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Design of a Tele Medical channel Dedicated to telemonitoring of cardiac Insufficiency by correlative analysis

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Abstract: *The Telemedicine is a new form of improvement of health care quality through new information and communication technologies, it also creator of a new services facilitating the daily lives of patients with chronic diseases such as cardiac insufficiency, like professionals, allowing them to be in permanent relation with their patients receiving vital and pertinent parameters representative of their physiopathological states.*
We propose in this work the presentation of a telemedical interface development dedicated to telemonitoring of cardiac function through a correlative analysis.
This interface comprises a DTE (Data Terminal Equipment Medical Treatment) which is dedicated to recording of the myocardium electrical activity (electrocardiogram ECG) revealing an eventual deficiency of cardiac function, using an electrocardiographic amplifier constructed around a microcontroller 16F876A, Charged to digitizing the signals issued from EDTM and transfer them to a terminal local computer. A Soft interface is developed on Visual Basic environment, which is charged to control the acquisition, correlative analysis, archiving and the transfer of a medical data through medical networks via TCP / IP protocol for purposes such as prevention of sudden death, therapeutic monitoring, medical assistance at home and the urgent intervention of telemedical actors.

Keywords*-cardiac Insufficiency, Electrocardiography, Tele monitoring, Correlative Analysis, Visual Basic, TCP/IP.*

I. INTRODUCTION

Cardiac insufficiency [1] is the incapacity of heart to pump enough blood to respond the needs of the [2] organism. It is a chronic disease touching approximately 2% of the world population and 10% of patients older than 80 years [3]. This last is at the origin of repeated hospitalizations and an impaired quality of life of patients with a very high risk of sudden death touching two on three patients [3]. Indeed, 40% patients die in the year of diagnosis cardiac Insufficiency.
Indeed, 40% of patients die in the year of their diagnosis of cardiac Insufficiency.
The objective of our work is Therefore to realize a telemedical channel able to ensure a telemonitoring of cardiac function by the acquisition of electrocardiographic signals.
These ECG signals benefit from a digital processing realizing the following functionality:
The autocorrelation, the layout of the envelope of the autocorrelation function, the approximation of the envelope of the autocorrelation function by determining their respective attenuation coefficients.
A follow-up in telemonitoring of patients with cardiac Insufficiency [4] and the closer clinical monitoring of patients suffering with this disease limits the number of hospitalizations [5].

II. MATERIALS AND METHODS

II.1. COLLECTION OF ELECTROCARDIOGRAPHIC SIGNAL

The ECG signal is collected on derivation DI [6] by means of a classical amplifier of instrumentation (figure1) [7].
It was constructed around a 16F876A microcontroller [8] equipped with a 10bits ADC module and a USART module with Sampling frequency of 2,4KHz .
Local Protocol Communication (RS232): The parameters RS232 [9] which we have used are:
Transmission speed 57600 bauds
8 bits of data
A bit of parity
A bit of stop
Distant Protocol Communication: The distant transmission of the electrocardiographic signals is done according to protocol TCP/IP [10] in order to connect the different actors of telemedicine.

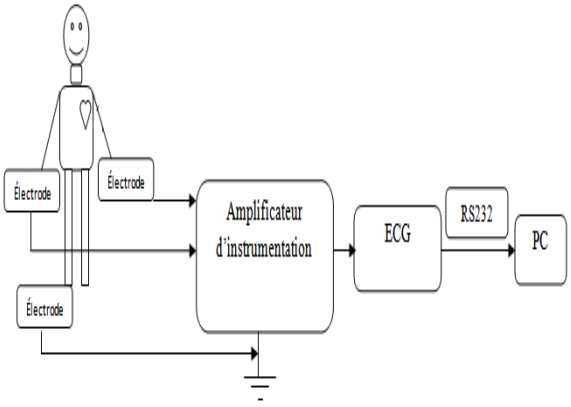

Fig.1 Diagram block of the ECG system

II.2. CORRELATIVE ANALYSIS

Correlative Analysis permits the calculation and plot of the autocorrelation function of the ECG signal. The calculating algorithm of the auto correlation discrete functions has been implemented in accordance with the following relation definition (i.e., (1)) [11]:

$$K_x(\tau) = \frac{1}{N}\sum_{k=\tau}^{N} x(k)*x(k-\tau), \text{avec:} N=2^q \quad (1)$$

et $\tau=0,..,N.$

We have $N=2^{12}=$ 4096 (Corresponding to the number of the sampling signal).

III. RESULTS

In this work, we are targeting the problematic of telemonitoring of cardiac Insufficiency by a correlative analysis showing in particular the attenuation coefficients, which seem to be relevant indices for pathological cases.

III.1. INTERFACE OF ECG ACQUISITION AND FILES TRANSFER

We present the interface of communication and ECG file transfer between the patient and the doctor implemented on Visual Basic environment.

The principal window of the patient consists of command buttons to manage connection, transfer and display of the patient files recorded previously.

The figure 2.a and the figure 2.b show the transfer interface of the file patient towards the televigilance center or telemedical center.

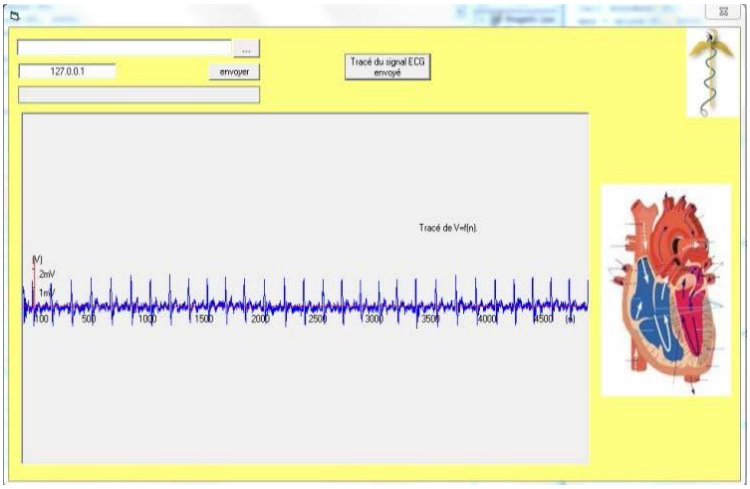

Fig. 2.a Patient acquisition and Transfer interface

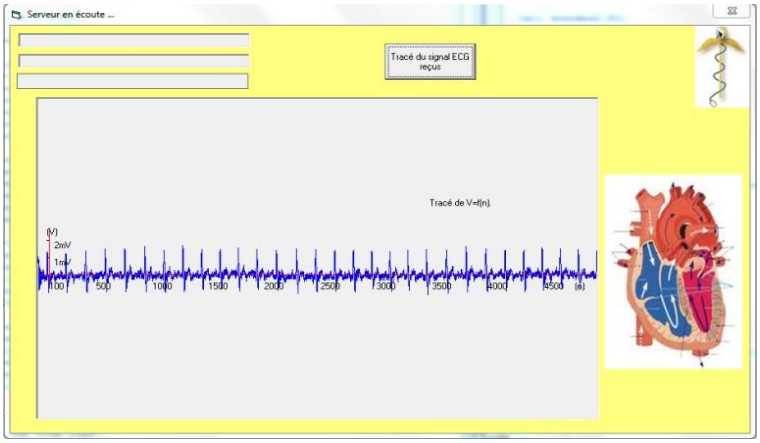

Fig. 2.b Doctor acquisition and transfer interface

III.2. AUTOCORRELATION FUNCTION

To extract the information from different signal we have used the autocorrelation function of an ECG signal is shown in figure 3

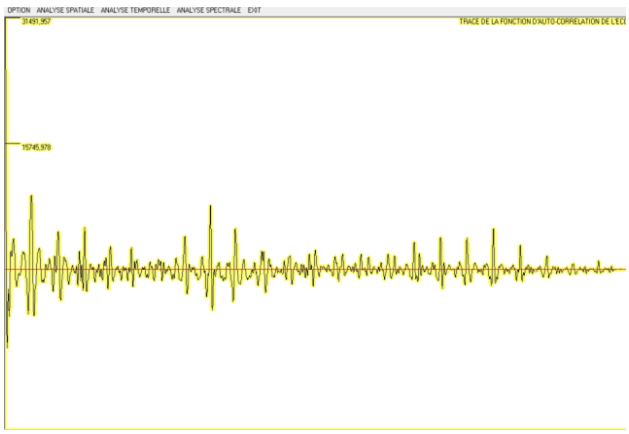

Fig. 3 Layout of the autocorrelation function of an ECG signal

III.3. LAYOUT OF THE ENVELOPE OF THE AUTOCORRELATION FUNCTIONS

Establishing relevant indices of informative processes such as physiological signals is fact by means of the envelope of the autocorrelation function which allows to deduce the attenuation coefficients of this one. It seems to us interesting to put at the disposal of medical practitioners these indices for the prevention of acute phases of cardiac Insufficiency.

The determination of the envelope and the calculation of the attenuation coefficients is done by using the low pass filter.

- The transfer function of an ideal low pass filter (i.e., (2)) is:

$$H(f) = \Pi_{2F_M}(f) \qquad (2)$$

Consequently its impulse response (i.e., (3)) is:

$$h(t) = 2F_M \frac{\sin 2\Pi F_M t}{2\Pi F_M t} \qquad (3)$$

The transfer functions of a simple filter in sight of its electronic materialization has a following equation (i.e., (4)):

$$\frac{V_S}{V_E} = \frac{1}{1+jRC\omega} \qquad (4)$$

Which have a cutting frequency (i.e., (5)): $f_c = \frac{1}{2\Pi RC}$ (5)

This filter is use to extract the averages values or the signal envelope.

Layout of the envelope of the autocorrelation function applied to the ECG signal (figure 4).

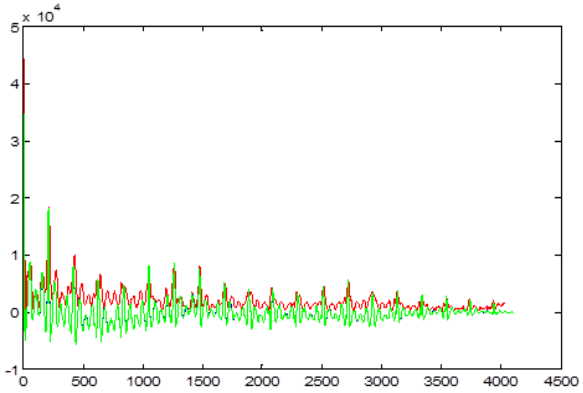

Fig.4 Plot of the envelope applied to signal ECG

• The approximation of the envelope of the autocorrelation functions:
The approximation of the envelope of the autocorrelation function was obtained by determining the attenuation coefficients using the algorithm that involves a decreasing exponential (figure 5) according to the following definition equation (i.e., (6)):

$$Y = Ae^{-\propto b} \qquad (6)$$

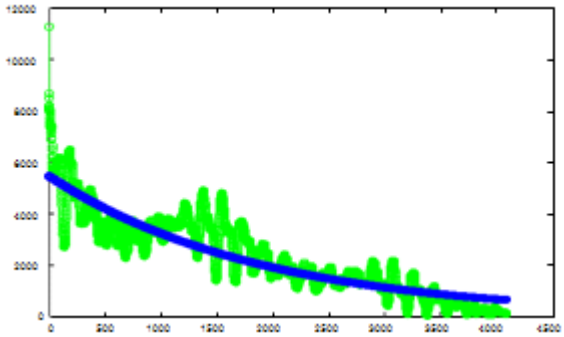

Fig.5 Plot of the envelope approximation applied to the ECG signal

• Presentation of attenuation coefficients α of autocorrelation function corresponding to the ECG signals (table 1).
From table 1, we remark that the attenuation coefficients (α) of ECG have the same value approximately around of 0.45.
Table 1. Presentation of the attenuation coefficients α of the autocorrelation function of ECG signals of ten volunteers.

Signal	$C_0(1)$ (A)	$C_0(2)$ (b)	Filter
Ecg1	$4.11*10^{3}$	$0.51*10^{-3}$	Low pass filter
Ecg2	$2.01*10^{3}$	$0.43*10^{-3}$	Low pass filter
Ecg3	$2.27*10^{3}$	$0.48*10^{-3}$	Low pass filter
Ecg4	$3.77*10^{3}$	$0.41*10^{-3}$	Low pass filter
Ecg5	$1.99*10^{3}$	$0.41*10^{-3}$	Low pass filter
Ecg6	$2.12*10^{3}$	$0.42*10^{-3}$	Low pass filter
Ecg7	$3.15*10^{3}$	$0.49*10^{-3}$	Low pass filter
Ecg8	$4.27*10^{3}$	$0.52*10^{-3}$	Low pass filter
Ecg9	$2.31*10^{3}$	$0.47*10^{-3}$	Low pass filter
Ecg10	$1.95*10^{3}$	$0.41*10^{-3}$	Low pass filter

IV. CONCLUSION

The assumption of responsibility of the chronic cardiac insufficient patient is a real problem of health public.

The incidence of this disease increases considerably with age and exposes patients to several hospitalizations.

This paper is for us the occasion to present works which are articulated around the design of a telemedical support dedicated to telemonitoring of the cardiac function by the means of a cardiac functional exploration using electrocardiography which permits to evaluate the severity of cardiac deficiency.

The elaboration of a telemonitoring process of the cardiac function by electrocardiography appeared to us the most interesting because of its mobility, its non invasivity, its reliability as well as the facility of its use by the patient himself or any else actor of the telemedicine.

The local control parameters established a hardware and software device based on a microcontroller and RS232 protocol. The distant control uses the TCP / IP protocol involving the Winsock component in Visual Basic programming environment.

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