POLITECNICO DI MILANO

Corso di Laurea in Ingegneria Biomedica
Dipartimento di Elettronica, Informazione e Bioingegneria

Long QT syndrome

QT Interval Analysis on Diagnostic Electrocardiograms

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Abstract

In this study we suggest a method for automatic mesaurement of the QT interval. The method derives from the standard technique of peak detecion and from the mesaurement of the distance between them. Our purpose is to recognize the QT interval and define if the pazient is affected or not by the Long QT Syndrome, a heart rhythm condition that can potentially cause fast, chaotic heartbeats.

Thanks to a good approssimation we identify the QT interval and, according to specific threshold,we classify patients in healthy, pathological or borderline.
We verified our algorithm using several signals taken from Physionet QT DataBase.

Chapter 1

Introduction

An ECG measures electrical impulses as five distinct waves. Doctors label these five waves using the letters P, Q, R, S and T. The QT interval is defined as the time interval from the beginning of the depolarisation of the ventricles, represented by the QRS complex within the ECG, and the end of the repolarisation, which is represented by the T wave in the ECG.

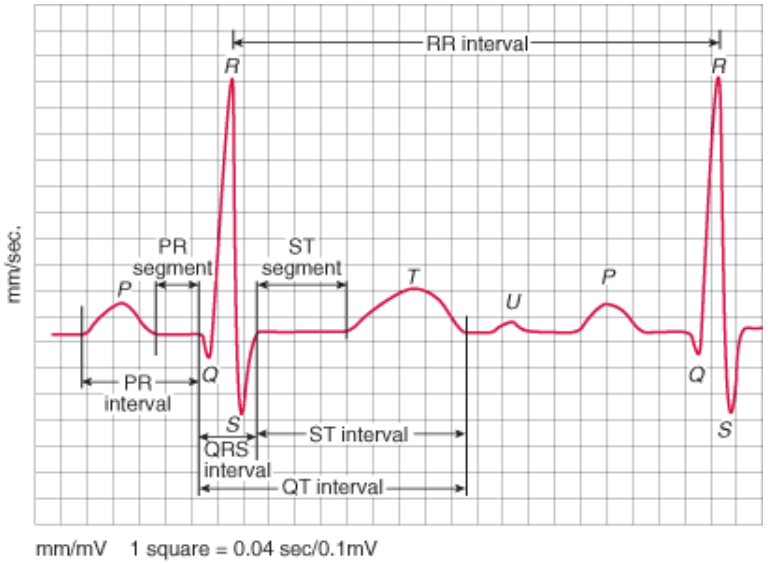

Figure 1.1: ECG

It is a well established parameter in clinical diagnostics; effectively we can establish that QT prolungation favours cardiac arrhythmias and, therefore, it is an important cardiac risk factor.
These rapid heartbeats might trigger a sudden fainting spell or seizure. In some cases, the heart can beat erratically for so long that it causes sudden

death. It results from an increased action potential duration of the ventricular myocardium.
Risk factors for long QT syndrome include the following:

- female sex;
- increasing age;
- liver or renal impairment
- family history of congenital long QT syndrome
- bradycardia
- pre-existing cardiovascular disease
- electrolyte imbalance
- concurrent administration of interacting drugs

Long QT syndrome is treatable: you might need to take medications to prevent a chaotic heart rhythm and, in some cases, treatment for long QT syndrome involves surgery or an implantable device.

Many ECG recording systems from several manufactures have implemented a QT measurement unit. Nevertheless, these measuring devices are often not very reliable. Especially in the case of abnormal T wave morphologies they often fail in correctly measuring the QT interval, that's why we had to do some approssimations too.
In this work we suggest an algorithm which, through the detecion of, first QRS complex, then Q and T waves significant points, mesaures the QT interval and establishes if the pazient is affected by the LQTS or not.

Chapter 2

Methods

We developed our algorithm on Python, a widely used high-level, interpreted, dynamic programming language. We actually used Python 2.7 because Python 3.5 didn't support some of the libreries we had to use.

The algorithm has been developed using the PhysioNet QT Database.
These files, which contain the samples of the signall you want to analyze, are csv file, so they have to be opened as follow:

```
with open('signal') as csvfile:
readCSV = csv.reader(csvfile, delimiter=',')
```

2.1 QRS detection

Before detecting the characteristic points, QRS complex markers had to be available, so the signal was split into single heart beats and for each beat the characteristic points were detected separately.
Another parameter we need to know is the sampling frequency (fs) calculated starting from the distance between two samples.
The code below loads an ECG signal from the examples folder, filters it, performs R-peak detection, and computes the instantaneous heart rate:

```
ecgout = ecg.ecg(ecgdata, fs, show=False)
```

In order to identify the heart rate we caluclated the R-R interval which is the time between QRS complexes. Here we had to introduce two approximations:

1. According to several statitics, the isoelectric segment (0 mv) after T wave find itself at 0.6

2. We calculated deltaT0 and deltaIndex(number of samples in deltaT0) as 1/20 of RR interval and choose it as Q significant point.

We need to find them because the QT interval is measured from the beginning of the QRS complex until the end of the T wave. The reason why we included in the calculation also the QRS is due to the fact that the repolarization of some areas begins when other are still depolarizing.

Before going on we filtered the signal in order to have it clearer.

2.2 Q and T detection

It is very important that the number of T significant points corresponds to the number of Q significant points beacuse we have to compare them beat by beat.
So we introduced two coinditions:

1. The first check if, when R peak is situated at the beginning of the registration, Q significant point is present or not (it *has* to be present);

2. The second check if, when R peak is situated at the end of the registration, T significant point is present or not (it *has* to be present too).

Thanks to the approximations done before and to these considerations we found Q and T peaks:

1. *Q detection*:we found it as the minimun of the function, cosidering as function the part of signal between

   R peak, identified by index "i"
   and
   the isoelectric part of the signal before the QRS complex, identified by
   i-2deltaIndex

2. *T detection* :we found it as the maximum of the function, considering as function the part of the signal between

   the end of R peak, identified by
   "i" + deltaIndex
   and
   the isoelctric part of the signal after T peak,identified by
   i+deltaIndex+K+1.

Once founded those peaks, we founded when they actually verified (time in ms) and, starting from Q peak detection, we founded its significant point that is when the signal counts 0 mv just before Q peak, while, starting from T peak detection, we founded its significant point that is when the signal counts 0 mv just after T peak.

2.3 QT interval mesaurement

After calculating the length of the QT interval as the difference between the end of T wave and the beginning of Q wave, we could established if the patient was affected or not by the syndrome. We compared our results with these thresholds:

QT interval	Men(ms)	Women(ms)
Normal	less than 430	less than 450
Borderline	431-450	451-470
Extended	more than 450	more than 470

Chapter 3

Results and Conclusions

The algorithm presented was developed and optimized using differnt QT-DBs only. Once given the ECG samples, it evidences the status of the patient. We imposed that even the presence of only one outlier meant a pathological status, an approximation, as actually the presence of an abnormal value doesn't necessarily mean that the subject is pathological (it could be physiological).

The programme gives as output the values of QT interval colored in green if the length in normal, yellow if borderline and red if pathological.
For exemple, using a QT-DBs taken from Physionet, we obtain:

QT interval:

0.424
0.428
0.428
0.424
0.432
0.424
0.428
0.432
0.428
0.424

BORDERLINE

Furthermore the ECG signals with its significants points is rapresented on a graphic:

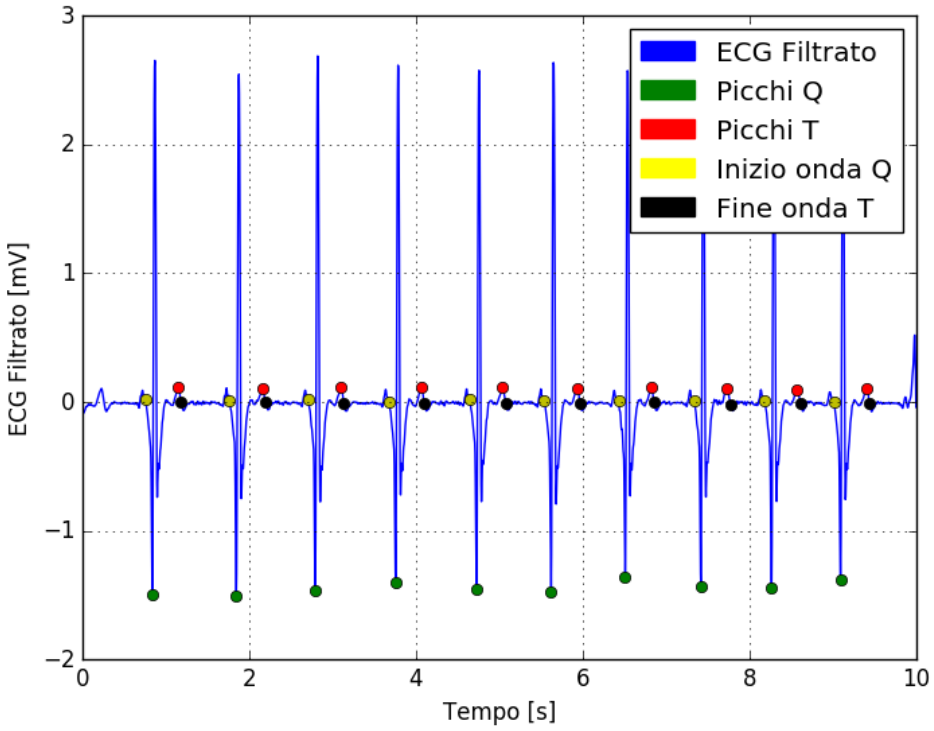

Figure 3.1: ECG signal and significant points

Bibliography

[1] Baldissera, F.(2009). *Fisiologia e biofisica medica*. Poletto.

[2] Downey, A. , Elkner, J. e Meyers,C. (2003). *Pensare da informatico - imparare con Python* .Green Tea Press.