Early Detection of Myocardial Infarction Using WBAN

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Overview

Algorithm

Detects Heart attack with 73 % Accuracy

Facts and Figures

- 25 % of ALL deaths[1]
- 326,200 die of out-of-hospital cardiac arrests[2]
- 10.6 % survival rate[2]

[1]Heart disease and stroke statistics— 2015 update: a report from the American Heart Association

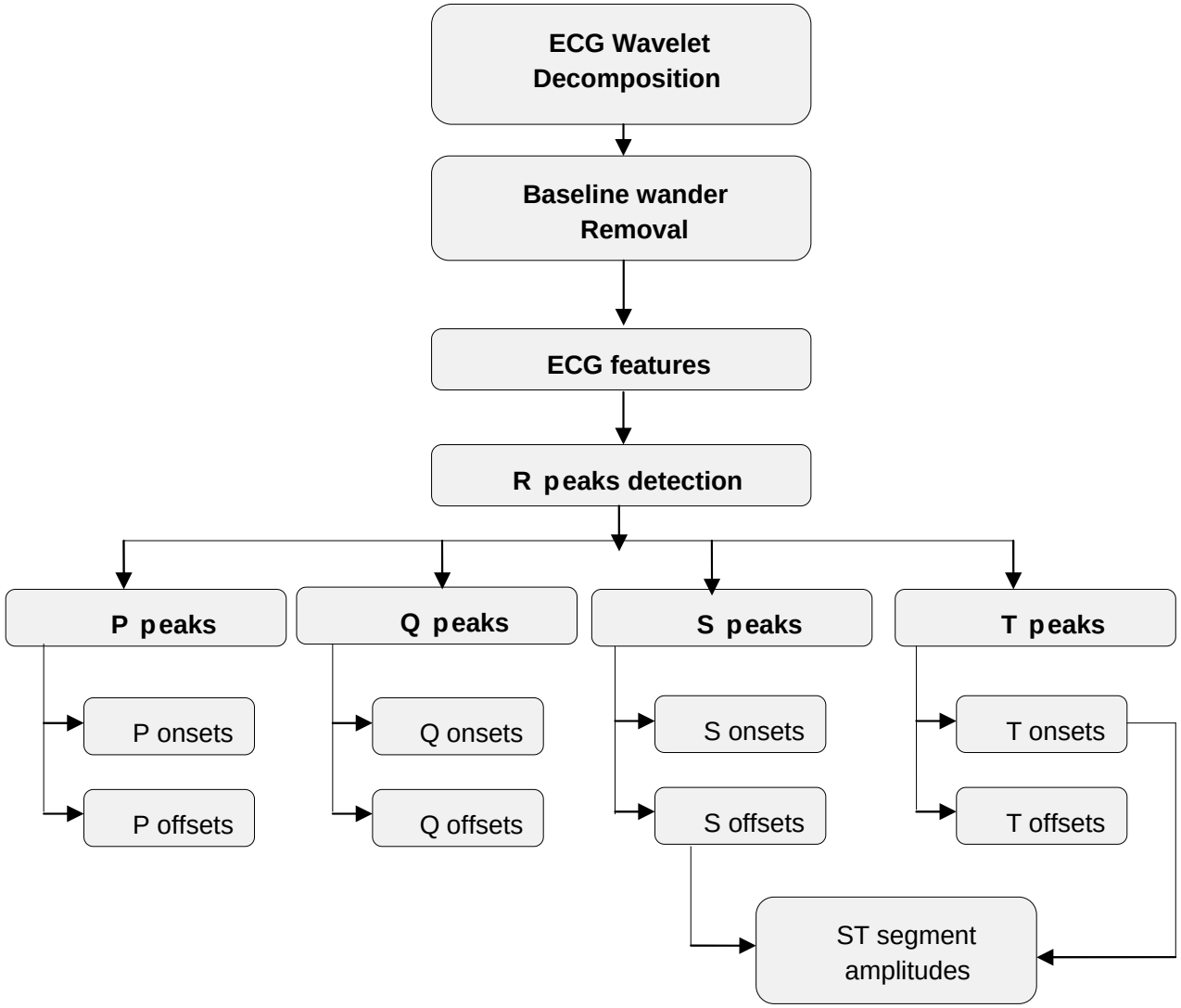
[2]AHA 2015 Heart and Stroke Statistics

Techniques	Accuracy	Specificity	Sensitivity
Hidden Markov Model (HMM) and Gaussian Mixture Models (GMM).	82.5%	79.82%	85.71%
K-Nearest Neighbor (KNN) Classifier	98.3%	99.6%	97%
Discrete Wavelet Transform (DWT).	95%	Not Specified	Not Specified
Bayesian ANN Classifier	94% for MI cases 93.3% for normal cases	Not Specified	Not Specified
SVM Naïve Bayes (NB) Random Forecast (RF)	82.8% for SVM 81.9% for NB 84.5% for RF	Not Specified	Not Specified

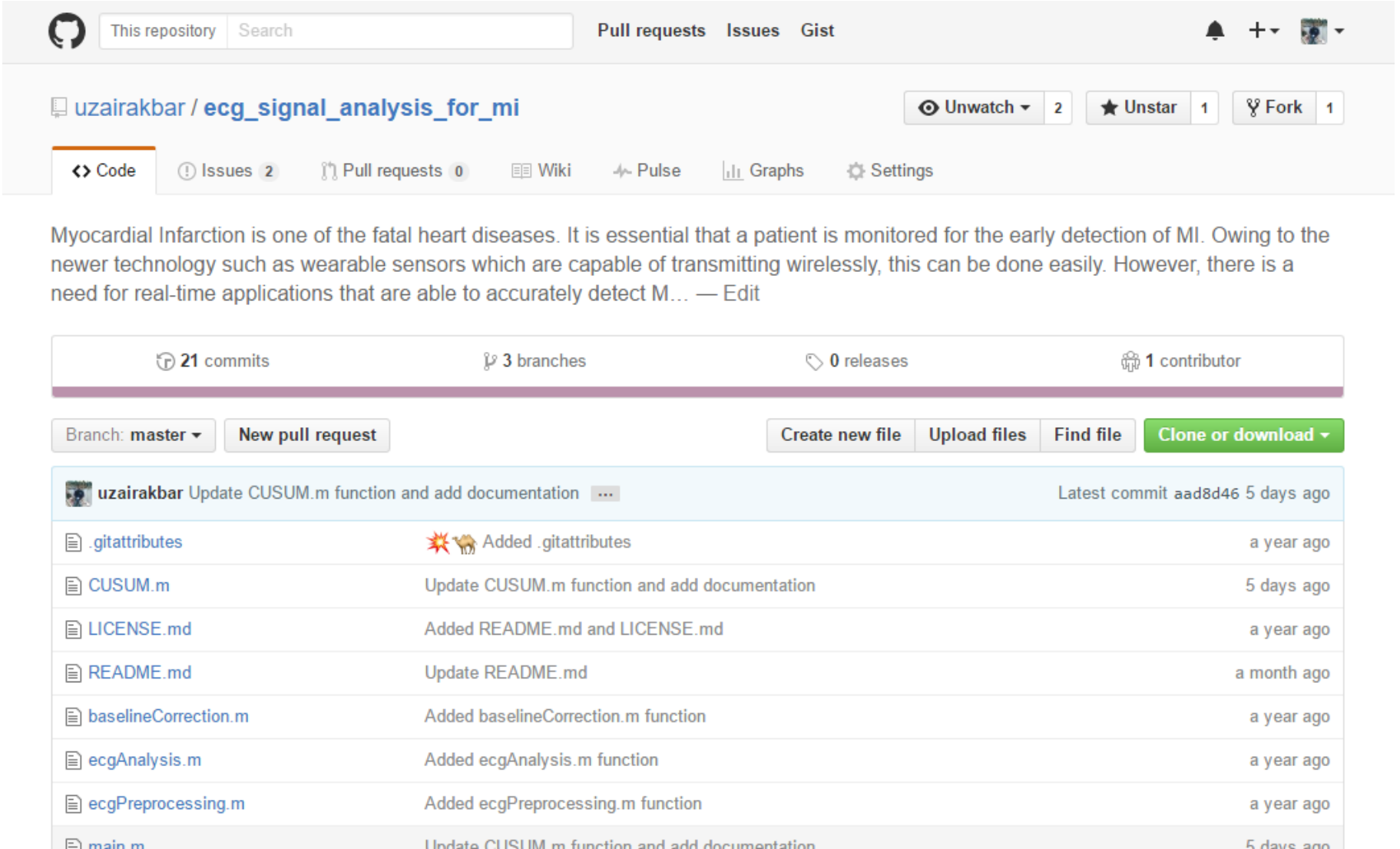
What This Paper Proposes

- A Real-time method for early detection of MI
- Autonomy of patients and remote capture of ECG using WBAN
- A low power consumption algorithm adapted to WBAN using CUSUM Method
- Detection rate 73 % and False alarm rate 5 %.

ECG Signal Processing & Feature Extraction



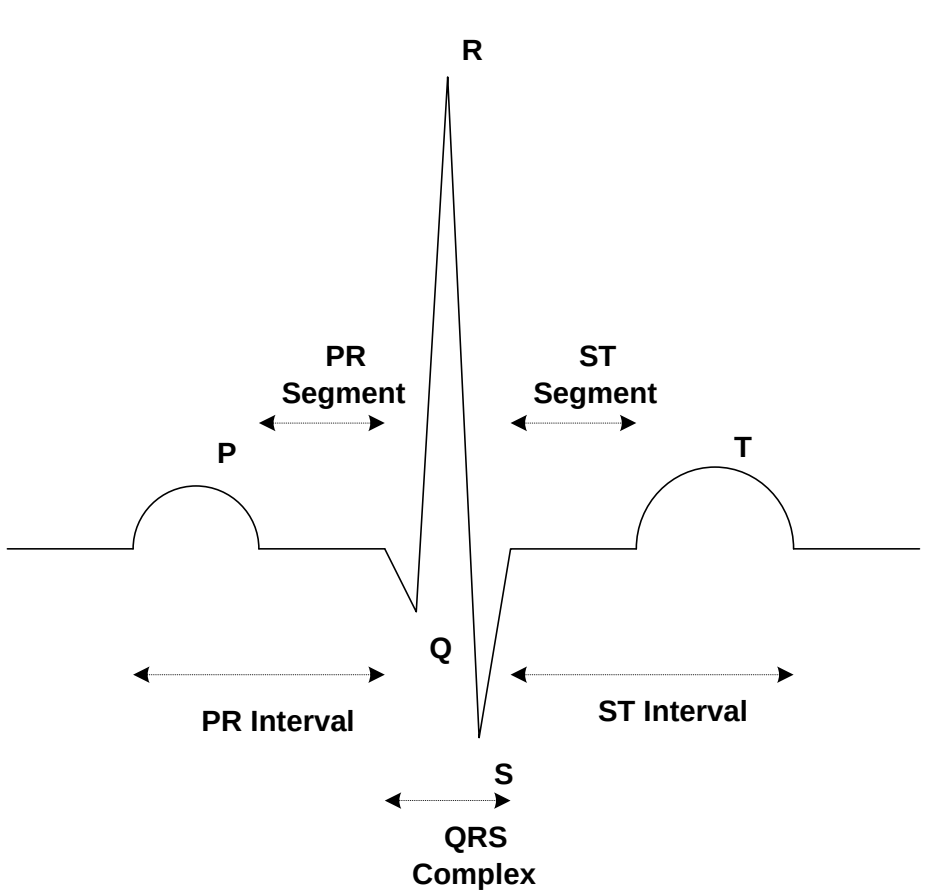
Implementation of the code



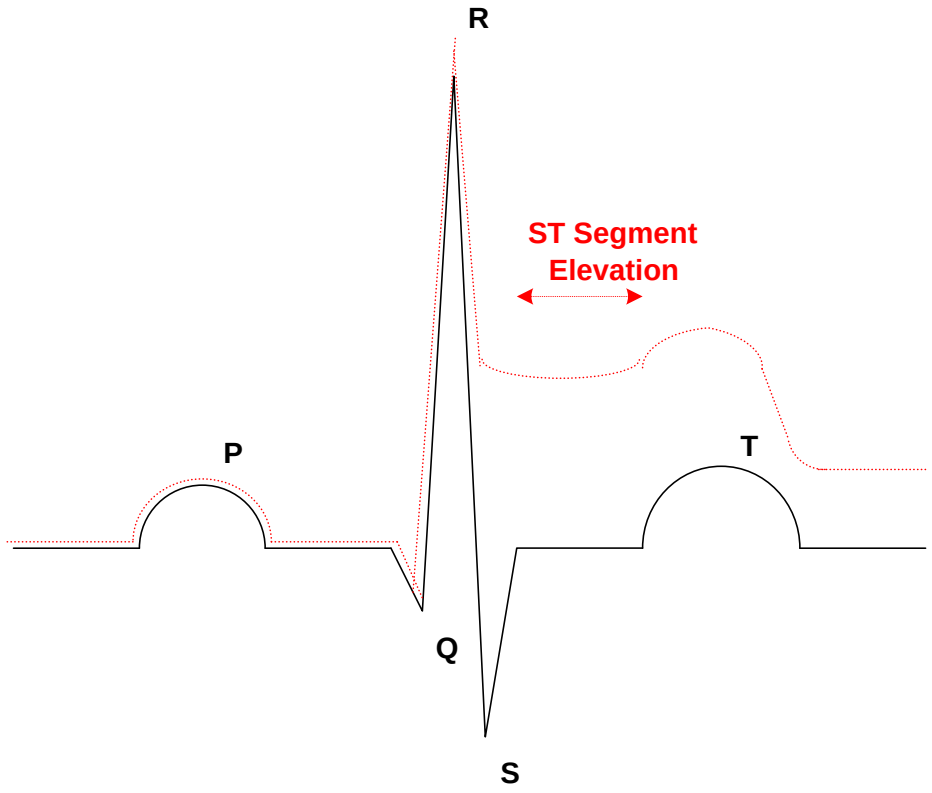
What Is Myocardial Infarction?

- Commonly referred to as “Heart Attack”.
- Occurs when heart’s supply of blood is stopped.
- Not fatal if proper medical treatment is given on timely diagnosis.

The ECG (Electrocardiogram)



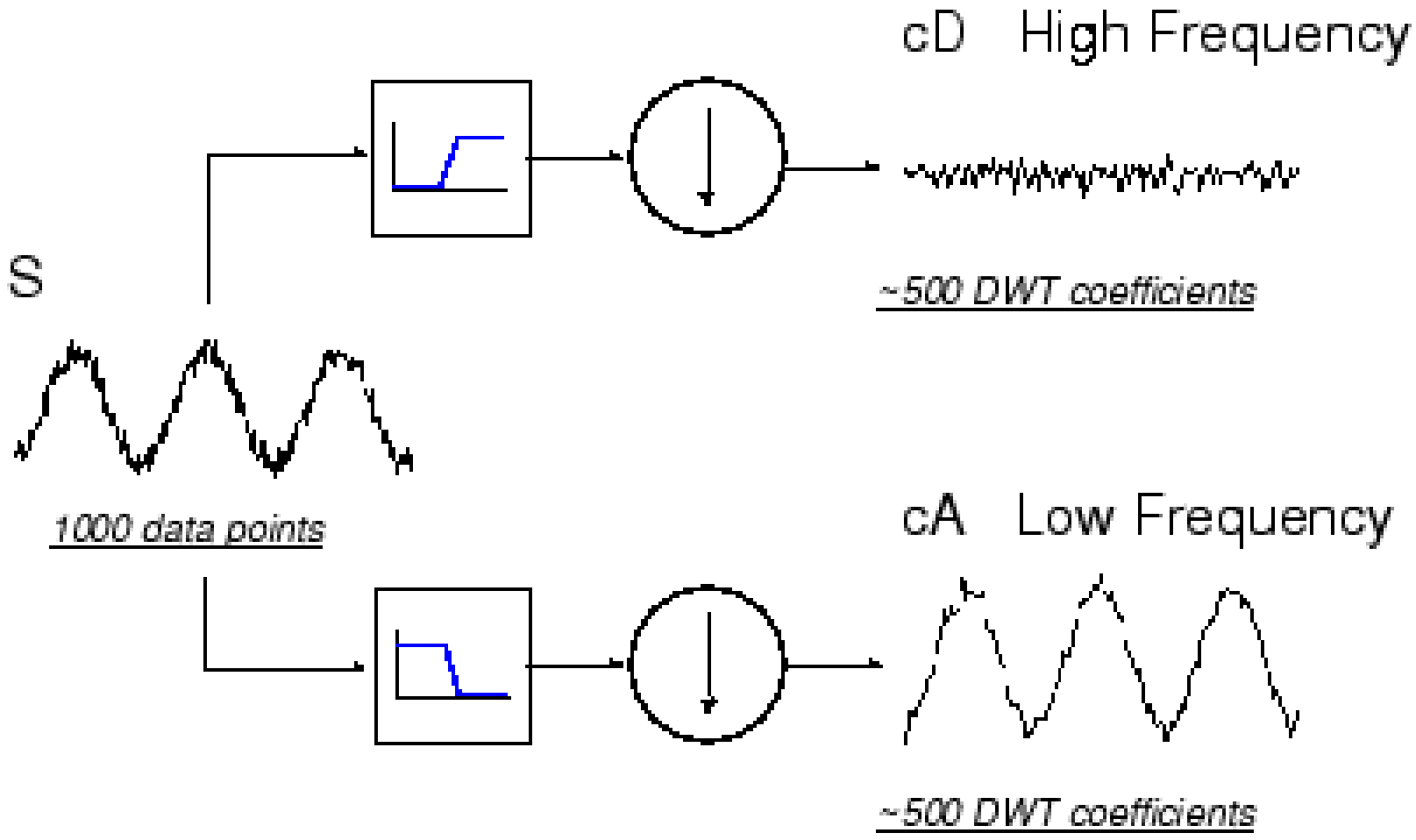
(a) One-cycle ECG tracing



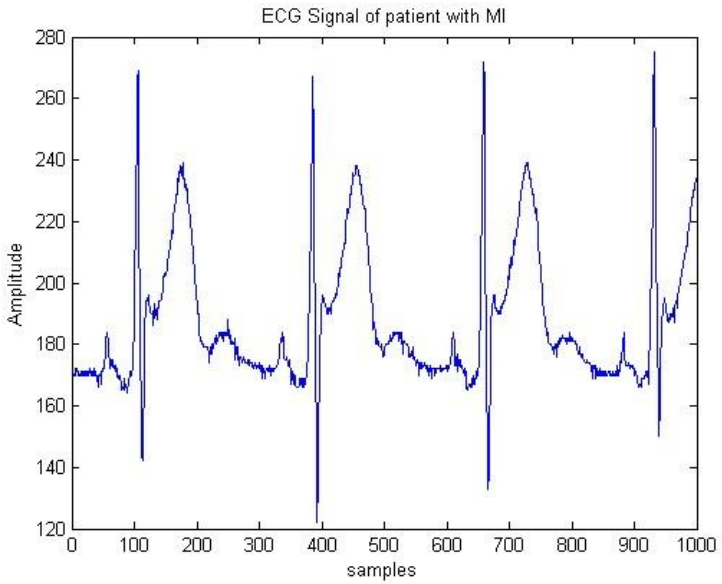
(b) ST Elevation ECG

Experimental Setup

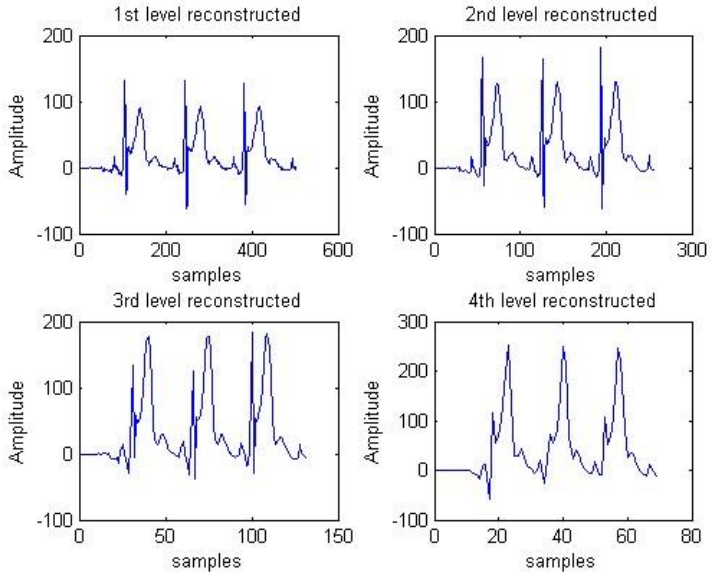
Wavelet Decomposition



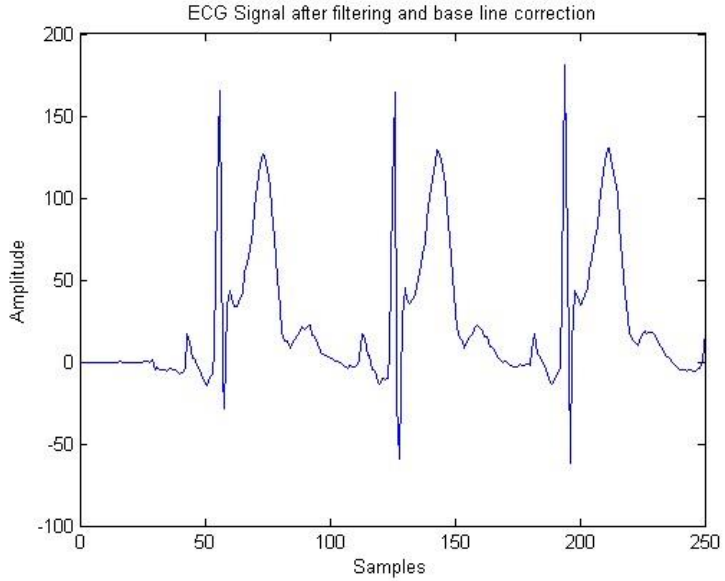
Wavelet Decomposition



(a) MI ECG signal from the edb database

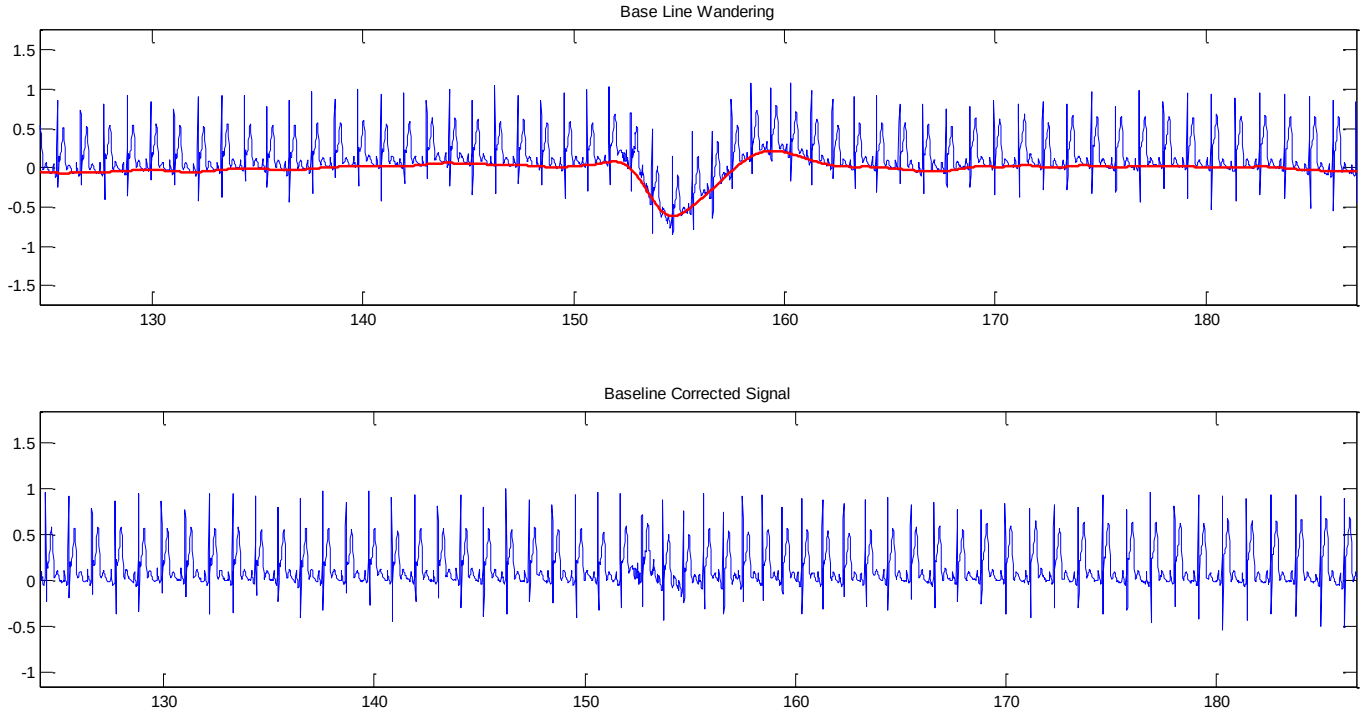


(b) MI ECG signal after Wavelet Decomposition

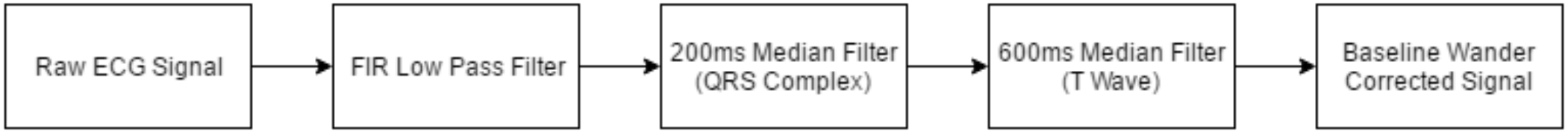


(c) ECG after filtering and base line correction

Baseline Wander Removal

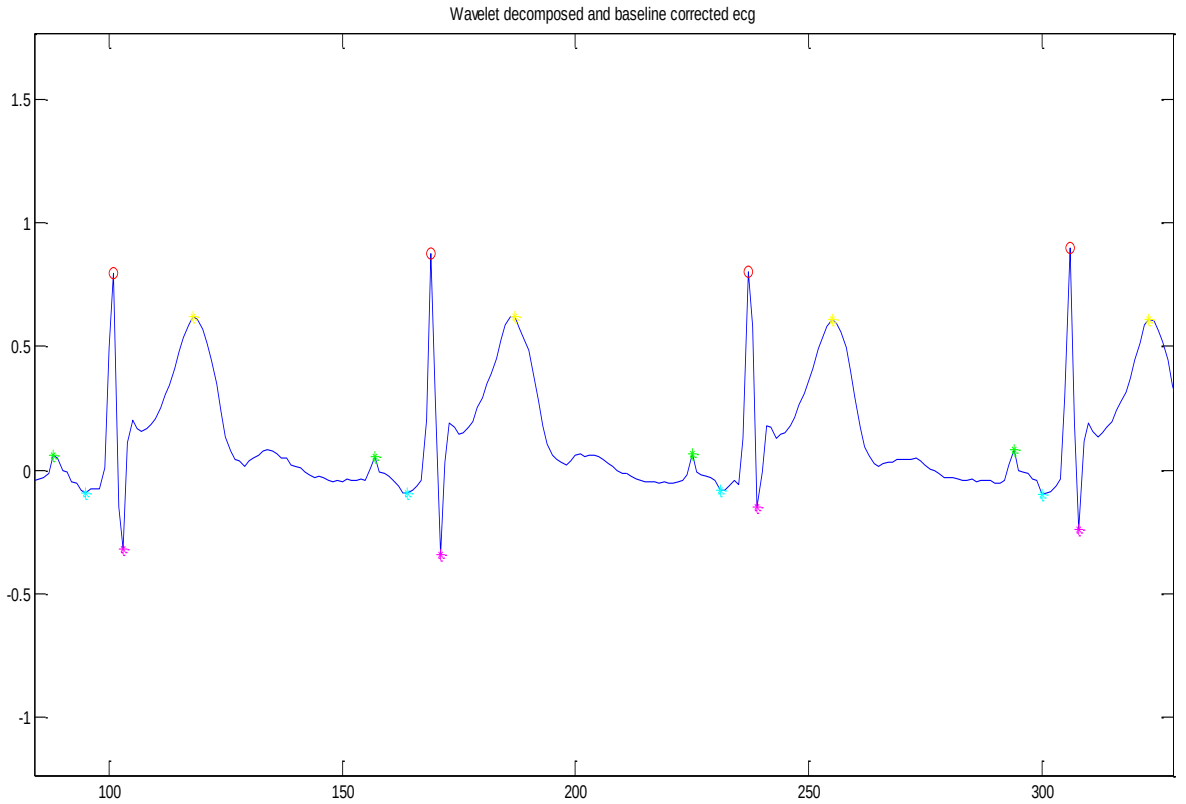


Baseline Wander Removal from ECG



Peak Detection

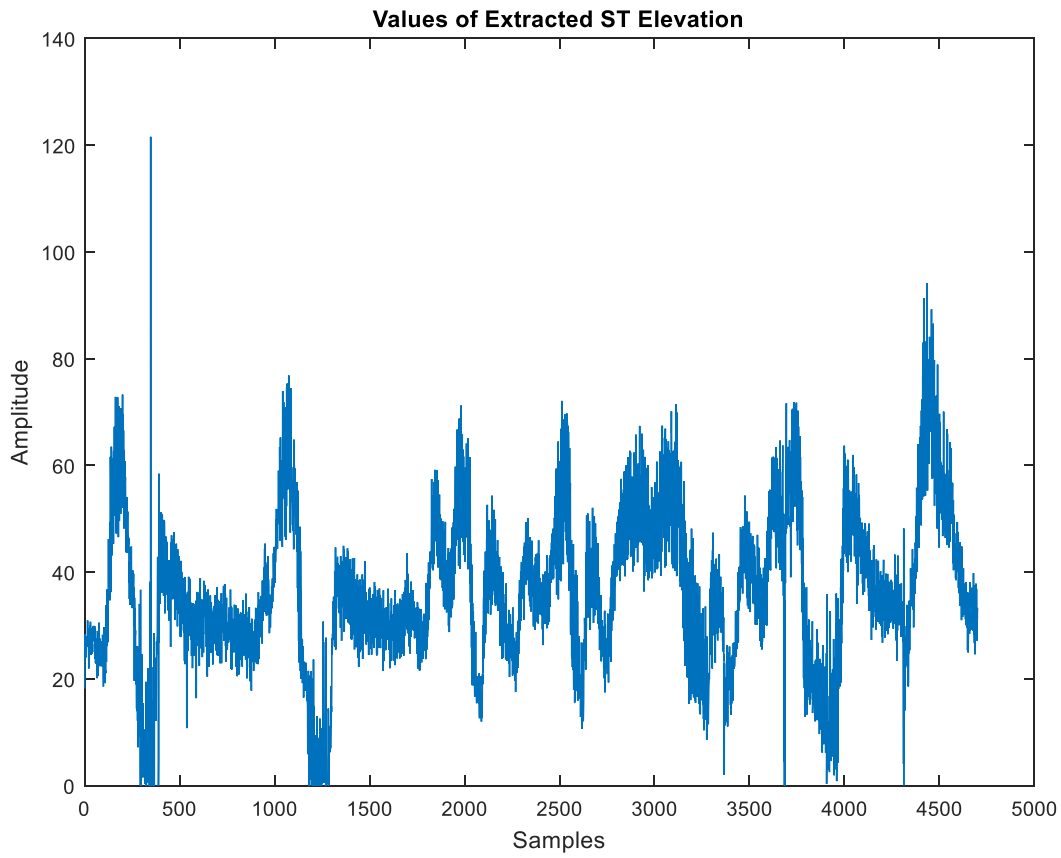
- **Extract Detail Coefficients**
- **Detect R-peaks**
- **Detect other peaks relative to R-peaks**



P, Q, R, S, T peak detection in ECG

ST Elevation Time Series Extraction

- **MI can be detected by the ST-segment elevation. MI patients have a significantly raised ST segment.**
- **Concerned with mostly the positive amplitudes of ST in our signal.**
- **Change Detection Algorithm is used to detect abnormality in ST Elevation of ECG.**



ST Elevation Time Series

CUmulative SUM (CUSUM) Algorithm

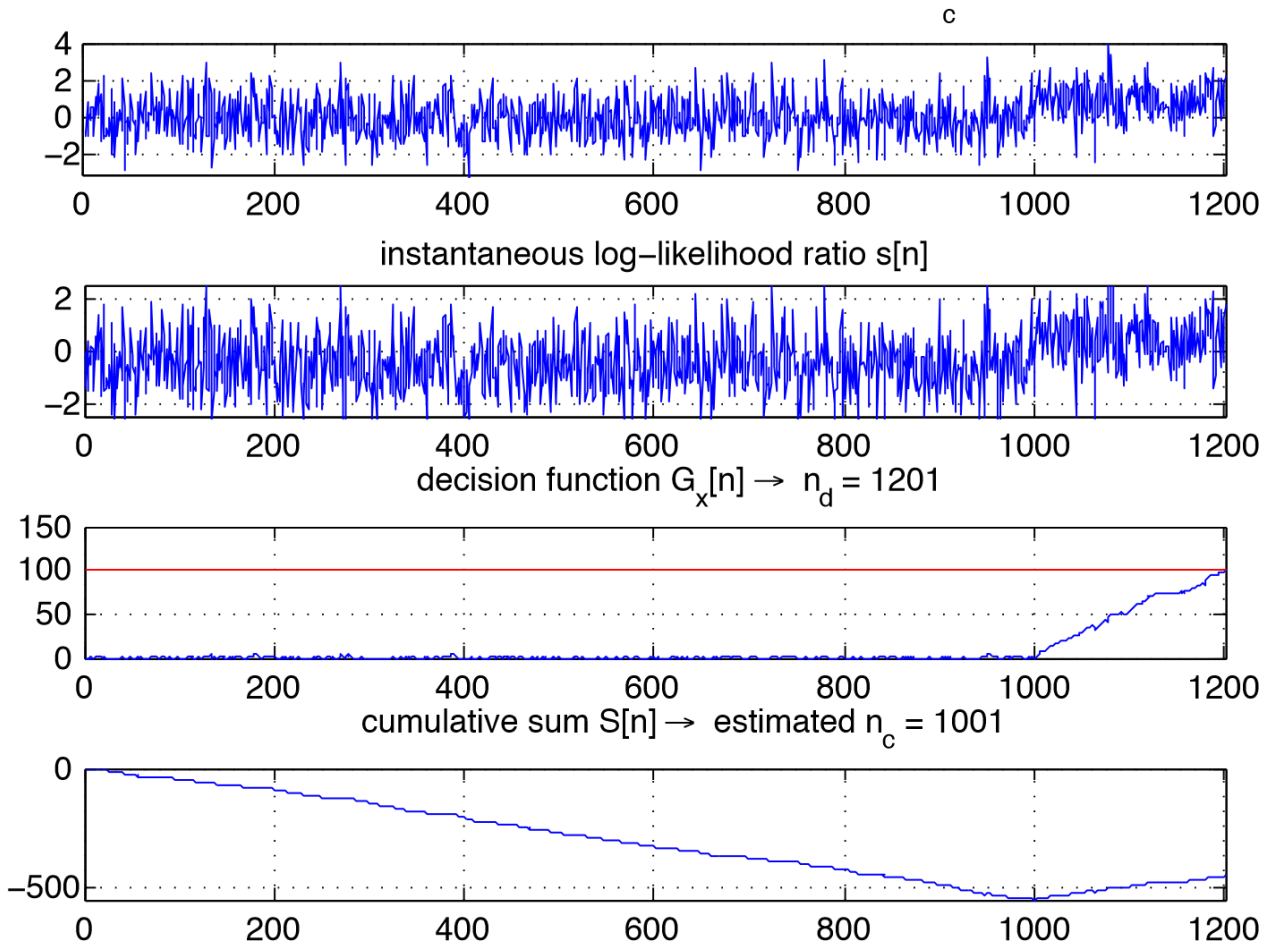
Initialization
    if necessary
end
while algorithm running
    measure $x[k]$
    decide between H_0 and H_1
    if H_1
        $n_d = k$
        estimate n_c
        stop or reset
    end if
end while

Max. Likelihood Estimates

- Log-Likelihood Ratio: $s[n] = \ln\left(\frac{p_{x|H_1}}{p_{x|H_0}}\right) = \frac{\mu_1 - \mu_0}{\sigma}\left(x[n] - \frac{\mu_1 + \mu_2}{2}\right)$
- Decision Function: $G[n] = \{G[n-1] + s[n]\}^+$
- Cumulative Sum: $S[n] = S[n-1] + s[n]$
- Change Point: $n_c = \underset{1 \le n_c \le k}{\arg\min}\, S[n_c - 1].$

As in practical cases, certain parameters cannot be known prior to the experiment, maximum likelihood estimates are used instead of unknowns.

Max. Likelihood Estimates



Typical behaviour of the CUSUM algorithm in the case of an Gaussian signal with a change in the mean at time $n_c = 1000$.

CUmulative SUM (CUSUM) Algorithm

initialization

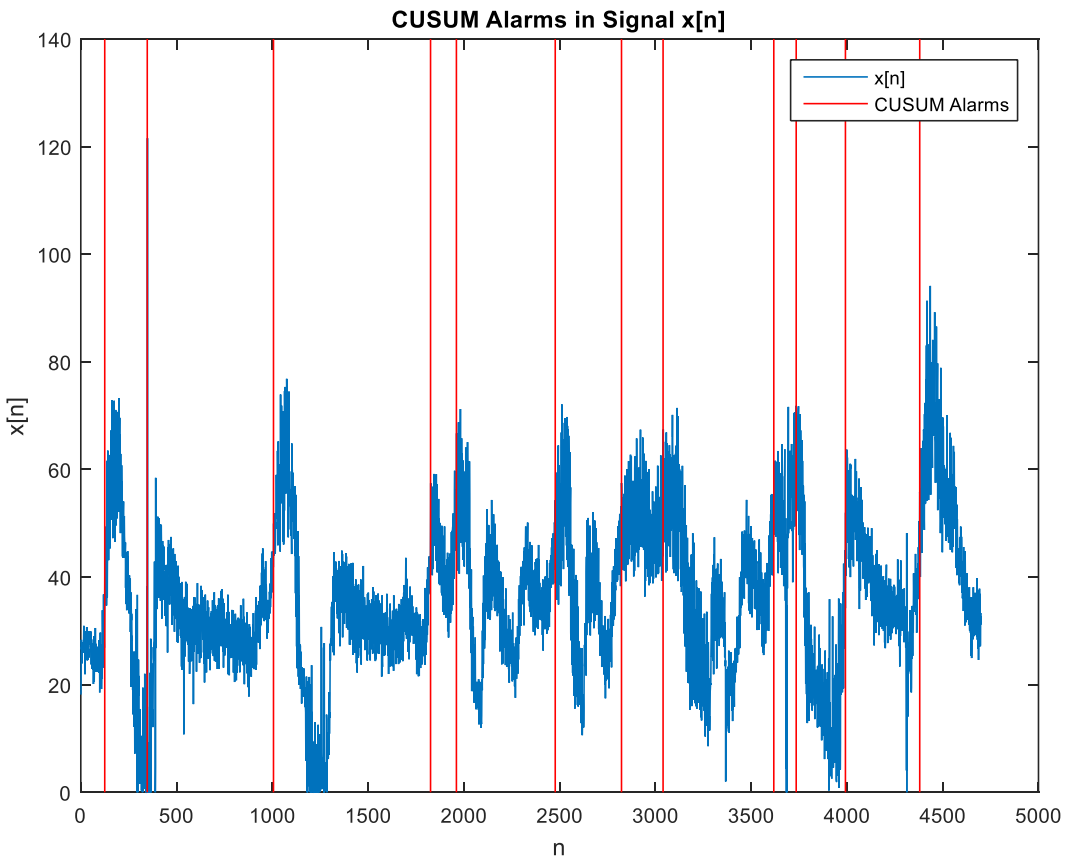
set $\tilde{\delta}$ to the most likely change magnitude
set the detection threshold $h > 0$
$S[-1] = G_{\mathfrak{X}}[-1] = 0$
initialize the estimators $\widehat{\mu_{\mathfrak{X}_0}}$ and $\widehat{\sigma^2_{\mathfrak{X}}}$
$k = 0$

end

while *the algorithm is not stopped* **do**

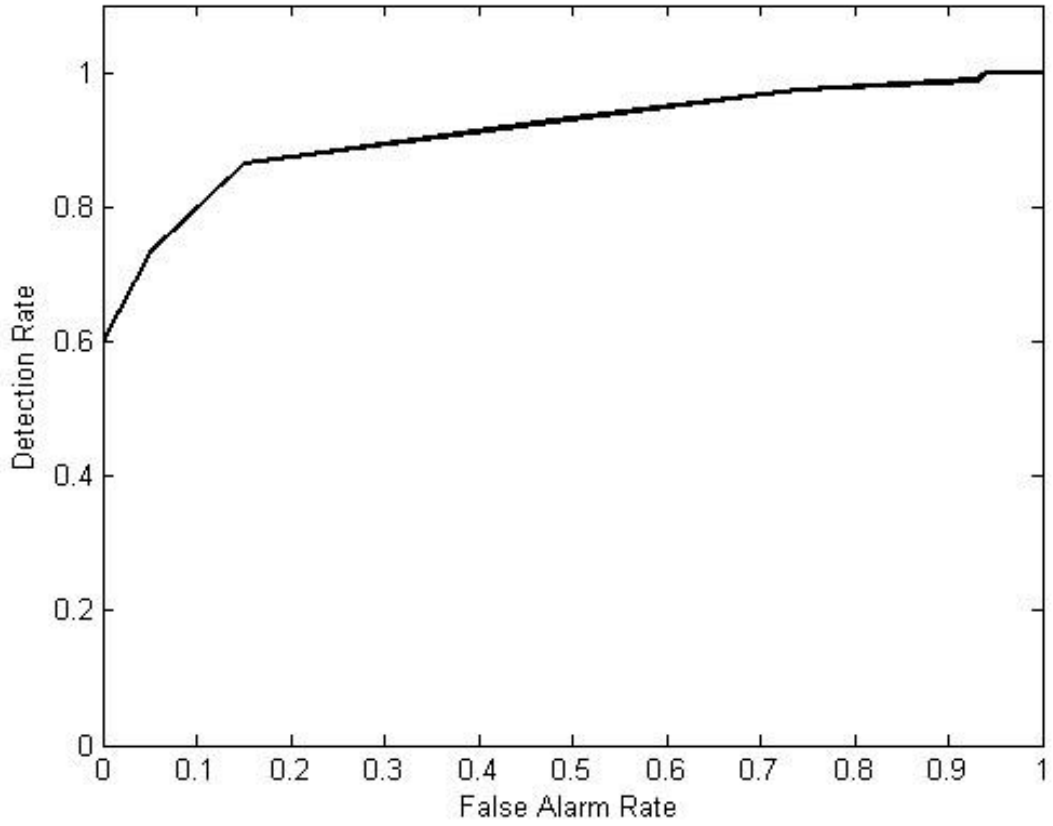
measure the current sample $x[k]$
calculate the current estimates $\widehat{\mu_{\mathfrak{X}_0}}[k]$ and $\widehat{\sigma^2_{\mathfrak{X}}}[k]$
$s[k] = \frac{\tilde{\delta}}{\widehat{\sigma^2_{\mathfrak{X}}}[k]} \left(x[k] - \widehat{\mu_{\mathfrak{X}_0}}[k] - \frac{\tilde{\delta}}{2} \right)$
$S[k] = S[k-1] + s[k]$
$G_{\mathfrak{X}}[k] = \{G_{\mathfrak{X}}[k-1] + s[k]\}^+$
if $G_{\mathfrak{X}}[k] > h > 0$ **then**
$n_d \leftarrow k$
$\widehat{n_c} = \arg\min_{1 \le n_c \le k} S[n_c - 1]$
stop or reset the algorithm
end
$k = k + 1$

end



CUSUM Alarms in the ST-Elevation Time Series

Receiver Operating Characteristics and Results



$$Detection\ Rate = TP/(TP + FN) = 73\%$$
$$False\ Alarm\ Rate = FP/(FP + TN) = 5\%$$