An approach using extreme value statistics to detect rare movement events in a bio-medical dataset

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Goal: Detecting hypermotor seizures during nocturnal monitoring of epileptic children based on data collected from accelerometers attached to the extremities

1 Seizure detection

- *Typical:*
  - Supervised model inference e.g. Support Vector Machines
  - Indication whether movements are seizures or not is necessary
    - ➔ Data annotation is necessary
    - ➔ Time consuming and expensive since data is patient specific
- *Our approach:*
  - No annotation is required. Completely unsupervised!
  - Patient dependent model is easily estimated

Dataset overview

Patient nr.	#Nights	#seizures	#normal movements
1	1	2	117
2	2	9	287
3	2	2	439
4	1	2	239
5	5	26	784
6	2	7	381
7	2	3	468

2 Feature extraction & selection

- **Sensors**: four 3-axial accelero meters (ACM)
- **Preprocessing**:
  - Select movement events using energy threshold $\{E_s\}_{s=1}^{|E_s|}$
  - Remove ACM orientation using L_2 -norm, retain:

$$E_s = \{x_i\}_i^N, \quad x_i = \left[x_i^{(L_{arm})} x_i^{(R_{arm})} x_i^{(L_{leg})} x_i^{(R_{leg})}\right]^T, \; x_i \in \mathbb{R}^4$$

  - P standard features [Jallon et al., 2010] on 50% overlapping sliding window of size L per E_s:

$$\{F_i\}_{i=1}^M, F_i \in \mathbb{R}^P, F_i = \varphi(\{x_i\}_i^L)$$

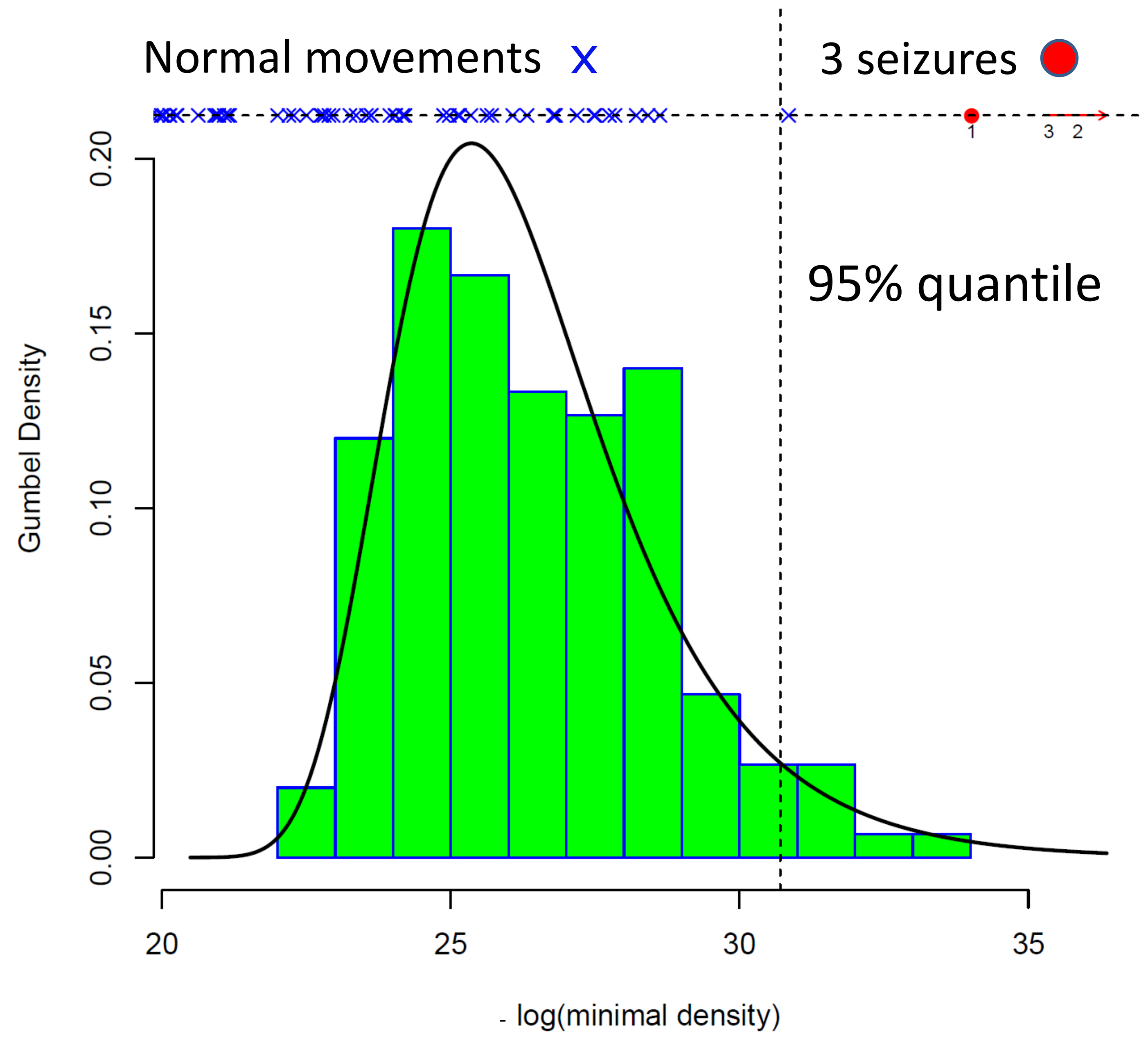
  - Standard feature selection suggested 3 features:
    1. Movement length: $|E_s|$
    2. Avg. energy limb movement: $\frac{1}{L}\sum_{i=1}^{L}\|x_i\|_2^2$
    3. Avg. energy movement: $\frac{1}{L}\sum_{i=1}^{L}\max(|x_i^{(R_{arm})}|, |x_i^{(L_{leg})}|)$

Subsampling: randomly select K samples from each E_s

3 Gumbel model for rare events

- 3D – model of normal behaviour using kernel density estimation ➔ $p = p(F), \;\; F \in \mathbb{R}^3$
- Gumbel model of minimal densities:

$$p_m = min\{p(F_i)|\, 1 \leq i \leq K\}$$



4 Results:

10-fold randomizations

Patient nr.	ss (%)		ppv (%)		spec (%)	
	mean	sd	mean	sd	mean	sd
1	100.00	0.00	49.09	37.39	92.18	7.21
2	100.00	0.00	60.01	20.04	97.29	2.31
3	100.00	0.00	56.33	17.80	97.18	1.43
4	70.00	25.81	31.78	25.18	92.96	4.31
5	27.77	12.00	20.77	9.96	96.29	1.08
6	100.00	0.00	56,65	17.29	97.79	1.47
7	100.00	0.00	44.02	9.79	95.77	1.49

5 Conclusions:

- Detection of all seizures in 5/7 patients
- An average ppv of 45%
- Patient 4: 1 of 2 seizures is less tractable
- Patient 5: seizures were not 'extreme' with respect to normal behaviour

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