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Analysis of Teager-Kaiser Energy Operator Pertinence for R Peak Detection in ECG Recordings on a Smartphone

This research is financially supported by the Ministry of Education and Science of the Russian Federation within project # 14.574.21.0060 (RFMEFI57414X0060) of Federal Target Program "Research and development on priority directions of scientific-technological complex of Russia for 2014–2020".





AMICT 2015 conference May 13–14, Petrozavodsk, Russia



Motivation

- Number 1 cause of death globally (31% of all global deaths in 2012)¹
- Can be prevented by addressing behavioural risk factors (tobacco use, unhealthy diet, obesity, physical inactivity, etc.)
- Need early detection and management

Contribution of CVDs to mortality in CIS (percents)

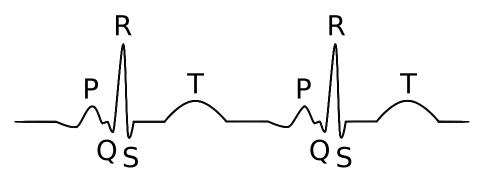
· ·	/ I
Georgia	67
Ukraine	64
Azerbaijan	60
Russia	57
Moldova	56
Belorussia	53
Kazakhstan	50
Armenia	50
Kyrgyzstan	49
Tajikistan	39



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¹Source: WHO

Electrocardiogram morphology





Significance of confident R peak detection

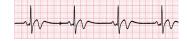
■ Normal sinus rhythm



■ Sinus tachycardia



Sinus bradycardia



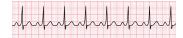
Sinoatrial block



■ Atrial flutter



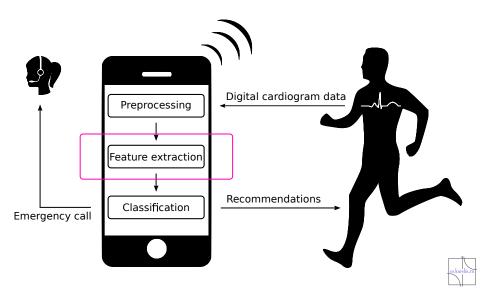
Wolff-Parkinson-White syndrome



Source: Medical Training and Simulation LLC http://www.practicalclinicalskills.com



Rhythm anomalies detection



Teager-Kaiser energy operator based approach

Consider the digital ECG recording represented by discrete signal \boldsymbol{x}_n

I Estimate the instantaneous energy of a signal

$$\Psi_d[x_n] = x_n^2 - x_{n-1}x_{n+1}$$

2 Emphasize the pulses

$$y_n = \Psi_d[x_n]^3$$

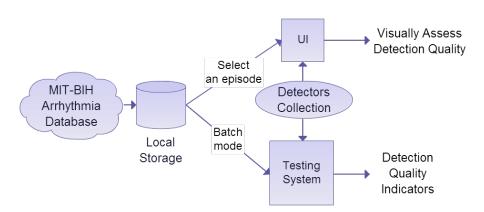
3 Choosing parameters N, α and β , apply the adaptive threshold

$$z_n = \alpha \frac{1}{N+1} \sum_{k=-N}^{N} y_k + \beta \sigma_y$$



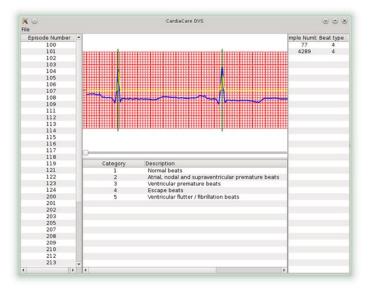
Source: Yamamoto and Yoshida, 2013

Experiments





UI of developed verification system





Results

- **1** TKEO-based algorithm for R peak detection have been implemented.
- 2 The system to examine the detectors on the set of recordings have been developed.
- Experiments show that the approach demonstrates sufficient sensitivity on almost all types of rhythm abnormalities.



