TELECOMMUNICATIONS

TS114

REPORT

Report

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1 Introduction

1.1 Presentation of the MICA project

The main purpose of this project is the development of a MATLAB application that will be used in the medical field to help cardiologists to quickly detect potential heart pathologies when given an electrocardiogram.

1.2 Cardiac anatomy and physiology

1.2.1 General presentation

The main pathologies studied will be Tachycardia, Bradycardia, Ectopic beat and Fibrillation. The aim of this application is therefore to be able to detect through an electrocardiogram different anomalies such as:

- A too high or too slow heart rate for Tachycardia and Bradycardia
- Ventricular premature contraction for Etopic beat
- A flat spectral content for the atrial fibrillation
- The absence of traditional P,Q,R,S and T waves in the case of a ventricular fibrillation

Here are two examples of electrocardiograms, one of a healthy person as shown on figure(1) and the second of a person suffering from ventricular fibrillation figure(2).

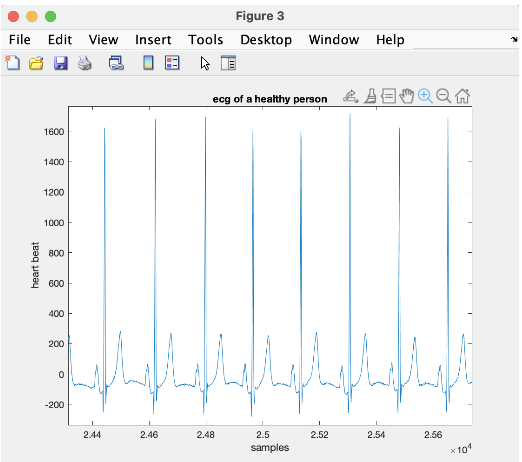

Figure 1: Electrocardiogram of a healthy person

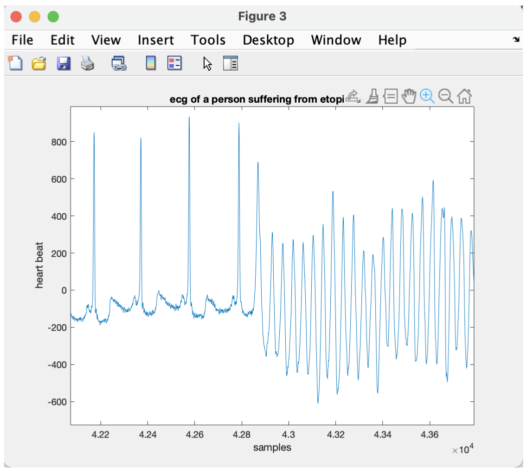

Figure 2: Electrocardiogram of a person suffering from ventricular fibrillation

Those electrocardiograms are clearly different, but the purpose of the project is to automatically detect which potential cardiac disease the patient might be suffering from.

Another way to visualise the cardiac features of a patient is the spectrogram, it represents the spectrum of the frequencies of a signal as it varies with time. Here are the spectrograms of the associated previous ECG (healthy person figure(3) and the person suffering from ventricular fibrillation figure(4)).

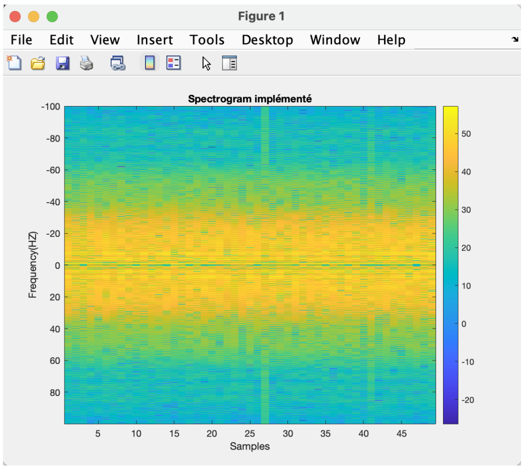

Figure 3: Spectrogram of a healthy person with a hamming window of 8 secondes

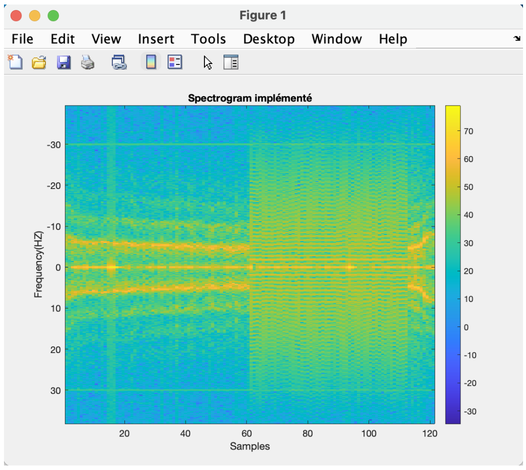

Figure 4: Electrocardiogram of a person suffering from Ventricular fibrillation

On the first spectrogram a wide frequency band can be seen disclosing the constant frequency of the heartbeat of a healthy person. On the other hand the second spectrogram, corresponding to the ventricular fibrillation, highlights, thanks to the fine yellow horizontal lines, the sinusoidal aspect of the signal. This aspect is only noticeable from the second half of the samples, due to the fact that the patient does not have ventricular fibrillation until a precise moment.

2 Detection of PQRST complexes

2.1 Pan and Tompkins algorithm

2.1.1 general presentation

The first objective of the project is to find the PQRST complexes (as shown in figure(5)) on an ECG signal in order to be able to analyze the various diseases related to the heart. Indeed, these complexes are highlights of a signal that characterize it.

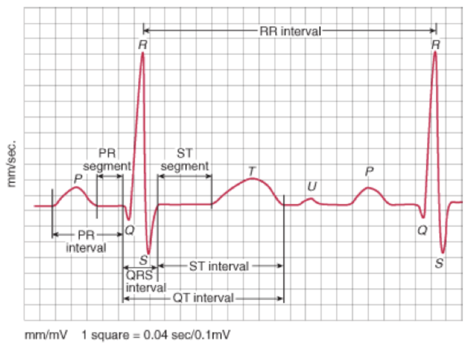

Figure 5: P,Q,R,S,T complexes

First of all, the R waves are the easiest to detect as they correspond to the maximums. The algorithm of Pan and Tompkins allows the detection of these complexes. This step process is described in the following diagram figure(6).

Figure 6: Signal after PTA

It is based on a windowing process that will generate a signal with an amplitude of zero except at the locations of the PQRST complexes, so that it will be much easier to detect these complexes when knowing an interval in which they are included.

2.1.2 Band-Pass filter

At the input of the algorithm is the ECG signal. A bandpass filter is applied to it, in order to reduce the signal's noise, which is implemented as a combination of a low-pass filter and a high-pass filter. Both filters are causal (the output of the filter only depend of passed instants), of Infinite Impulse Response (IRR) (the output at the instant n depends of the output at instants $n - \tau$), are linear phases filters with a group delay of respectively 3 and 6 samples. The output signal after filtering for a healthy heart is represented in figure(7).

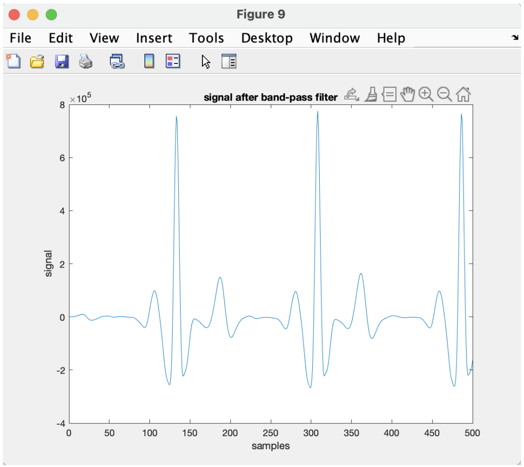

Figure 7: signal after band-pass filter

However, filtering induces a delay due to the convolution which will have to be handled later with the function $fvtool()$

2.1.3 Derivative Filter

After filtering, the signal is differentiated to provide information on the slope of the QRS complex using a five-point differentiation filter. This filter is this time non-causal (because the output at an instant t depend of the output at instants $t + \tau$ with $\tau > 0$) it has a Finite Impulse Response (FIR), a linear phase and a group delay of 5 samples. After filtering this is the shape of the signal figure(8):

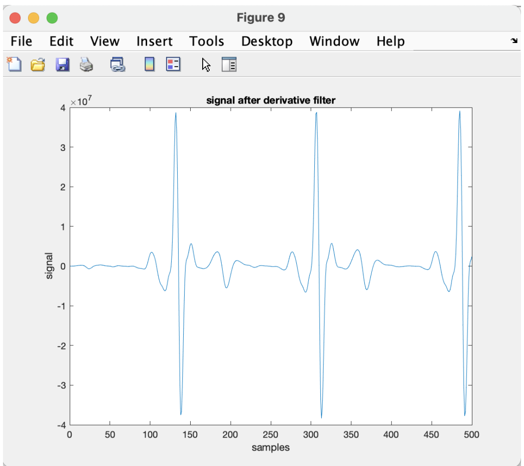

Figure 8: signal after derivative filter

2.1.4 Signal Squared and Moving Window Integration

The signal is then squared to intensify the local extremas. Then, convolved by a window in order to work on a precise interval. The output signal is represented in figure(9).

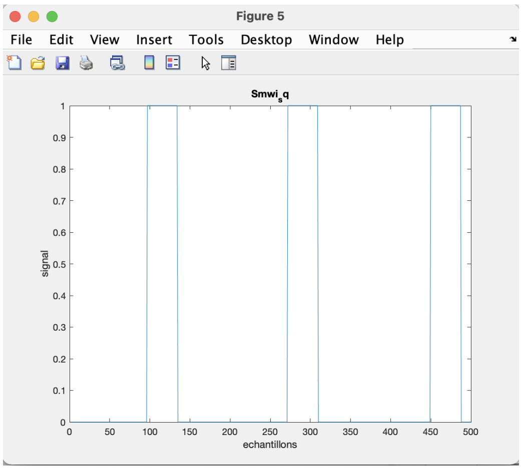

Figure 9: signal after window moving integration process

2.1.5 Thresholding

Finally, the thresholding step is used to translate the signal in a binary one, so that when convolved with the initial ECG, the final signal has an amplitude of zero everywhere except where the R pics are located. The R_{waves} will then be the maxima of the signal in each section where the signal is not zero. Here is the result of the Pan and Tompkins algorithm figure(10).

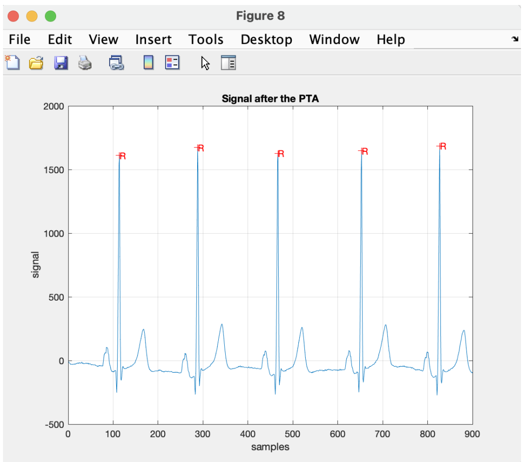

Figure 10: Signal after the detection of maxima

The position of the R waves will be enough to detect all the other complexes.

2.1.6 PQRST Complexes

Once the R waves are located, the Q and S waves are defined respectively as the first minimum before and after the R waves.

Figure 11: Signal with detection of QRS complexes

The T_{wave} is then the maximum between the first R peak and 0.7 times the R,R interval. To find it, the ECG signal must be filtered with a differentiator and then a low pass is applied to it. This makes it possible to detect the position of the T_{waves} symbolized as the moment when the signal obtained crosses 0. Finally, the P_{wave} is the maximum in the remaining part of the interval used for the T_{waves}. Once obtained these different points will lead us to identify diseases with the help of given ECG signals.

3 Presentation of the application and of results

3.1 Tachycardia/Bradycardia

Once the PQRST complexes have been detected, the application will be able to determine the heart rate and therefore be able to detect pathologies linked to an unusual cardiac rhythm such as Tachycardia or Bradycardia. Indeed a Bradycardia is declared when the cardiac rhythm falls under 60 bpm while Tachycardia is characterized by a rhythm above 100 bpm. The application will therefore compute the mean of all the occurrences of R-R intervals contained in the ECG signal considered. The bpm obtained for a normal patient is the following one:

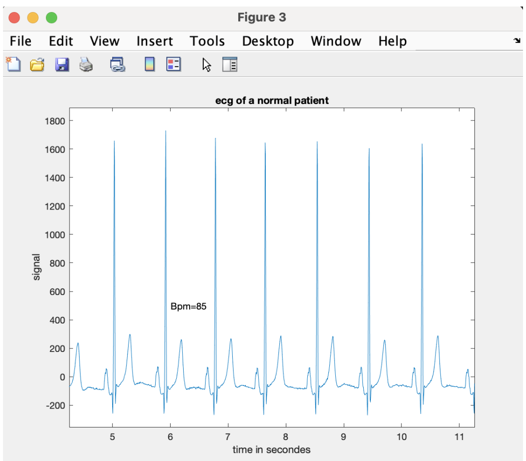

Figure 12: ECG of a normal patient bpm=85

3.1.1 Bpm Comparison

signal	AF	noiseBL	noisePL	normal$_1$	normal$_2$	normal$_3$	normal$_4$	PVC	SSS	VF
bpm	132	74	74	67	67	69	104	76	64	110

3.2 Ectopic beats

Ectopic beats are defined as an atrial or ventricular premature contraction. They alter the duration of the R-R interval. More precisely they induce the appearance of an early R wave, followed by a prolonged R-R interval until the next normal beat. To detect them it is a bit more complex than an increasing or decreasing heart rate because the general cardiac rhythm won't be too affected by a simple premature contraction. However, Etopic beats can be declared when the difference between the instant of the n-th and the $(n+1)$-th R_wave is greater than ϵ, a number chosen as a reference value of the ideal time of the R-R interval.

$$|\Delta_n - \Delta_{n-1}| > \epsilon$$

3.3 Fibrillation

3.3.1 Atrial Fibrillation

The atrial fibrillation is in practice define by an almost flat spectral content, unfortunately the application does not yet allow the detection of this type of cardiac anomalies.

3.3.2 Ventrial Fibrillation

Ventricular fibrillation is characterised by a total absence of traditional P,Q,R,S and T waves and by an ECG similar to a pure sine (as shown in figure(13)).

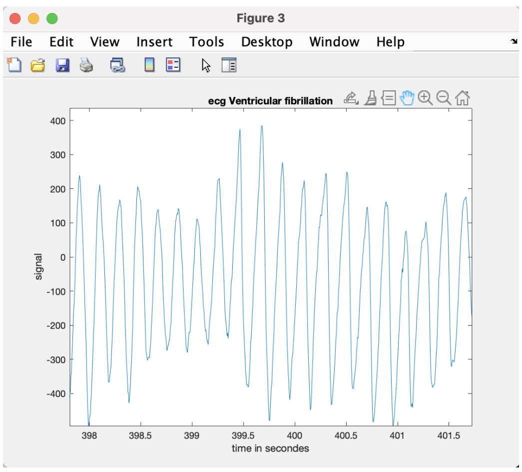

Figure 13: ECG Ventricular fibrillation

The algorithm implemented on the project is not able to process this kind of signals and can't correctly figure out the location of P,Q,R,S and T complexes and therefore can't compute the real bpm of the signal.

4 Conclusion

This project highlights the principle heart disease detection. First, with the implementation of a Matlab function to visualise spectrograms of ECG, then by working on an algorithm to detect points of interest in an electrocardiogram (PQRST complexes). The algorithm (Pan and Tompkins Algorithm) is based on signal processing with the use of filters to reduce potential noises (band-pass filter), to provide QRS complex slope information (derivative filter), to intensify local extremas (squared filter), and to select a specific zone (windowing process).

The summary of the processed signals is illustrated in figure(14).

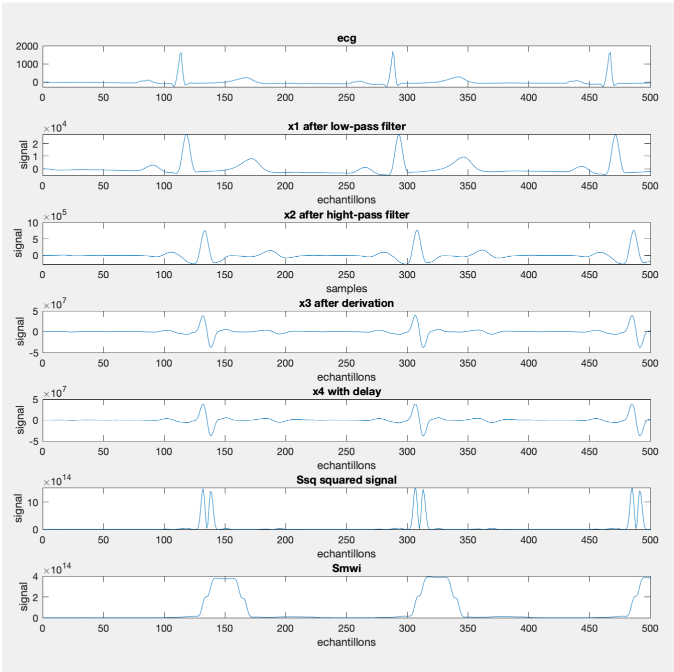

Figure 14: ECG Ventricular fibrillation

The project goals was then to take advantage of these signal processing means to detect cardiac pathologies. The project still need to be improved, indeed the scripts made for etopic beat and fibrillation do not allow the abnormalities to be detected correctly. this project was carried out in pairs with an equivalent participation of both of the two members.

5 References

[1] Project subject:https://rtajan.github.io/assets/cours/TS114/TS114-project.pdf

Rapport de stage:

Introduction:

L'entreprise FCP-Digitale est l'agence de création du Groupe Copy-media. Son champ d'intervention s'étend de la creation de support de communication institutionnelle, promotion des ventes, publicité, marketing, événementiel, site internet, web, blog, e-commerce, digital marketing jusqu'à l'impression. L'entreprise Copy-média crée il a 27 ans dans la région bordelaise est aujourd'hui constituée de 25 collaborateurs, des designers, graphistes, développeurs web, imprimeurs, et des administratifs. En tant que développeur web mes missions étaient de répondre aux besoins de clients demandant des prestations liées à la création ou la maintenance de sites internets. Dans la première partie sera faite une présentation succincte de la structure de l'entreprise. La seconde partie abordera l'ensemble des travaux qui m'ont été confiés. Enfin une conclusion dressera un bilan des résultats obtenus ainsi que des perspectives de travail.

Présentation de l'organisme d'accueil:

Fonctionnement global de la société:

L'ensemble des 25 collaborateurs de l'entreprise Copy-media travaillent dans un même bâtiment situé à Canéjan. Le bâtiment contient plusieurs presses numériques dernière génération ainsi que du matériel de façonnage et de reliure pour la conception d'ouvrages, cartes de visites, menus de restauration où tout visuel demandé par un client. Le fonctionnement générale de l'entreprise fonctionne de la manière suivante: Les commandes des clients sont reçues majoritairement par appels téléphoniques pris par un des deux téléconseillers, un devis sera effectué dans la journée pour la demande du client qui sera rappelé pour déterminer avec exactitude le cahier des charges demandé par le client. Pour accélérer ce mode de fonctionnement une de mes missions que je détaillerais par la suite, aura été d'implémenter un système de formulaire par lequel les clients pourront effectuer eux même un pré-devis via le site internet. Une fois le devis effectué la commande est traité par un des 7 graphiste qui se chargera du visuel du produit (carte, site internet, livre) une fois le produit designé numériquement celui ci est envoyé au client afin de validé si le produit est bien conforme au attentes du client. Une fois la validation effectuée le produit est envoyé en mise en production soit au niveau de l'imprimerie dans le cas d'un produit physique, soit au niveau du service web dans le cas où le client demande la création d'un site internet. Enfin dans le cas d'un produit physique celui ci est envoyé via un service de livraison. La structure de l'entreprise étant de petite taille il était très intéressant de pouvoir observer la totalité de la chaîne de travail de la commande à la livraison en passant par la chaîne de production.

Fonctionnement de mon service