Validation of an Automated Seizure Detection System on Healthy Babies

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# Neonatal Seizure

- 1.8-3.5 per 1000 live births (higher in babies with low birth weight and <38 wks GA)
- 25-30% of high-risk babies will develop seizures
- Occur early in life - 87% within first 48 hrs
- Harmful to the developing brain
Diagnostic Approaches

Clinical diagnosis (~10%)  

Amplitude integrated EEG  
(low sensitivity, misses focal, short duration (<1 min), and low amplitude seizures)

Conventional EEG - “gold standard”
EEG:
- Seizure detection rate 100%
- Monitoring of seizure treatment
- Long-term prognosis

EEG interpretation:
- Requires special expertise
- Not widely available
- Not available 24/7

Automated seizure detection using computerised analysis of EEG - “Holy grail” in neonatal EEG research
Previous Work*

SVM-based multi-channel patient-independent neonatal seizure detector

The best up-to-date performance estimated on a dataset of ~268h using leave-one-out performance assessment

* A. Temko et al., An SVM-Based System and Its Performance for Detection of Seizures in Neonates, EMBC 2009

* A. Temko et al., Neonatal Seizure Detection with Support Vector Machines, submitted to Clinical Neurophysiology, 2010
Newborn EEG Database

- Newborn EEG Database
  - Neurologically Compromised Babies
    - Term
    - Preterm
  - Healthy Babies
Recruitment Criteria For Healthy Babies

- Gestation > 37 weeks
- Normal foetal heart rate prior to delivery
- No requirement for resuscitation following delivery
- Apgar scores of > 8 at 5 mins
- Normal cord pH (>7.1)
- Normal neurological examination (Amiel Tison assessment)
Montage Mismatch

Seizure babies: 10-20 system of electrode placement modified for neonates F4-C4, C4-O2, F3-C3, C3-O1, T4-C4, C4-Cz, Cz-C3 and C3-T3.

Healthy babies: a simpler montage was used in order to minimize the time of interference F3-P3, F4-P4, T4-Cz, and Cz-T3.

different levels of energy of incoming signals
Histogram-Based Energy Normalization

Many features used are based on the absolute energy of the signal → the system is sensitive to the mismatch in energy levels of EEG signals → equalize the energy levels of background EEG

Many features use the absolute energy of the signal, meaning the system is sensitive to the mismatch in energy levels of the EEG signals. To equalize the energy levels of the background EEG, a normalization method is applied. This method involves calculating a coefficient (\(\text{coef} = \sqrt{10^{E_{\text{tr}} - E_{\text{test}}}}\)) that depends on a channel but not on a patient. The standard deviation of the coefficient for a patient (\(\text{std}(\text{coef})_{\text{patient}}\)) is much smaller than that for a channel (\(\text{std}(\text{coef})_{\text{channel}}\)).
Experiments

• Test on healthy babies (47 patients)

• No seizure present (no Good Detection Rate computable)

• To observe the number of False Detections per hour obtained on healthy babies for the same probabilistic threshold (i.e. the same GDR and FD/h for seizure 17 seizure babies)
Experimental Results

- Introduced normalization successfully compensates the energy mismatch
- The performance on healthy babies compares favourably to that on sick babies
- A practically useful range of probabilistic thresholds
- System performance depends on the database statistics (seizure density)
Summary

- **Validation** of the neonatal seizure detector on healthy babies
- Histogram-based energy normalization – a step forward to more robust neonatal seizure detection
- **Useful observations**
  - useful range of probabilistic thresholds
  - minimum duration restriction
  - an influence of the database statistics on the system performance.
Questions

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