A MODIFIED CUSUM ALGORITHM FOR DETECTION OF TACHYCARDIA IN PATIENTS WITH EPILEPTIC SEIZURES

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GOAL To develop and validate a simple, self-learning algorithm for the detection of major nocturnal seizures using heart rate data

EPILEPSY AND HEART RATE (HR)
• Epilepsy is a disorder manifested by recurrent seizures
• ~50 million people are affected in the world
• 30% refractory -> seizures despite best possible treatment
• Sometimes, seizures can lead to brain damage or even death (early warning is needed)
• Often, seizures alter autonomic functions such as heart rate (tachycardia)
• Heart rate increase before, and/or in the same time with any clinical symptoms (such as movement)

EXAMPLES OF HR INCREASE DURING SEIZURES

Classical CUSUM algorithm
Accumulation of deviations above/below target mean (µ0)

\[ CS^+(i) = \max[0, x(i) - (µ_0 + K)] + CS^+(i-1) \]
\[ CS^-(i) = \min[0, x(i) - (µ_0 + K)] + CS^-(i-1) \]

\[ K = |µ_1 - µ_0|/2 \]

µ0 = reference value; µ1 = out of control mean

Adaptive CUSUM algorithm

\[ CS^+(i) = \max[0, x(i) - (µ_0 + K)] + CS^+(i-1) \]
\[ µ_0 = \text{mean}(hr(1:i)); µ_1 = 110; \]
\[ CS^-(1) = 0; hr(1) = 80 \text{ BPM (Beats Per Minute)}; \]

hr(i) = instantaneous value; hr(1:i) = baseline;

Algorithm is iterative, self learning, no additional parameters required

DATA PROCESSING
ECG recorded in patients with epilepsy
100 Hz sampling rate, V2-V6 configuration

Offline RR interval detection
Convert to HR (BMP)
Remove outliers
Apply CUSUM algorithm

RESULTS

Patient 1
Patient 2

CONCLUSIONS
• Heart rate pattern during seizure is very complex, after a seizure, the HR can return to baseline, stay at high arousal level or retain wakefulness state
• The proposed algorithm detects all seizures that show heart rate increase above 110 BPM.
• Algorithm performance is robust against motion artefacts
• Arousal or short awakenings are the main source of false positives.

FUTURE WORK
• Improve the CUSUM algorithm to reduce the false positives (fusion with accelerometer data)
• Embed the algorithm for real-time use

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