Analysis of ECG signals with moving avarage based filtering for QRS complex detection

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***Abstract*—The aim of this analysis is to follow the methods used in the original article [1], to summarize the results obtained after execution on the "MIT-BIH Arrhytmia Database" [2] and to approximate and clarify the very development of the applied signal processing algorithm.**

I. Introduction

QRS Complex (henceforward "QRS") represents a ventricular depolarisation and activation on the ECG in order to check hearts rhythm and electrical activity. QRS detection is important as it has been set as a baseline for many automated diagnostic devices and it has proven to be the correct approach. Haphazardly a lot of noise signal can be caught when patient is undergoing a ECG test, thus veracious QRS detection is needed in order to do any type of analysis over ECG results. QRS Detection algorithm using moving average is a technique used to detect the onset of the QRS complex in a patient's ECG signal. This technique involves calculating the moving average of the signal, which is a smoothed version of the ECG signal. The moving average is calculated by taking the average of the last N samples of the ECG signal. Once the moving average of the signal is obtained, the onset of the QRS complex is detected by comparing the moving average with the ECG signal and by looking for a sudden increase in the amplitude of the signal. If a sudden increase in the amplitude is detected, it is assumed that the QRS complex is present. This technique is used to accurately detect the onset of a QRS complex and is used in various medical applications.

II. Methodology

In accordance with the original paper, the proposed algorithm has three distinct steps. Initially, a linear high-pass filter (HPF) based on a moving average is implemented. Subsequently, a nonlinear low-pass filter (LPF) is used to further refine the signal. Finally, a decision-making stage is employed to complete the algorithm.

Linear high pass filtering of QRS signal is a method used to remove low frequency components of the signal, such as the baseline drift and low frequency noise, while preserving the higher frequency components, such as the QRS complex. This is done by using a high pass filter to remove frequencies below a certain cutoff frequency. This cutoff frequency is typically set slightly higher than the lowest frequency of the QRS complex.

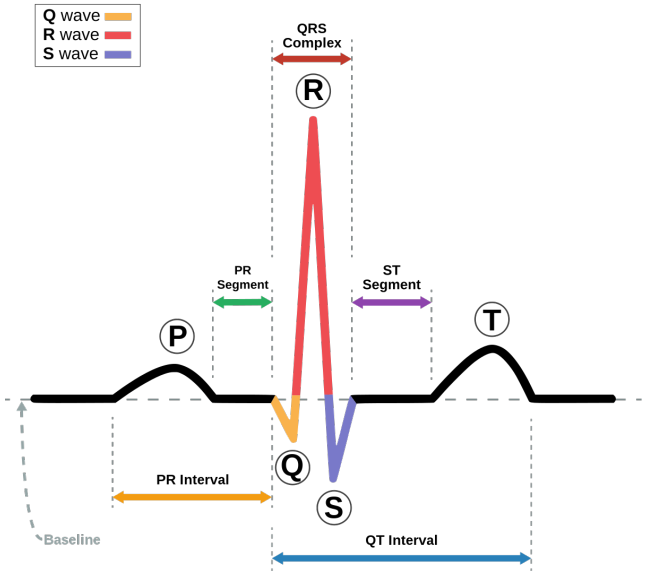

Fig. 1. A graphical illustration of the QRS complex. It is comprised of three parts: the Q wave, the R wave, and the S wave. The Q wave is a small, negative-going wave that is usually present at the beginning of the complex. The R wave is the highest and often the most prominent wave of the complex. The S wave is a small, negative-going wave that follows the R wave. Together, these three waves create the QRS complex that is found on an electrocardiogram.

Non-linear Low Pass Filtering of QRS signal is the process of removing unwanted high frequency noise from the signal while preserving the original shape of the signal. This additionally allows for the precise extraction of the QRS complex from the noisy ECG signal, as the low frequencies contain the most relevant information about the QRS complex. Visual representation can be observed on Fig. 2

The decision making process of filtering a QRS signal with a moving average involves taking the average of adjacent points in the signal in order to smooth out the overall signal. In this analysis I am using the minimum and maximum to set thresholds for the QRS complex and any signal that falls above or below these thresholds is discarded. Treshold is being calculated using the following formula from the original paper. Treshold = $\alpha \times \gamma \times$ peak + $(1 - \gamma) \times$ Treshold; α –

The forgetting factor alpha is a parameter used to control the amount of weight given to a given sample in the signal. It is used to set the balance between the current sample and the past samples in the signal, with a higher alpha value giving more weight to the current sample. This parameter is important in order to ensure that the QRS detection algorithm is able to accurately detect the QRS complexes in a signal, as it allows the algorithm to adapt to changes in the signal over time.; γ – Weighting factor gamma is a coefficient used in the QRS detection process that helps to reduce false positives and false negatives. It is used to adjust the weighting of the QRS detector, which helps to minimize the number of false detections in the signal.; Visual representation can be observed on Fig. 3

III. Results

For the experiment I have used 48 ECG samples from MIT-BIH Arrhytmia Database. Parameters were set to the values that can be observed in the table I.

TABLE I
PARAMETERS THAT SHOWED BEST RESULTS

Alpha	Gamma	MovingAverageWindow	SumInterval	Step
0.0385	0.16	5	10	180

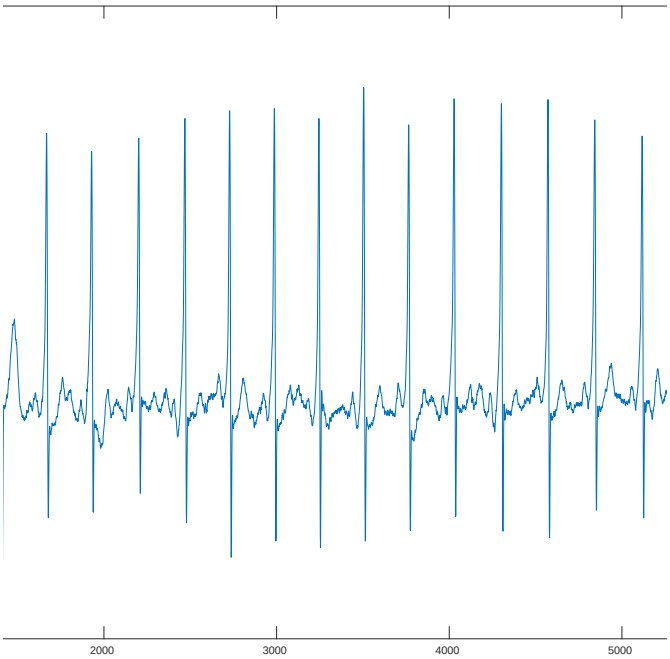

Fig. 2. A visual representation of the Signal's response to non-linear low pass filtering.

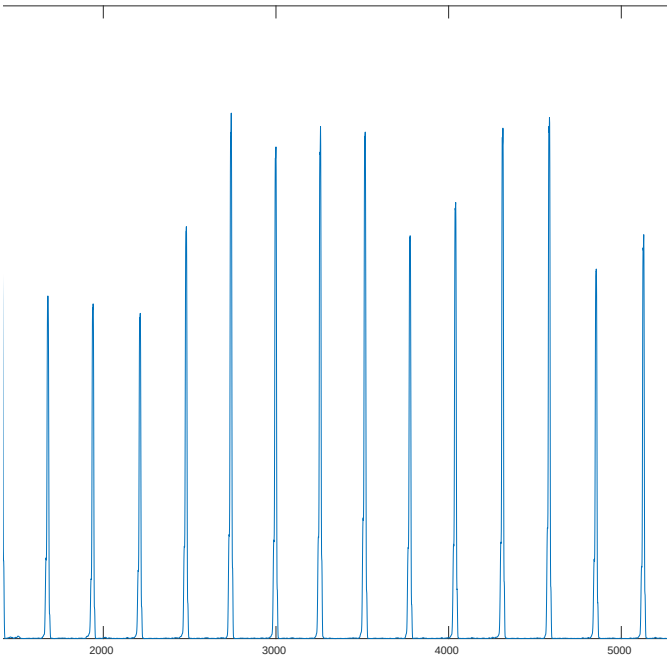

Fig. 3. A visual representation of Signal's outcome after the decision making process.

An average sensitivity of 99.17 and positive predictivity of 88.95 was achieved using the described methods. It is conceivable that the score of positive predictivity could be increased by altering the transition of the sliding window and the procedure used to select the peaks in the final decision-making process.

IV. Conclusion

Using moving average for QRS detection is a simple and effective method for detecting peaks in an ECG signal. It is easy to implement and provides reliable results with minimal computational overhead. The moving average method is especially useful in environments where real-time processing is needed, such as in the medical field. In addition, this method can be used to detect beats in any type of signal, not just ECG signals. Overall, the use of moving average for QRS detection is a great tool for cardiovascular health monitoring and other applications.

References

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

[2] G. B. Moody and 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.