A Patient-Adaptive Profiling Scheme for ECG Beat Classification

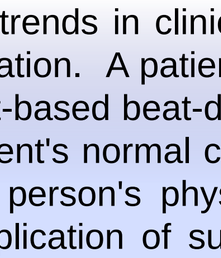
Miad Faezipour et al., *Member, IEEE*

Abstract - Recent trends in clinical and telemedicine applications highly demand automation in electrocardiogram (ECG) signal processing and heart beat classification. A patient-adaptive cardiac profiling scheme using repetition-detection concept is proposed in this paper. We first employ an efficient wavelet-based beat-detection mechanism to extract precise fiducial ECG points. Then, we implement a novel local ECG beat classifier to profile each patient's normal cardiac behavior. ECG morphologies vary from person to person and even for each person, it can vary over time depending on the person's physical condition and/or environment. Having such profile is essential for various diagnosis (e.g., arrhythmia) purposes. One application of such profiling scheme is to automatically raise an early warning flag for the abnormal cardiac behavior of any individual. Our extensive experimental results on the MIT-BIH arrhythmia database show that our technique can detect the beats with 99.59% accuracy and can identify abnormalities with a high classification accuracy of 97.42%.

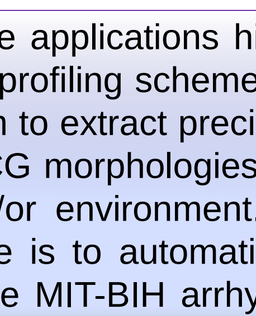
ECG Beat Classification

Mean R-peak
Average RR Interval
Mean Power Spectral Density
Autocorrelation Value
Area under QRS

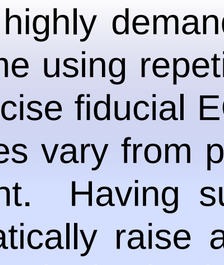
One Feature Vector for each Heart Beat



Learning Algorithm
- Profiling
- SVM
- ANN



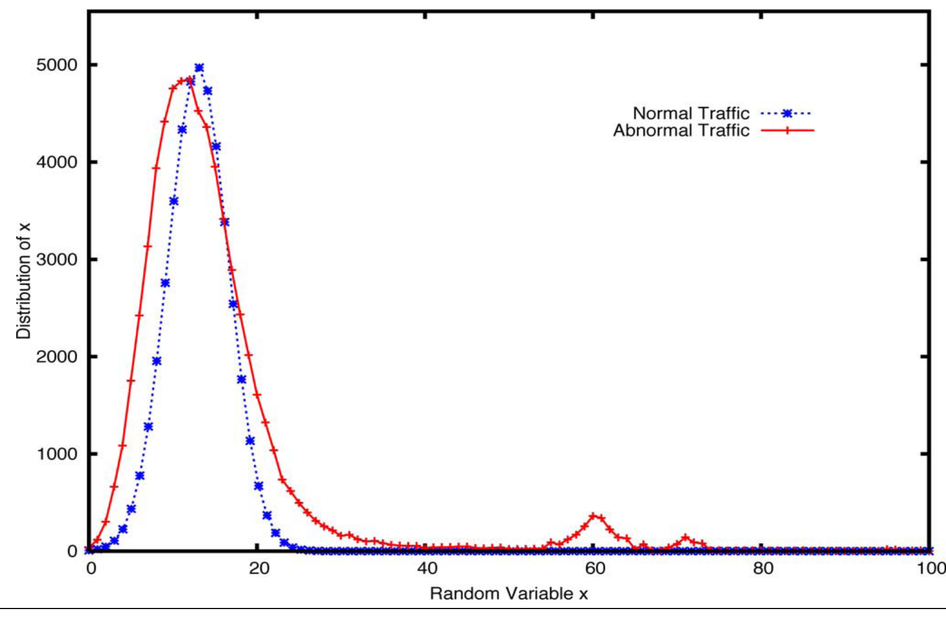
Classified Heart Beats



- Accurate ECG beat detection and classification is critical for correct arrhythmia assessment.
- Support Vector Machines and Artificial Neural Networks are the most widely used ECG beat classification approaches.
  - Local Classifiers
  - Global Classifiers
- Key Contribution
  - A novel ECG beat classifier proposed based on packet processing based repetition detection/profiling

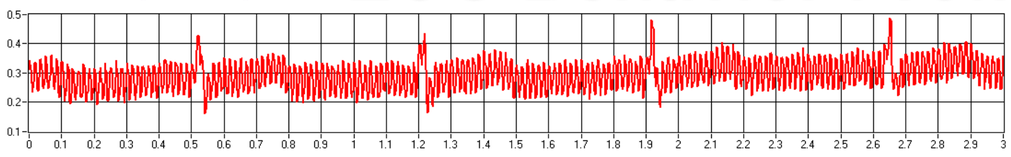
Packetized Repetition-Based Behavior Analysis

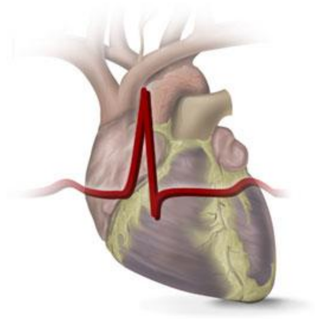
- A Two-Phase Architecture; hashing functions used.
  - Phase I: Packet stream divided into L bytes. W-bit window of the stream processed at a time. Borders b are determined for data chunks.
  - Phase II: m memory units with size of 2^n behaving as multiple shared counter units functioning in parallel.
- Abnormalities detected as high (low) repetitions at the distorted tail(s) of the distribution (profiling) curve.
- Negligible false positives/negatives



ECG Behavior Profiling for Beat Classification

Original ECG Signal





ECG Records

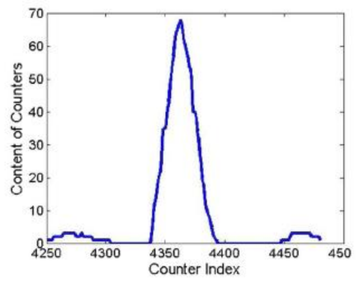
Denoising
- Baseline Wandering Removal
- Wide-band Noise Suppression

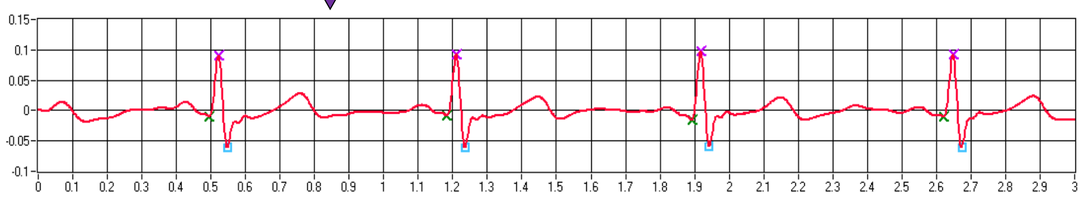
Preprocessed ECG Data

Feature Extraction
- QRS Complexes Extraction

To ECG Beat Classification

Profiling curve

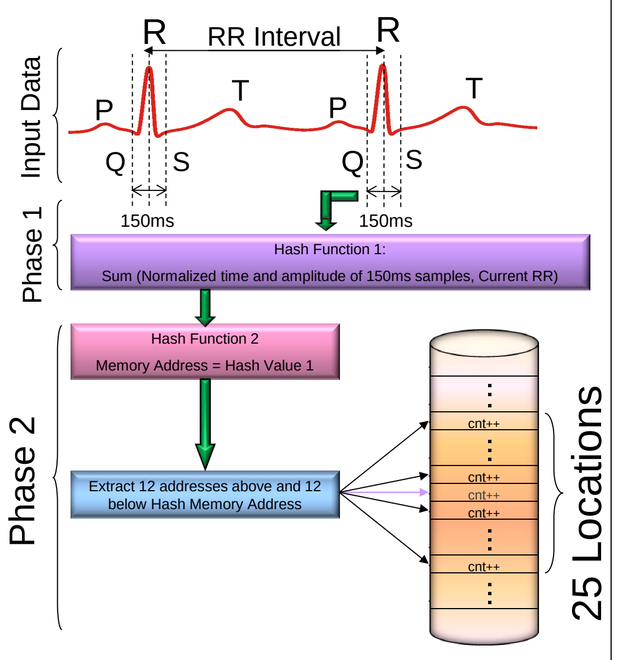




Profiling ECG Packets

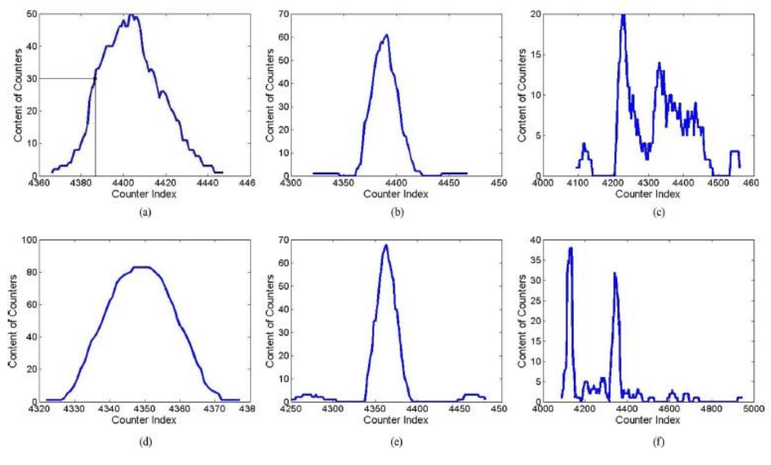
- Empirically, 92-116% (difference of 25) of average RR is considered normal for an individual
- Algorithmic Fine-tuning:

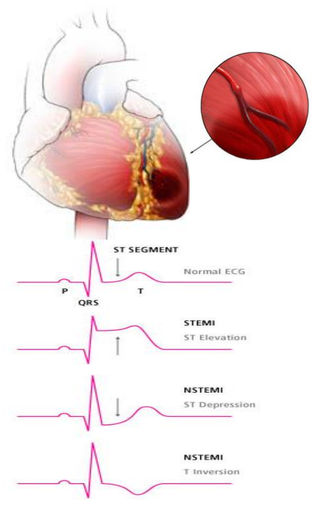
$$L \approx RR_{interval}$$
$$W = 150ms$$
$$b = RR_{interval}$$
$$m = k = 1$$
$$n = 16$$



Performance Evaluation

- Distribution of counter contents for MIT-BIH arrhythmia database readings





- Overall error of 6.44% for a minute of the entire database.