Detection of Ventricular Arrhythmias on a Smartphone

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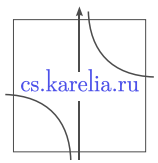
Outline

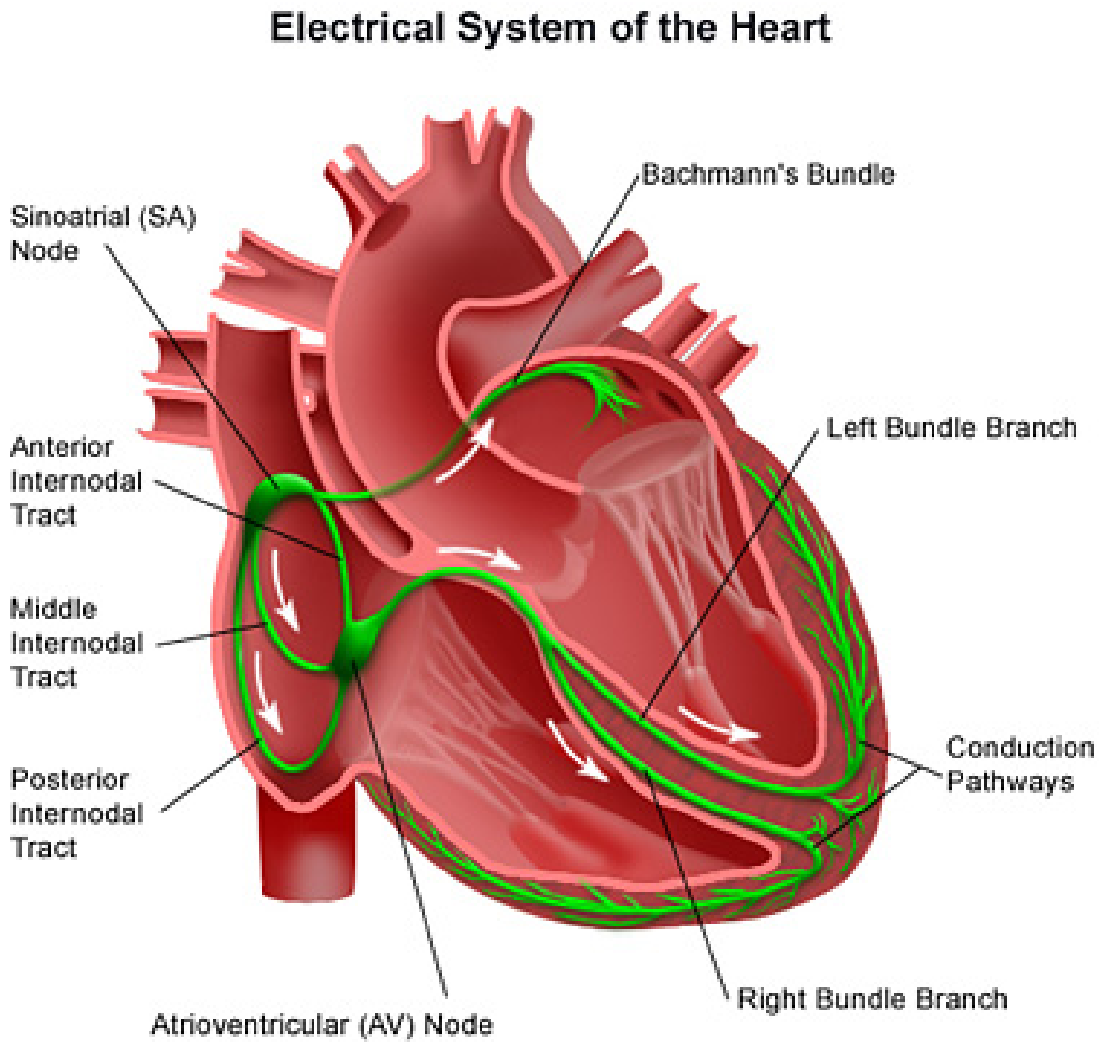
- Why do we need to be able to detect rhythm anomalies of this kind?
- Ventricular arrhythmias overview.
- Detection algorithm selection criteria.
- Detection of ventricular arrhythmias based on Hilbert transform.
- Recognition of ventricular arrhythmias based on multiscale non-linear descriptor.



Motivation and Goal

- Ventricular arrhythmias detection feature should be added to CardiaCare app.
- Ventricular arrhythmia episode shapes of ECG recordings differ from normal sinus rhythm substantially.
- The number of ventricular arrhythmia detection algorithms have been developed recently but most of them require essential computational capabilities.
- At this stage of the project the approach should be selected to reach a trade-off between detection accuracy and computational complexity.

Electrical Heart Model



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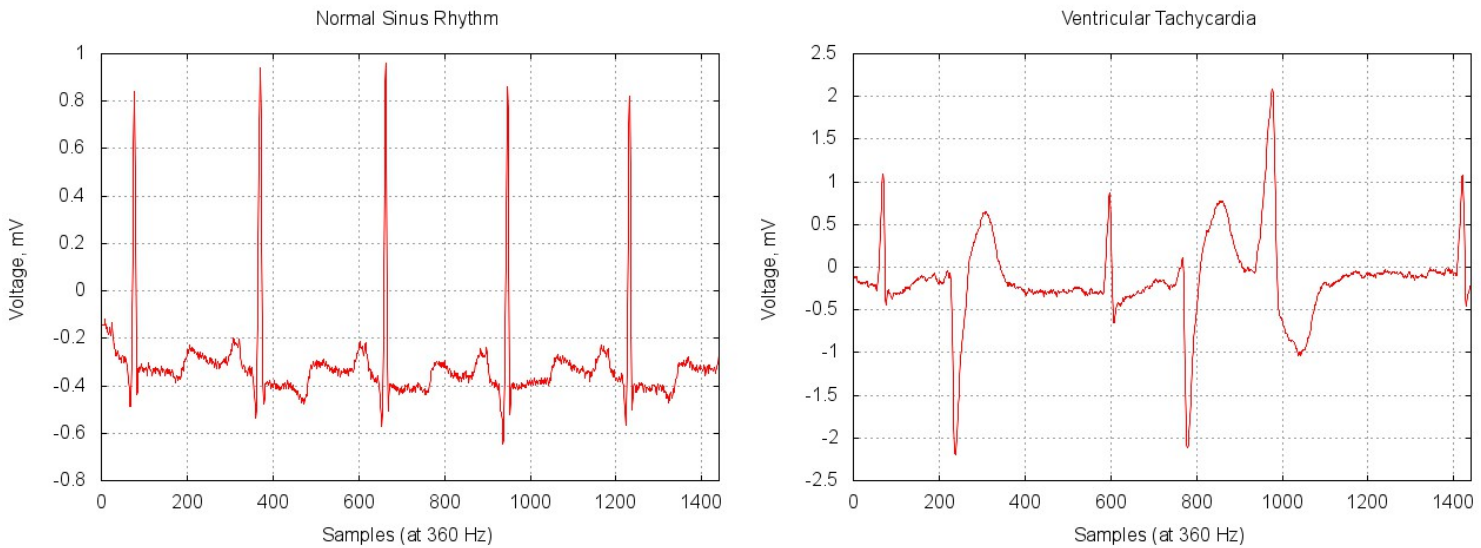
Normal Sinus Rhythm vs. Ventricular Arrhythmia



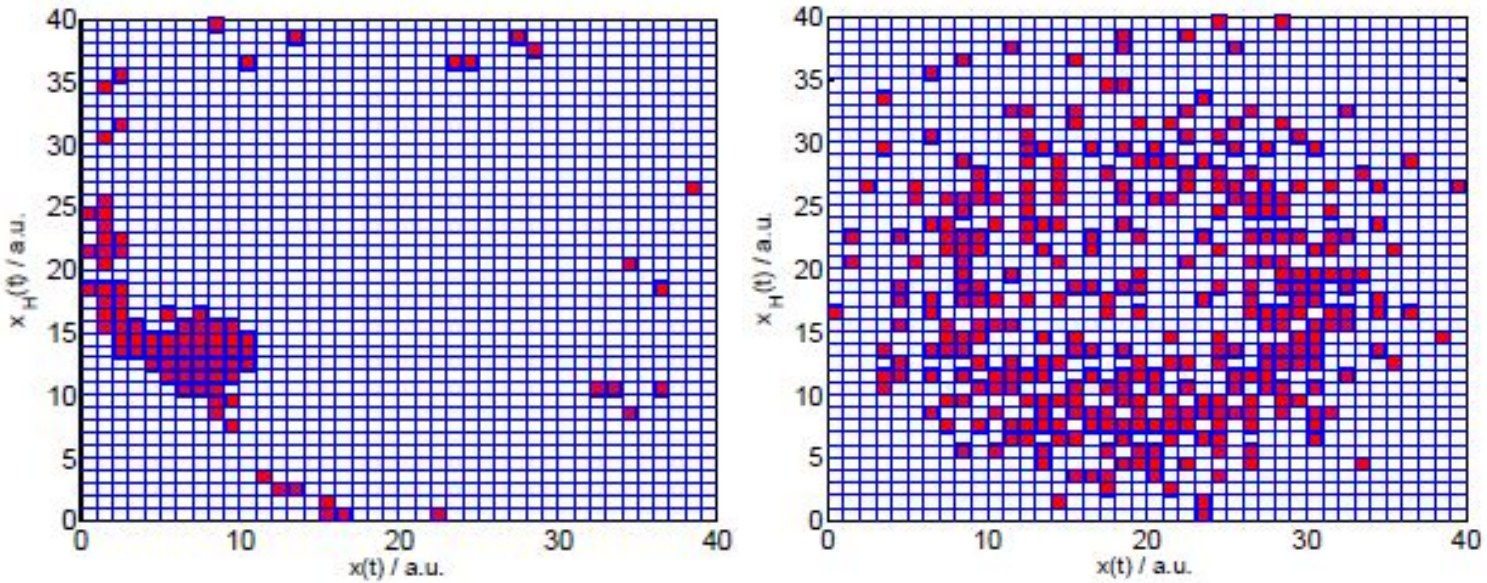
Source: Goldberger et. al. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals, 2000

Detection Algorithms Selection Criteria

- There are a lot of ventricular arrhythmia detection algorithms published with proven accuracy.
- Virtually the algorithms rely on heavy computations and should not be considered as an option.
- We should take into account that arrhythmia detection on a smartphone is preliminary and rough to some extent.
- We should prevent battery drain without sacrificing quality.

Hilbert Transform Based Approach

- Generate a plot with original signal $x(t)$ on the x-axis and Hilbert transform $x_H(t)$ of the signal on the y-axis.



- Decide whether the ventricular arrhythmia has been occured comparing the ratio of visited cells to overall number of cells to empirical threshold.

Source: Amann, Tratnig, Unterkofler. A new ventricular fibrillation detection algorithm for automated external defibrillators, 2005

Hurst Index Based Approach

- Apply the fractal Brownian motion model for non-stationary signal analysis
  - Compute the components of wavelet transform of the signal at different scales.
  - Calculate a Hurst index to measure self-similarity of the process.
- The complexity of the algorithm is estimated to have the $O(N \times \log N)$ complexity class.

Source: Sun et. al. Life-threatening ventricular arrhythmia recognition by nonlinear descriptor, 2005

Conclusions and Future Work

- Ventricular arrhythmias present the most life-threatening class of rhythm abnormalities and should be recognized timely. Consequently, the ability of detection of ventricular arrhythmias is of high importance for continuous monitoring of heart function.
- Two detection algorithms that provide acceptable accuracy and avoid heavy computations at the same time were selected.
- The problem of distinguishing different kinds of ventricular arrhythmias first of all, ventricular tachycardia and ventricular fibrillation, is scheduled to be solved in the near future.
- Integration of ventricular arrhythmia capabilities to the CardiaCare app is planned to the next half of the year.