

# Early Detection of Myocardial Infarction Using WBAN

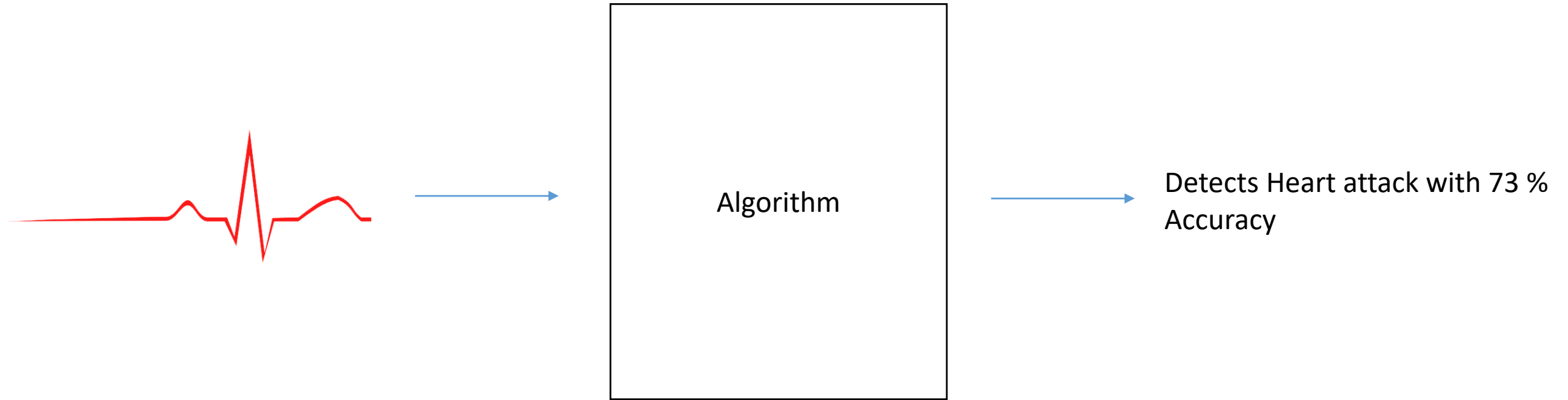
IEEE Healthcom 2013

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# Overview



# Facts and Figures

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

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

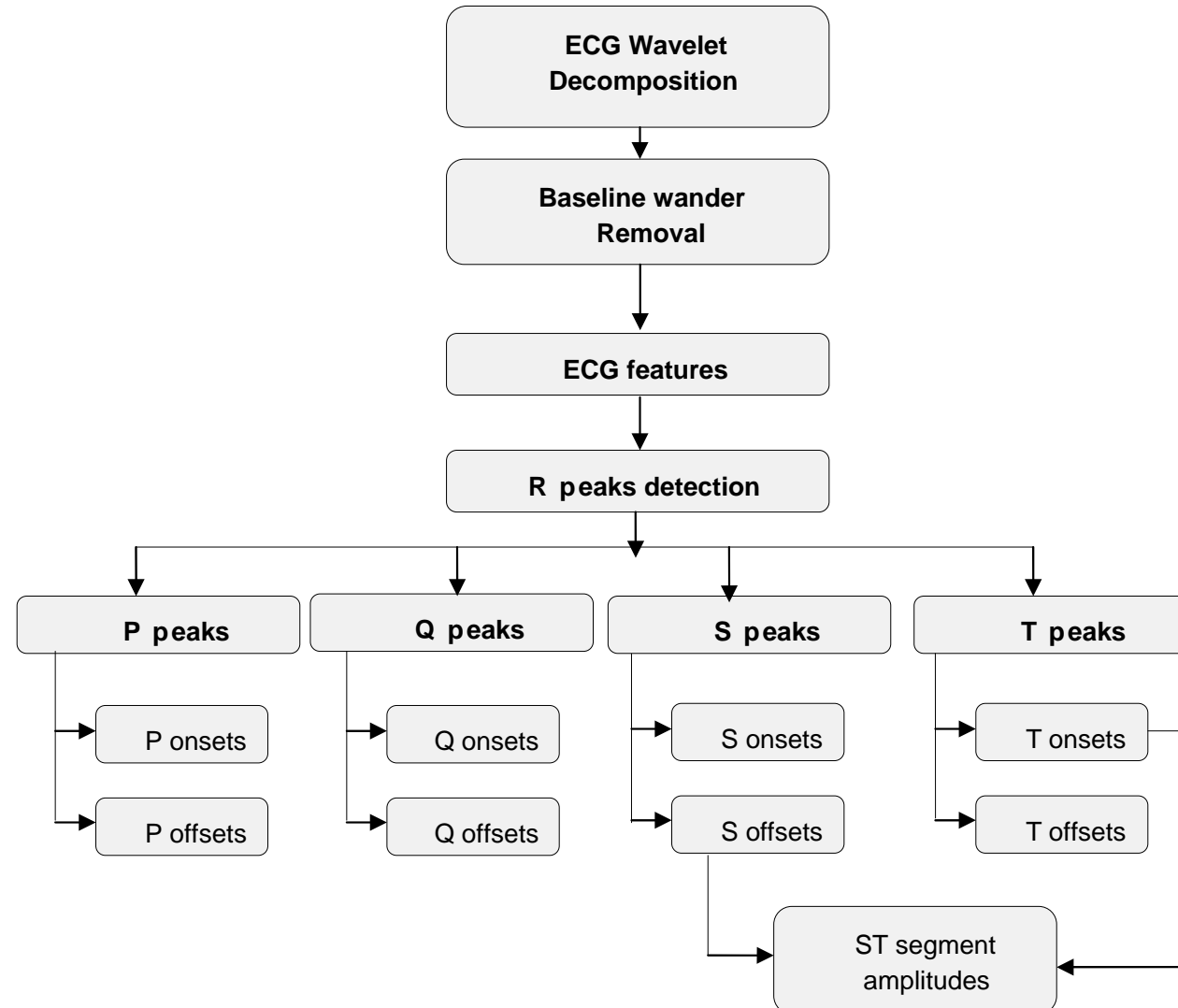
<sup>[2]</sup>AHA 2015 Heart and Stroke Statistics

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 Forest (RF)	82.8% for SVM 81.9% for NB 84.5% for RF	Not Specified	Not Specified




# What This Paper Proposes

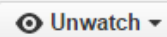

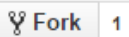
- A Real-time method for early detection of MI
- Autonomy of patients and remote capture of ECG using WBAN
- A low power consumption algorithm adapted to WBAN using CUSUM Method
- Detection rate **73 %** and False alarm rate **5 %**.

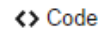
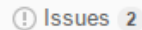
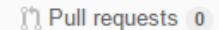




# ECG Signal Processing & Feature Extraction







# Implementation of the code

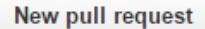

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uzairakbar / **ecg\_signal\_analysis\_for\_mi**  2  1  1










 Code  Issues 2  Pull requests 0  Wiki  Pulse  Graphs  Settings

Myocardial Infarction is one of the fatal heart diseases. It is essential that a patient is monitored for the early detection of MI. Owing to the newer technology such as wearable sensors which are capable of transmitting wirelessly, this can be done easily. However, there is a need for real-time applications that are able to accurately detect M... — Edit

 21 commits  3 branches  0 releases  1 contributor

Branch: master  Create new file Upload files Find file 

 uzairakbar Update CUSUM.m function and add documentation ... Latest commit aad8d46 5 days ago

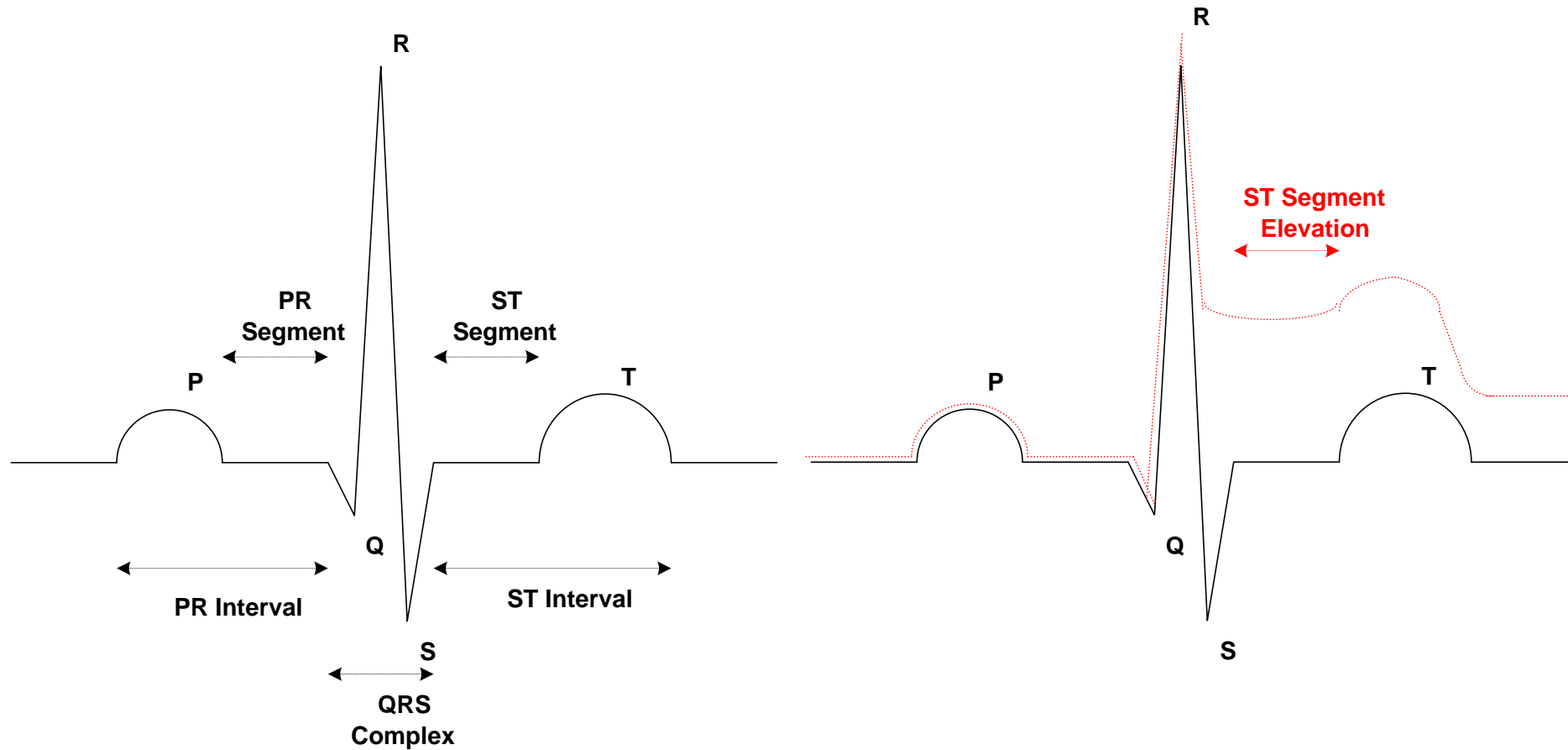
 .gitattributes	 Added .gitattributes	a year ago
 CUSUM.m	Update CUSUM.m function and add documentation	5 days ago
 LICENSE.md	Added README.md and LICENSE.md	a year ago
 README.md	Update README.md	a month ago
 baselineCorrection.m	Added baselineCorrection.m function	a year ago
 ecgAnalysis.m	Added ecgAnalysis.m function	a year ago
 ecgPreprocessing.m	Added ecgPreprocessing.m function	a year ago
 main.m	Update CUSUM.m function and add documentation	5 days ago

# 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)

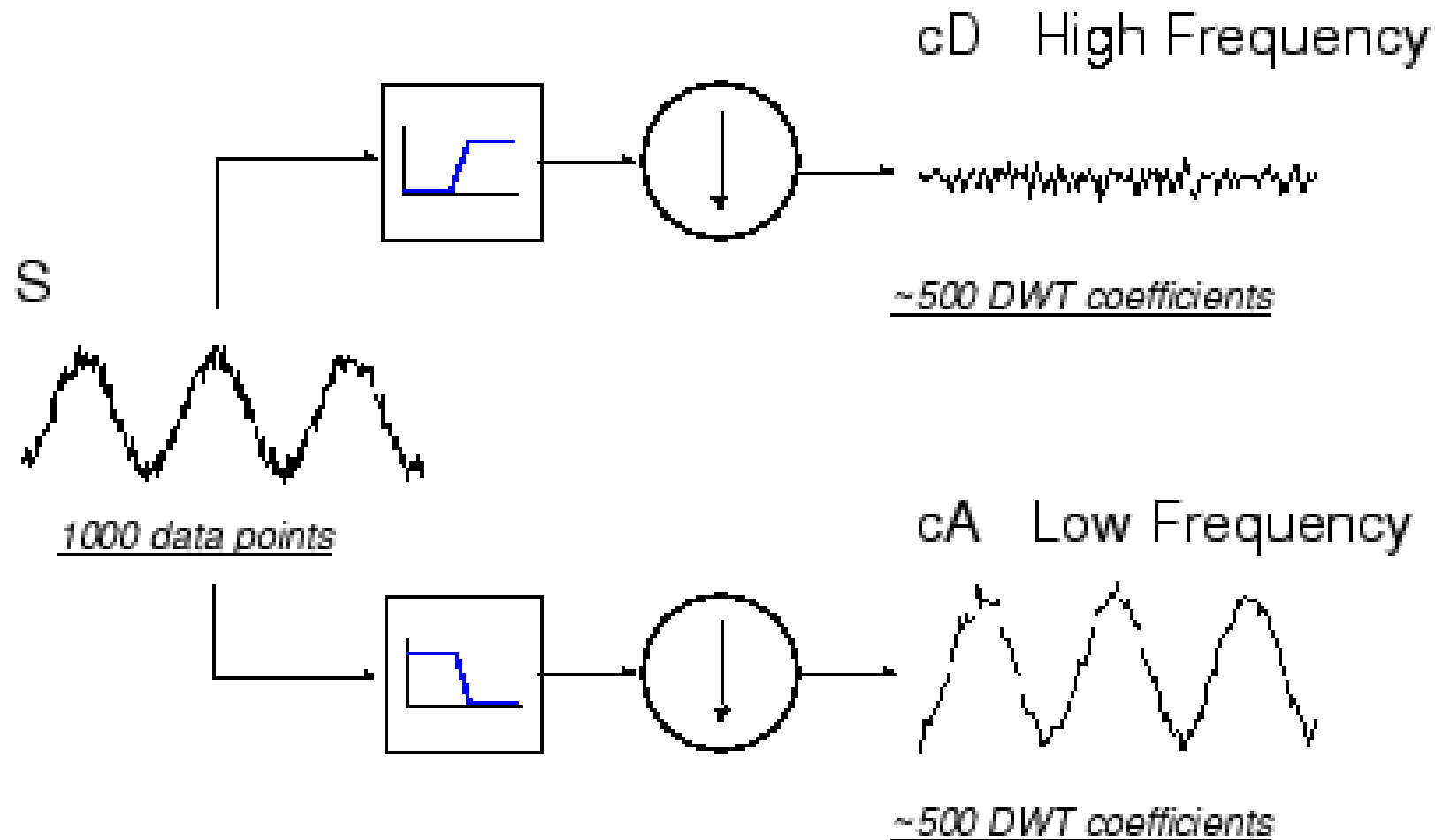


(a) One-cycle ECG tracing

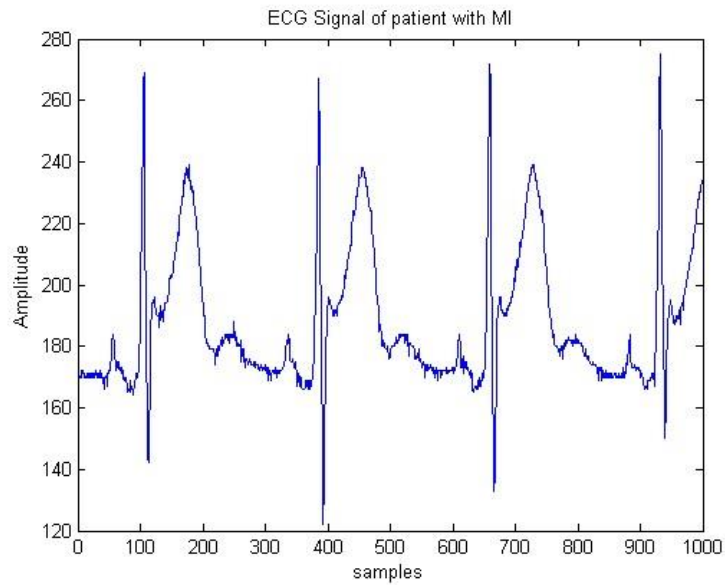
(b) ST Elevation ECG

# Experimental Setup

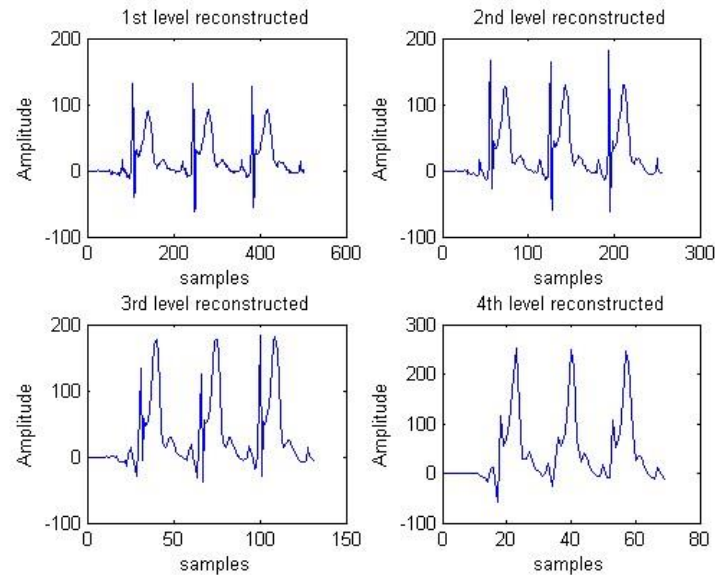
# Wavelet Decomposition



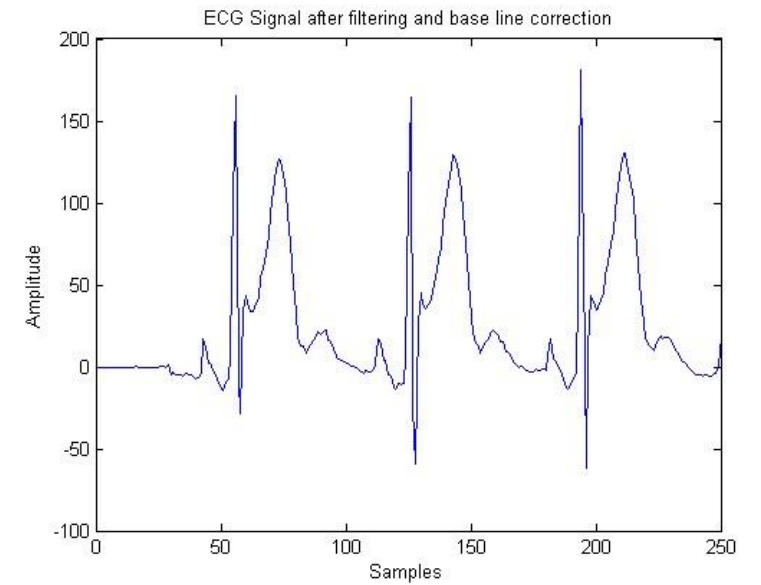
# Wavelet Decomposition



(a) MI ECG signal from the edb database

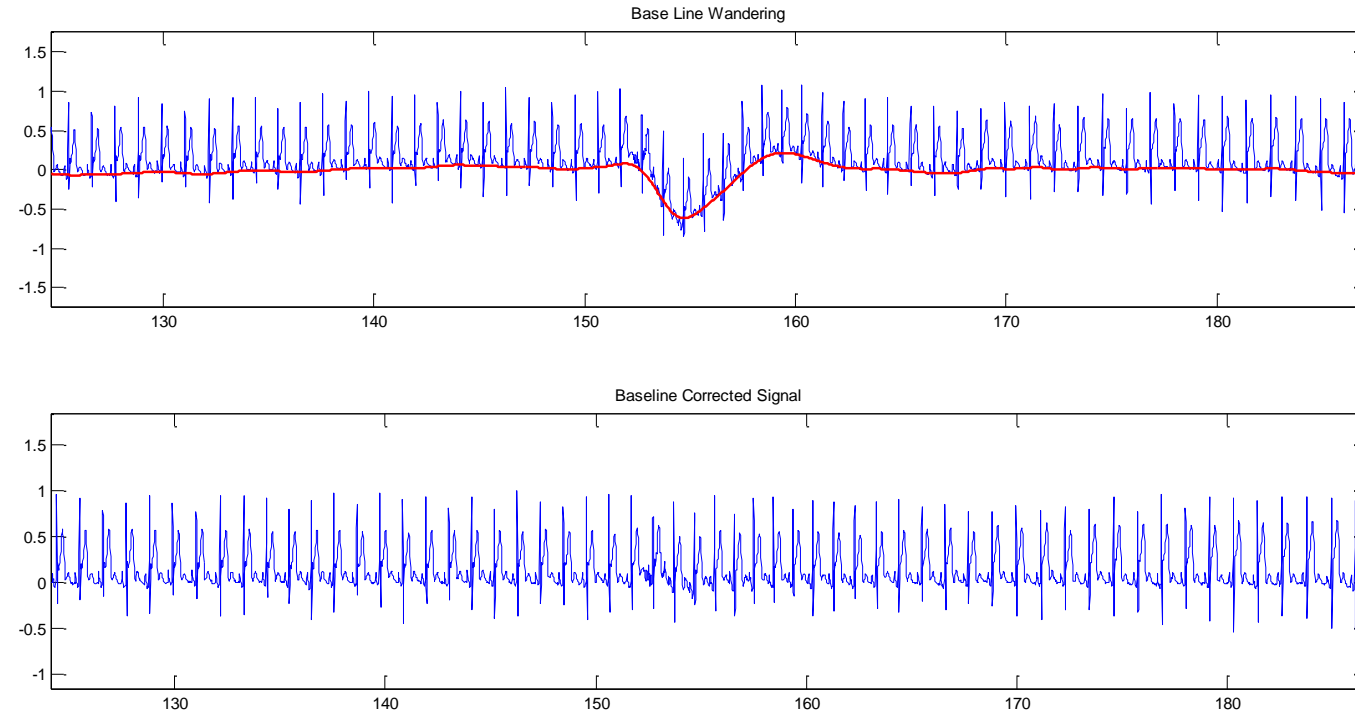


(b) MI ECG signal after Wavelet Decomposition

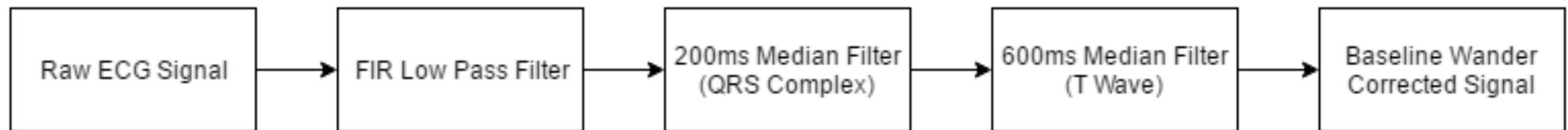


(c) ECG after filtering and base line correction

# Baseline Wander Removal

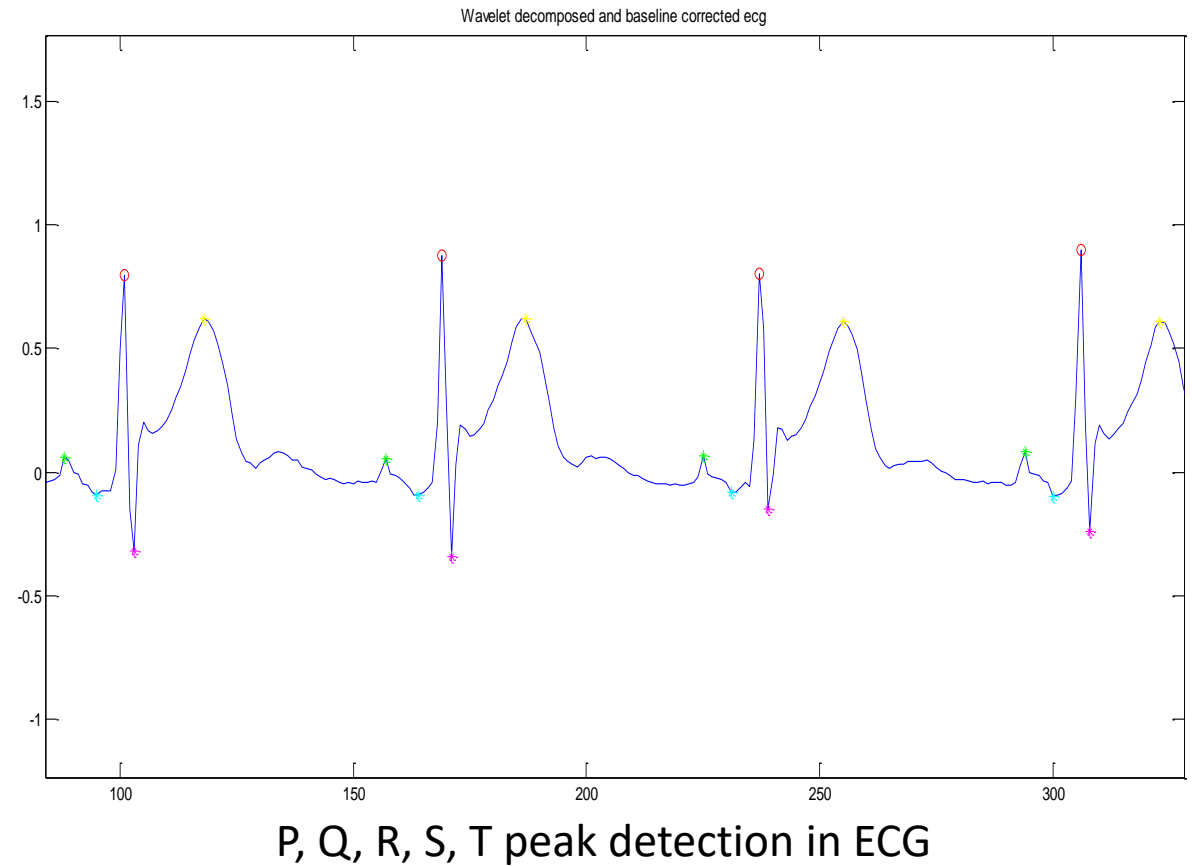


Baseline Wander Removal from ECG



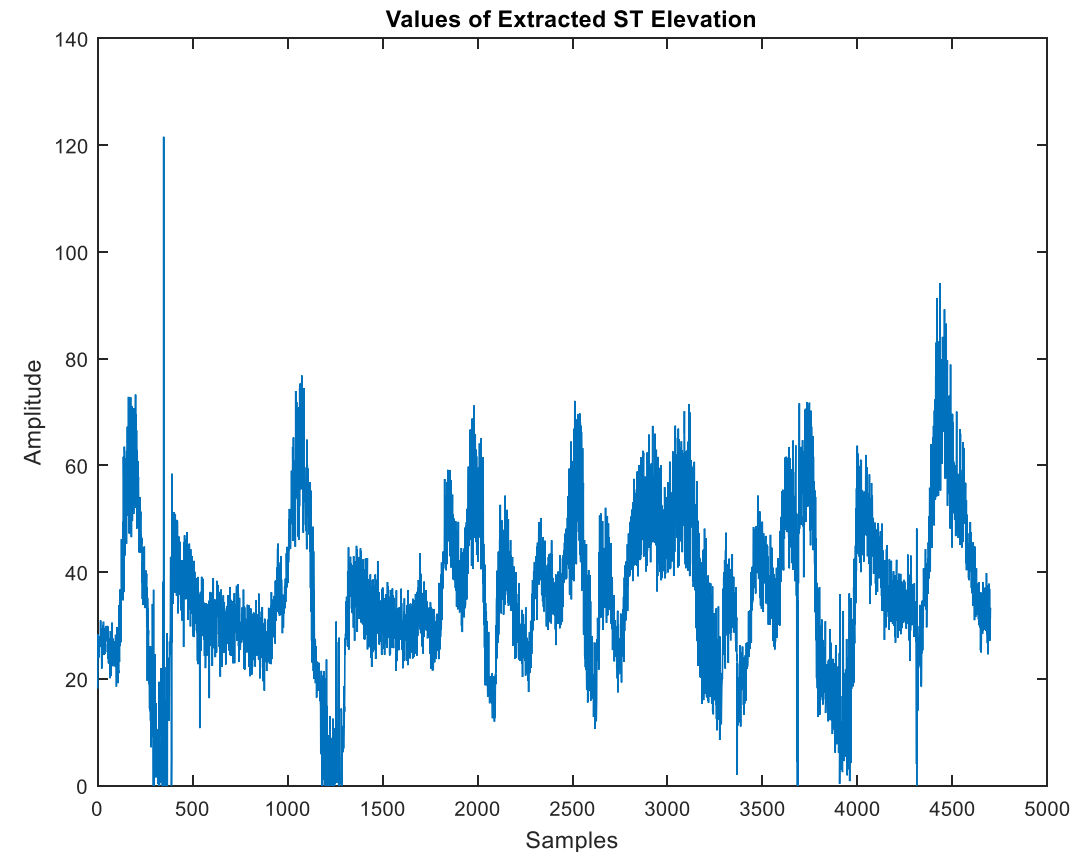
# Peak Detection

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



# 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
```

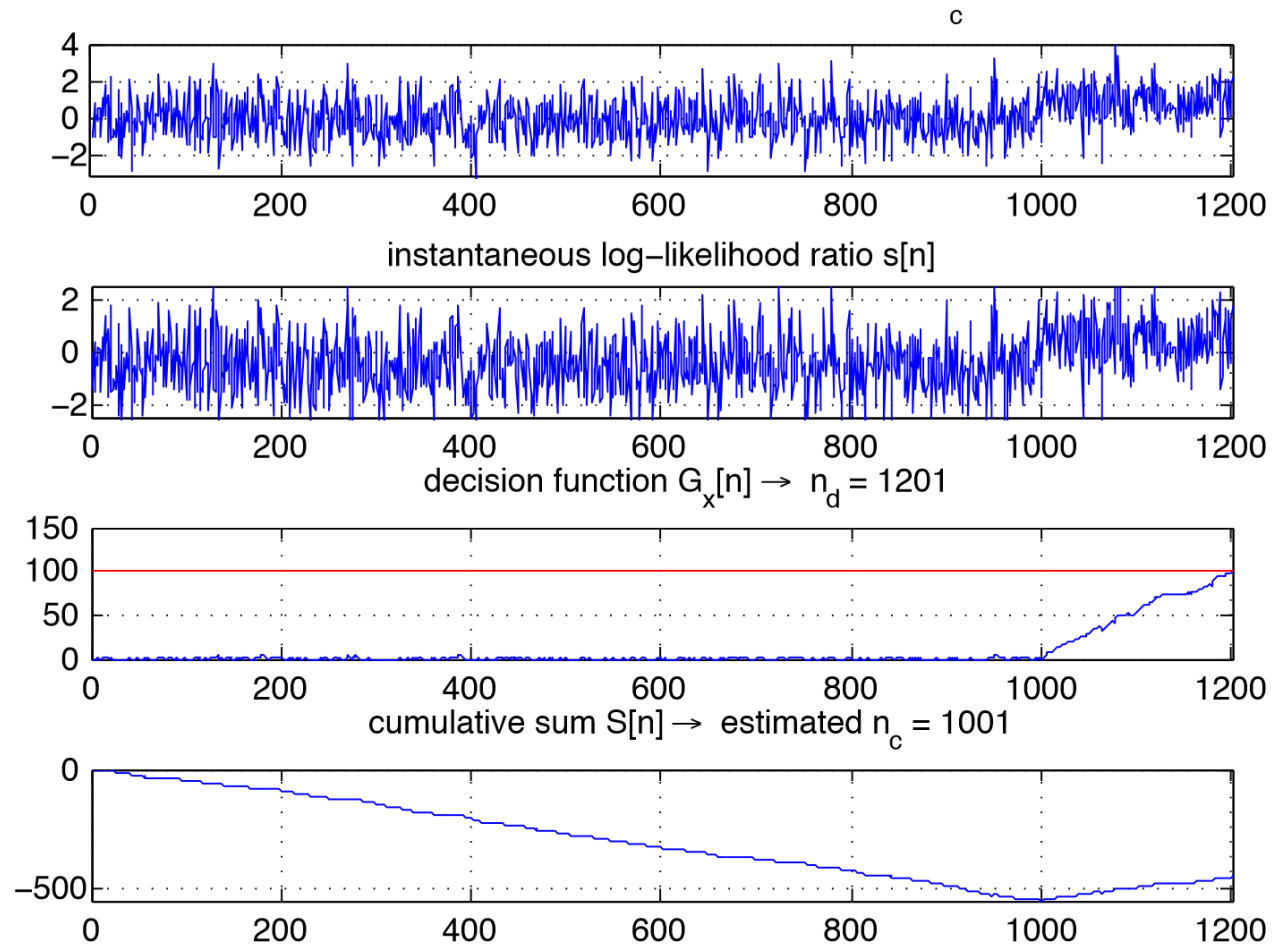


# Max. Likelihood Estimates

- 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:  $n_c = \arg \min_{1 \leq n_c \leq k} S[n_c - 1].$

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  $h > 0$   
 $S[-1] = G_{\mathbf{x}}[-1] = 0$   
initialize the estimators  $\widehat{\mu}_{\mathbf{x}_0}$  and  $\widehat{\sigma}_{\mathbf{x}}^2$   
 $k = 0$

## end

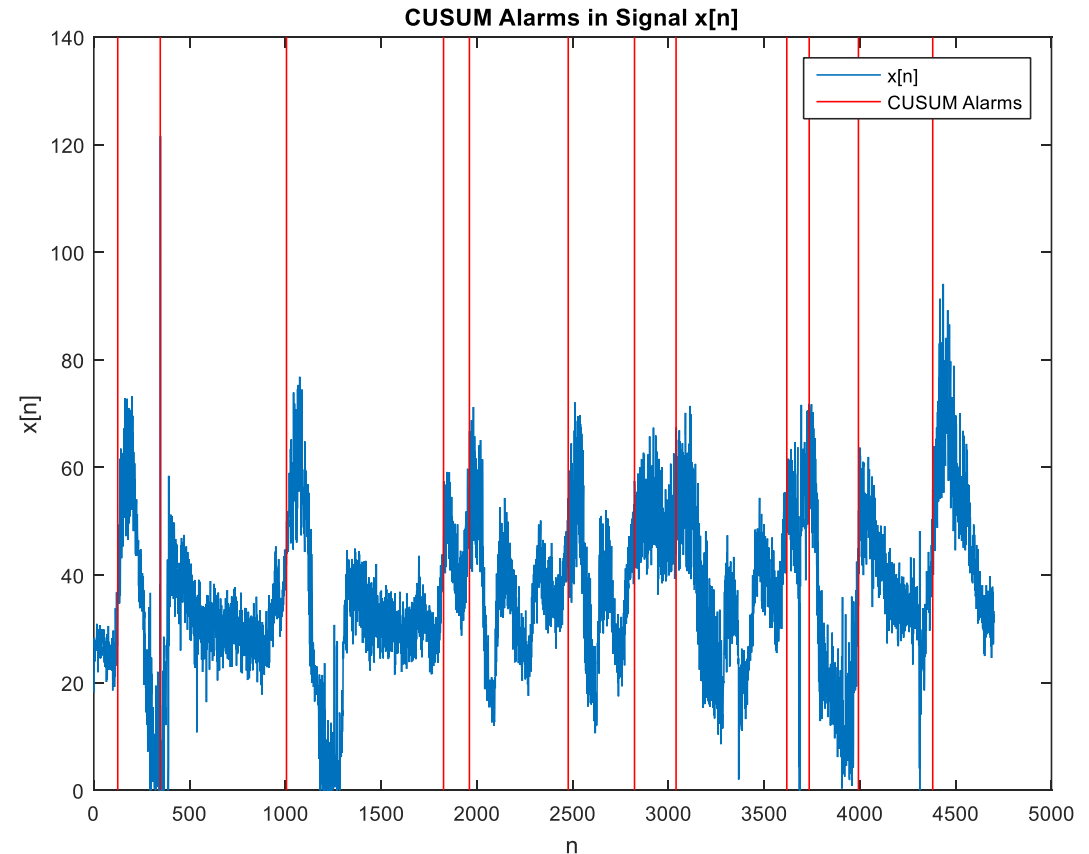
## while the algorithm is not stopped do

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

## end

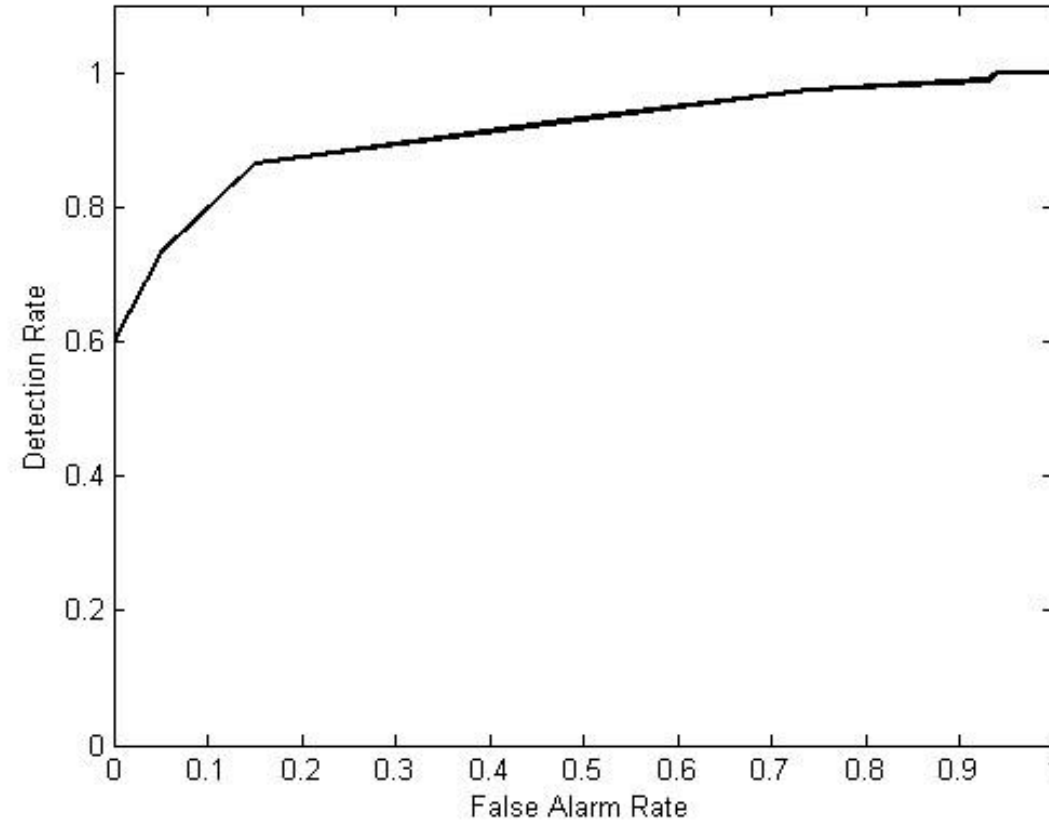
$k = k + 1$

## end



CUSUM Alarms in the ST-Elevation Time Series

# Receiver Operating Characteristics and Results



$$\text{Detection Rate} = TP / (TP + FN) = 73\%$$

$$\text{False Alarm Rate} = FP / (FP + TN) = 5\%$$