion of the atria. Also, AV block can be detected. As an example, in first-degree heart block, all atrial impulses reach the ventricles, but the P-R interval is abnormally because an increase in transmission time through the affected region (Figure 6) (Petrutiu et al., 2006).

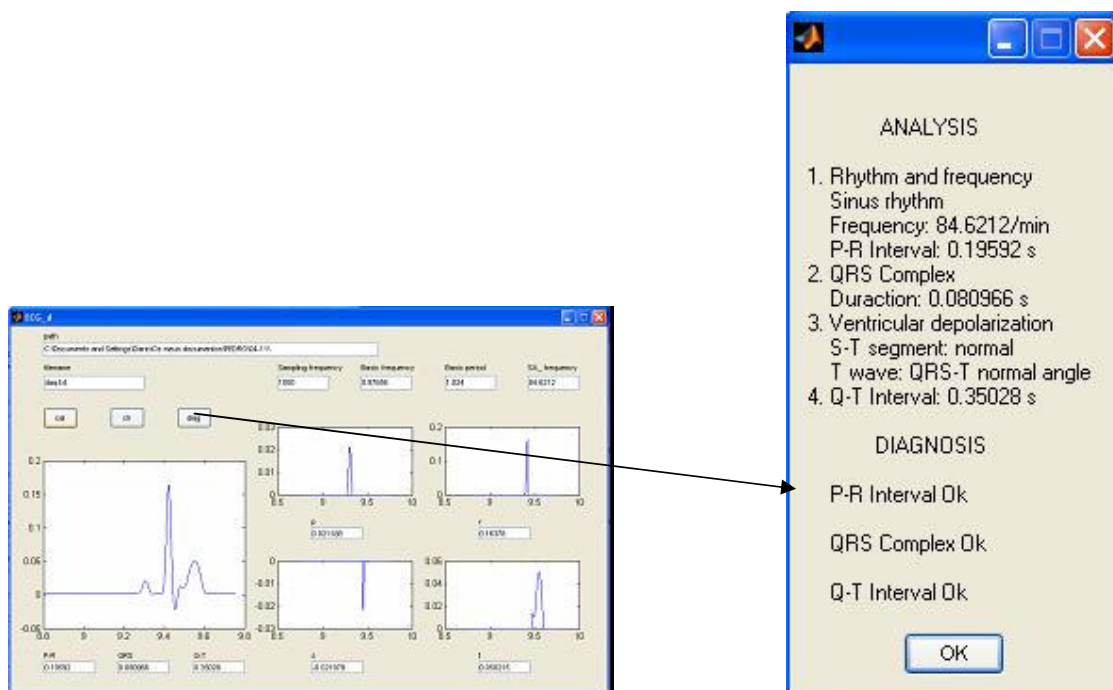


Figure5. Print-screen of MATLAB software for ECG analysis.

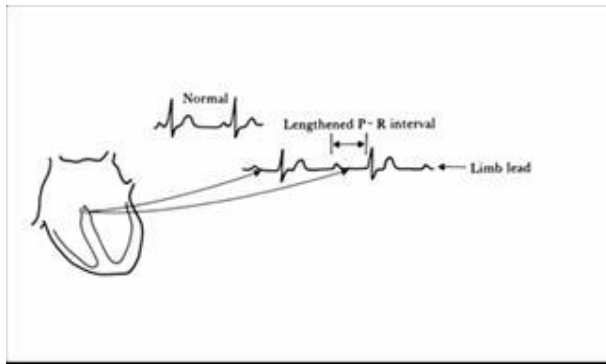


Figure 6. Atrioventricular block.

4 CONCLUSIONS

The main goal of this work is to develop an electrocardiogram with self-diagnosis functionality. An experimental setup was designed. The hardware acquisition system was developed in order to pre-amplify and filter the ECG signal. Also, it includes an interface for the electrodes. A MATLAB-based software was developed for ECG signal acquisition and processing. The algorithms used determine the peaks P, Q, R, S and T and calculate the correspondent intervals P-R, QRS and Q-T. The user can select an interval and obtain information about the contents. The first tests were done for cardiac problems related with the P-R interval.

As future work, the extraction of atrial signal during atrial fibrillation requires nonlinear signal processing since atrial and ventricular activities overlap spectrally and, therefore, cannot be separated by linear filtering. Average beat subtraction is the most widespread, best validated, and clinically applied technique for atrial signal extraction and relies on the fact that AF is uncoupled to the ventricular activity. Principal component analysis (PCA) and independent component analysis (ICA) are other approaches that can be used to separate atrial fibrillation from ventricular activity (Bollman & Lombardi, 2006).

This low-cost ECG system shows good results and can easily be used as rapid and reliable point-of-care diagnosis equipment.

5 REFERENCES

- Berberi, E. J., 2000, Principles of Electrocardiography, The Biomedical Engineering Handbook: Second Edition, Boca Raton: CRC Press LLC.
- Bollmann, A. & Lombardi, F., 2006, Electrocardiology of atrial fibrillation, IEEE EMBC Magazine, pp.15-23, December.
- Neuman, M. R., 1992. Medical Instrumentation, Application and design, Webster Editor, Second Edition, USA.
- Petrutiu, S., Ng, J., Nijm, G. M., Al-Angari, H., Swiryn, S., & Sahakian, A.V., 2006, Atrial fibrillation and waveform characterization," IEEE EMBC Magazine, pp.24-23, December.
- Stein, E., 2000. Rapid Analysis of Electrocardiograms, Lippincott Williams & Williams Inc., USA.