

# 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

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:

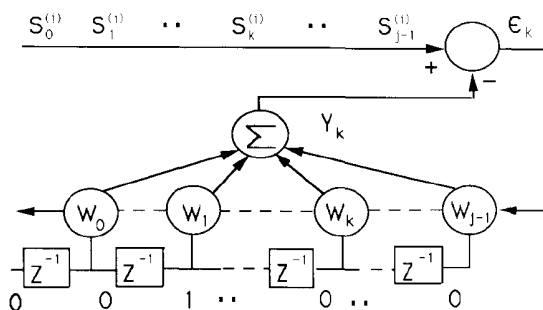


Fig. 1. Basic diagram of an ARF

## II. EASE OF USE

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### A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

### B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
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- Use a zero before decimal points: “0.25”, not “.25”. Use “cm<sup>3</sup>”, not “cc”).

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Number equations consecutively. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \quad (1)$$

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 . . .”

### D. *L<sup>A</sup>T<sub>E</sub>X*-Specific Advice

Please use “soft” (e.g., `\eqref{Eq}`) cross references instead of “hard” references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don’t use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in *L<sup>A</sup>T<sub>E</sub>X* will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you’ve discovered a new method of counting.

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- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
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- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
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- Do not confuse “imply” and “infer”.
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”.
- The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [?].

### F. Authors and Affiliations

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Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you

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TABLE I  
TABLE TYPE STYLES

Table Head	Table Column Head		
	<i>Table column subhead</i>	<i>Subhead</i>	<i>Subhead</i>
copy	More table copy <sup>a</sup>		

<sup>a</sup>Sample of a Table footnote.



Fig. 2. Example of a figure caption.

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#### ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

#### REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [?]. Refer simply to the reference number, as in [?]*—do not use “Ref. [?]” or “reference [?]” except at the beginning of a sentence: “Reference [?] was the first ...”*

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For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [?].

#### 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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