Analysis of electrocardiographic (ECG) signals

Abstract

Our goal was detection of heart beats using ECG and pulsatile signals. We implemented detection algorithm in Matlab, inspired by an article by Marcus Vollmer [1]. Testing on the dataset from 2014 PhysioNet challenge [2], using 100 records, we obtained 99.71% sensitivity and 99.86% positive predictivity.

Introduction

Detecting heart beats is a ubiquitous problem in analysis of ECG and pulsatile signals. Therefore it is important to have automatic detection algorithms with high accuracy, i.e. high sensitivity and positive predictivity to control patient's heart beats and trigger an alarm, if necessary.

Methods

Our algorithm at start takes first 30 seconds of the record and tries to detect heart beats twice, using ECG and BP signal separately. Then it decides which mode (ECG or BP) it will use for the whole record. ECG signal is default, but if it uses BP signal we also need to consider and calculate the delay it has according to the ECG signal.
First we apply trimmed moving average filter to the signal and after that we apply range filter, as it was proposed by Vollmer. Range filter uses local maxima and minima, use of which represent dynamic threshold for beat detection. Then we use squared maximal value in a certain time window and set the final threshold as the mean of the obtained signal. After that we go through the raw input signal again and detect beats using final filtered signal. Finally, we check RR intervals and compare the time between detected beats. Differences between RR intervals show us which beats were probably incorrectly detected, so we remove them. At the end we calculate time delay, if we are using BP signal for detection.

Results

Our final results are very similar to the ones mentioned in Vollmer's article. Comparison is shown in the table below. Our algorithm obtained almost as good results as in the original work from Vollmer and is also relatively fast, it needs around 1 second to detect beats in a 10 minute record.

	Vollmer's report	Our algorithm
Sensitivity (SE)	99.89%	99.71%
Positive predictivity (+P)	99.93%	99.86%

Discussion

We believe that our algorithm has pretty good accuracy and could be used in real life problems. There were very few beats that were not detected or they were detected but did not exist, so possible improvements on used database [2] would be hard. Perhaps we could test our algorithm on some other dataset and if the results would not be so good, we would need to look at those records and improve the way our algorithm works in those cases.

References

[1] http://cinc.org/archives/2014/pdf/0569.pdf
[2] https://physionet.org/challenge/2014/
[3] https://ucilnica.fri.uni-lj.si/course/view.php?id=151