OBSS Assignment #1: Analysis of electrocardiographic (ECG) signals

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We have implemented a simple QRS detector and evaluated it on the MIT-BIH database.

1 Introduction

In this assignment we implemented and evaluated QRS detector based on the idea presented in paper *"A moving average based filtering system with its application to real-time QRS detection"* [1]. We evaluated our implementation on the MIT-BIH database [2] and compared our results to the results presented in the original paper.

2 Methods

The detector is composed of the 3 stages: (1) linear high-pass filter stage, (2) nonlinear low-pass filter stage and finally (3) threshold based detection stage. These stages are visualized on the Figure 1.

In the first stage, we calculate (1) M-point moving average of the raw signal and (2) delay of $(M+1)/2$ samples of the raw signal. The result of the first stage is difference between delayed and smoothed signal. As we can see from the Figure 1, baseline drift is removed and QRS complex segments are enhanced. M is parameter that should be of odd value, they recommend value 5 or 7 to be used.

In the second stage we calculate point-by-point squaring and a moving window integration. The recommended window size (parameter WSP) for 200 Hz sampling rate is 30 samples. The result of the second stage are peaks at the location of the QRS complex.

In the final stage we first detect peaks using a non overlapping sliding window. The size of the window is not stated in the original paper. We found out that the size of 90 samples (parameter WSD) gives best results. After that the threshold is dynamically computed using the recursive equation

$$Threshold = alpha * gamma * PEAK - (1 - alpha) * Threshold$$

, where alpha is forgetting factor (recommended 0.05) and gamma is weighting factor (recommended 0.15).

The locations of the detected peaks that exceedes the corresponding threshold value are the locations of the detected hearth beats.

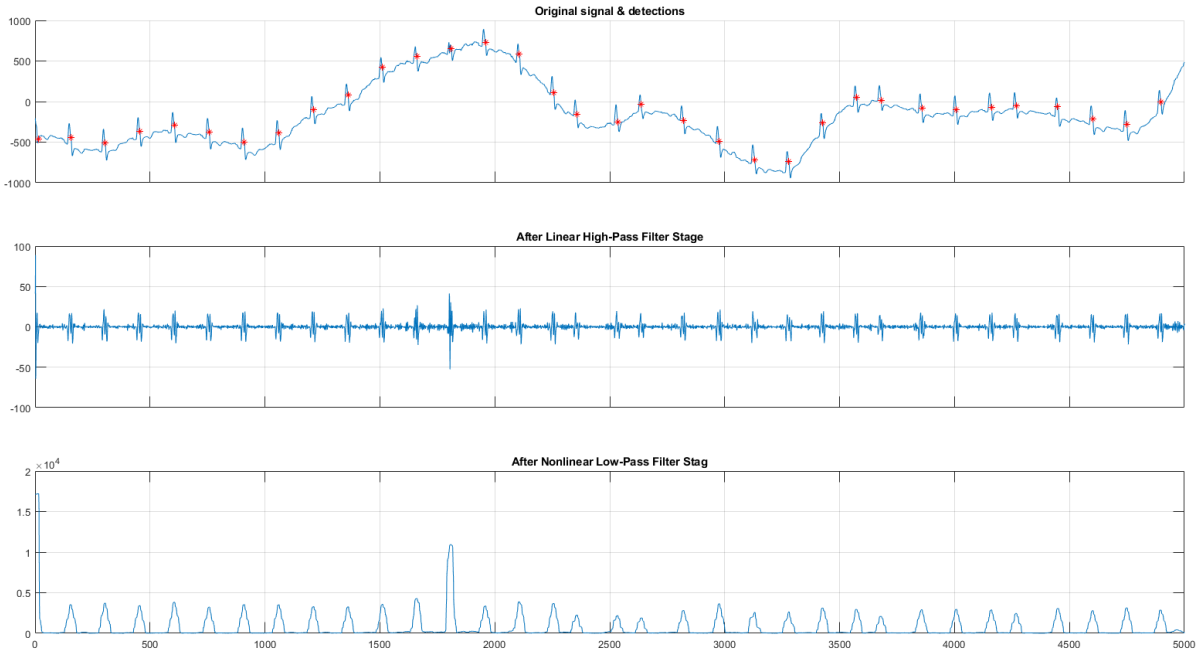

Figure 1: Visualization of the original signal and the detections along with the intermediate signals after the stage 1 and after the stage 2 processing. Parameters used: *M = 5; SWP = 30; SWD = 90; alpha = 0.05; gamma = 0.15.*

3 Results

We have evaluated our implementation with different parameters on the MIT-BIH database [2] using the WFDB Software Package and found the best set of parameters for the our implementation: *M = 5; SWP = 30; SWD = 90; alpha = 0.05; gamma = 0.15.* This setup give an average sensitivity of 99.79 and an average positive predictivity of 68.48. From the Figure 1 we can also observe that the detected hearth beats are a bit delayed, but still very close to the R point.

4 Conclusion

Despite its simplicity the implementations brings good results. We should further investigate the cause if a small detection delay. This method probably won't work for the extremely high/low hearth beat rate because of the fixed sliding window size.

References

[1] H. Chen, S.-W. Chen, A moving average based filtering system with its application to real-time qrs detection, in: Computers in Cardiology, 2003, IEEE, 2003, pp. 585–588.

[2] G. B. Moody, R. G. Mark, The mit-bih arrhythmia database on cd-rom and software for use with it, in: [1990] Proceedings Computers in Cardiology, IEEE, 1990, pp. 185–188.