Detection of heart anomalies by use of adaptive LMS filters in ECG signals*

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***Abstract*—An implementation of a heart anomaly detector for non-paced rhythms using different adaptive filter structures is proposed.**

The detection algorithm uses an Adaptive Recursive Filter (ARF), for which the impulse input is previously determined via a peak localization and time shift estimation algorithm.

The detection of each anomaly by itself is product of the direct observation of the magnitude of the ARF output. The design and testing of the detector was based on the MIT-BIH Arrhythmia Database with almost none false-negative and few false-positive results.

***Index Terms*—ECG analysis, heart anomaly detection, Adaptive Filtering, LMS filters**

I. Introduction

A. Electrocardiogram signals

An Electrocardiogram (ECG) signal is a non invasive recording (electrodes are placed on the patient's skin) of the electrical activity of a heart. There are several places where the signals may be recorded, and usually as many as ten electrodes are used to perform an ECG, where the polarization and repolarization of the heart muscles are recorded.

An ECG portrays an incredibly large amount of information from the patient, such as the rate and rhythm of heartbeats, the size and position of the heart chambers, the presence of any damage to the heart's muscle cells or conduction system, the effects of heart drugs, and the function of implanted pacemakers.

These polarization cycles form the main three components of a heart signal, which are listed as follows:

1) P-wave : Depolarization of the atria. This component is frequently the one with the lowest amplitude.
2) QRS complex: Depolarization of the ventricles. In the QRS complex a peak of high frequency and the highest amplitude is detected.
3) T-wave: Repolarization of the ventricles.

These components were enumerated in their usual order of appearance. However, some patients with heart abnormalities exhibit a P-wave that superposes over the QRS complex, so the techniques developed below should take into account this factor when analysing the ECG signal even with no previous knowledge of the abnormality. Adaptive filters have been proven efficient in such cases.

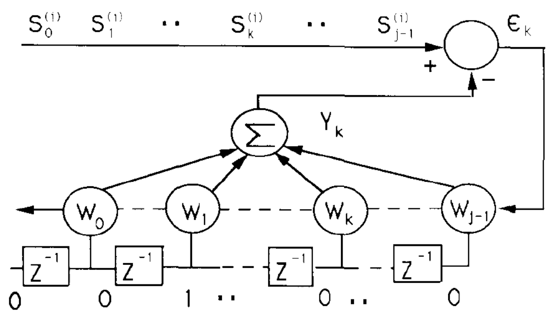

Fig. 1. Basic diagram of an ARF

B. Adaptive Recursive Filters

An Adaptive Recursive Filter (ARF) is an adaptive filter whose coefficients change so that when it is adapted, its impulse response converges to a single pseudo-period of an ideally periodic signal. The ARF is therefore applied to signals that are known to have periodic behaviour with considerably small changes through time in both its pseudo-periods and its fundamental period.

The signal in question may be then considered to be stationary between time intervals of a given length.

A diagram of the ARF, taken from [1] is shown below:

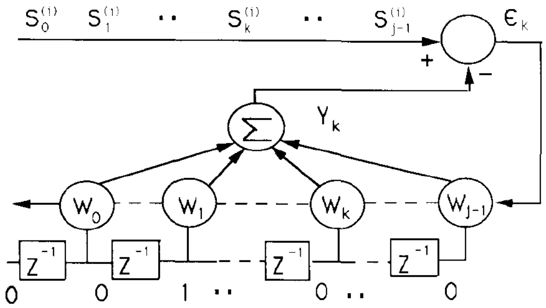

Fig. 2. Basic diagram of an ARF

II. LMS PREDICTION

The first approach taken was the implementation of an adaptive predictor based on the following diagram:

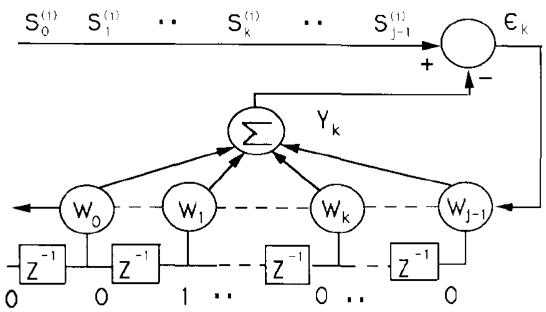

Fig. 3. Basic diagram of an ARF

The implementation achieved its desired purpose of predicting the signal, as shown in the following figure:

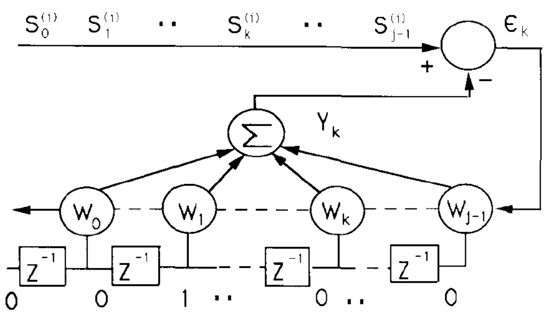

Fig. 4. Signal 202 of the MIT-BIH Arrhythmia Database, minute , and the predictor's response.

The magnitude of the error signal was afterwards processed in order to get its peaks, which where considered anomalies when its amplitude exceeded a designated value. This method of anomaly detection did not manage to achieve acceptable results as the predictor error tends to raise when the ECG signal has high frequency changes, and so the the peaks of the QRS complex were also taken as anomalies.

Although this problem disqualified the method, if the QRS complex is detected via a previous analysis of the signal, discarding the false positives that appear with its peaks may be a path to be followed in future investigations.

A. Implementation of the ARF

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$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

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TABLE I
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

Fig. 5. Example of a figure caption.

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ACKNOWLEDGMENT

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REFERENCES

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REFERENCES

[1] Nitish V. Thakor and Yi-Sheng Zhu, "Applications of Adaptive Filtering to ECG Analysis : Noise Cancellation and Arrhythmia Detection", IEEE Transactions On Biomedical Engineering. Vol. 18. No 8. August 1991.

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