Low power interictal detection algorithm to facilitate long term and wireless AEEG monitoring

LOW POWER INTERICTAL DETECTION ALGORITHM TO FACILITATE LONG TERM AND WIRELESS AEEG MONITORING

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1 Objectives

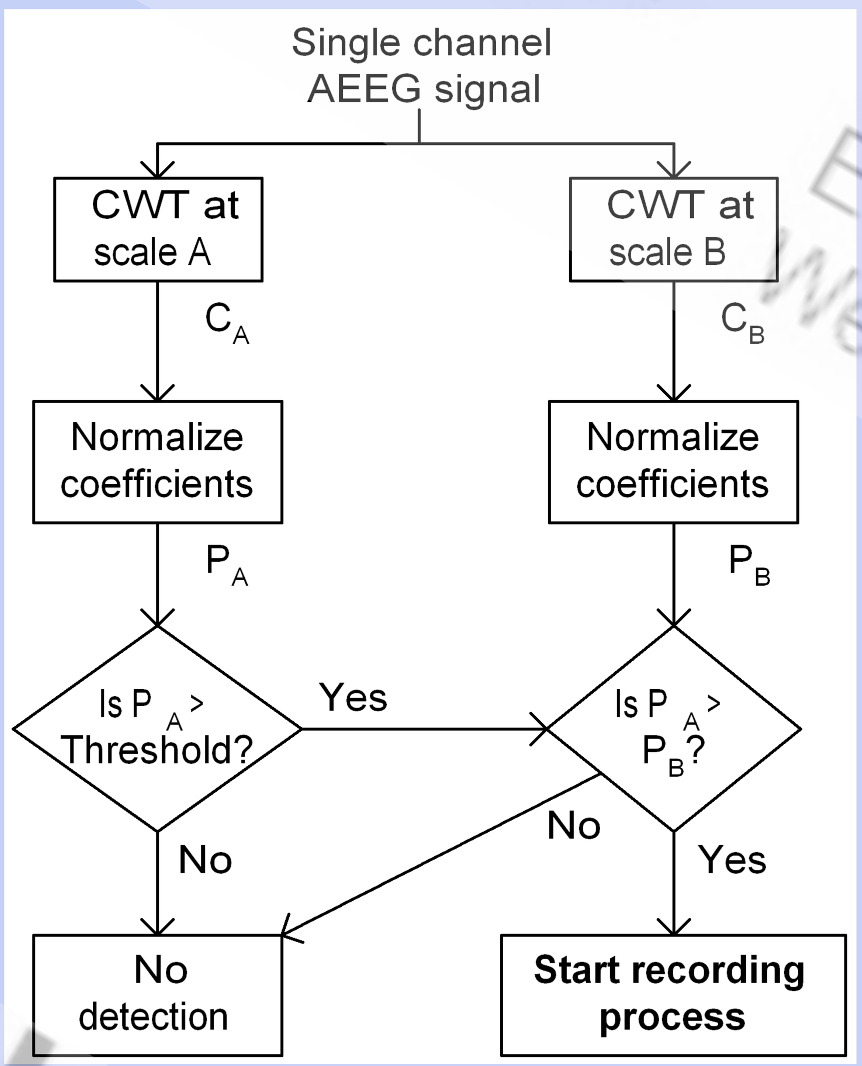
- **To define an EEG data reduction algorithm which is based upon recording only candidate interictal activity. The algorithm must be suitable for implementation in low power circuits.**
- **To outline an ambulatory EEG (AEEG) system which incorporates this algorithm to reduce power consumption.**
- **To present the algorithm results to show that significant data reductions can be made whilst still recording the relevant events.**

2 Motivation

- The electroencephalogram (EEG) is a key tool in epilepsy diagnosis.
- Ambulatory EEG systems allow patient monitoring in their home and work environments.
- However, current systems have several limitations:
  1. Electrodes must remain attached for the duration of the testing and wearing them must be socially acceptable.
  2. Systems can be large, limiting their portability.
  3. Long term recordings generate large amounts of data for storage and analysis.
- Wireless systems could alleviate the portability issues but are infeasible due to the amount of power needed and the restriction in battery size for a small portable device [1].
- Online data reduction is required [2].

4 Algorithm

- The current algorithm aims to record interictal events only.
- It is based upon the Continuous Wavelet Transform (CWT) as a suitable low power implementation is known [5].
- One wavelet scale (A) is used to identify candidate features.
- A second (B) provides a simple rule to reject artefacts.
- A Mexican hat based mother wavelet at scales A=5 and B=20 is used, following the procedure in [5].
- Wavelet coefficients are normalized to correct for EEG signal amplitude changes.



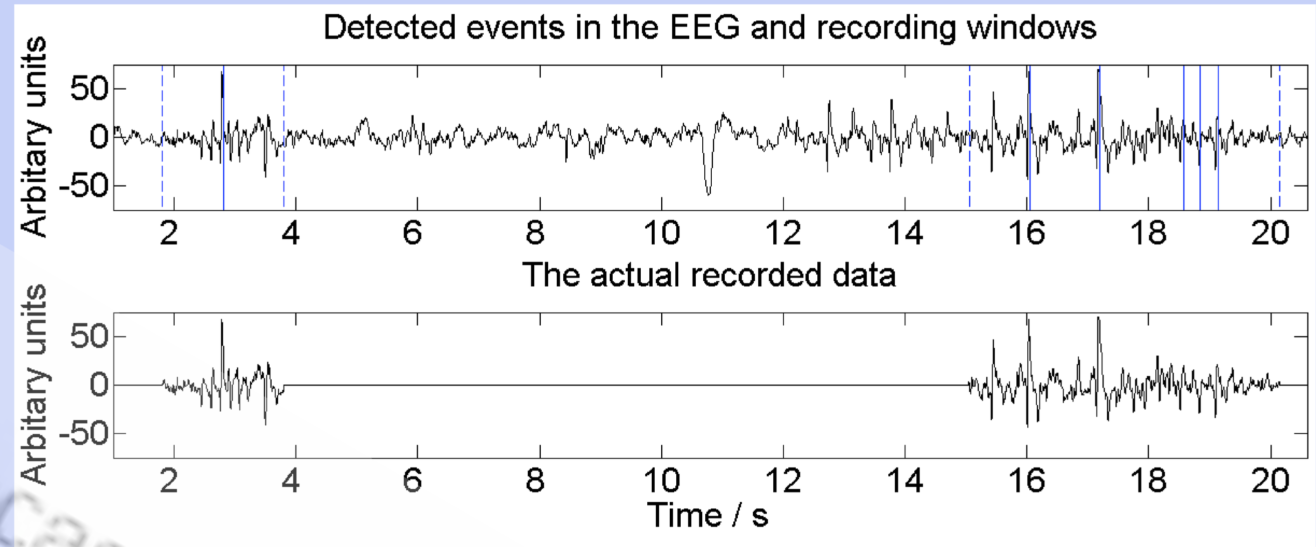
- All EEG channels are analysed separately and a detection in any one causes all of the channels to record.
- Future work will investigate different system topologies analysing only subsets of channels.
- All algorithm blocks have direct circuit equivalents, such as with filters and comparators, making the entire algorithm suitable for the low power implementation that is required.

6 Conclusions

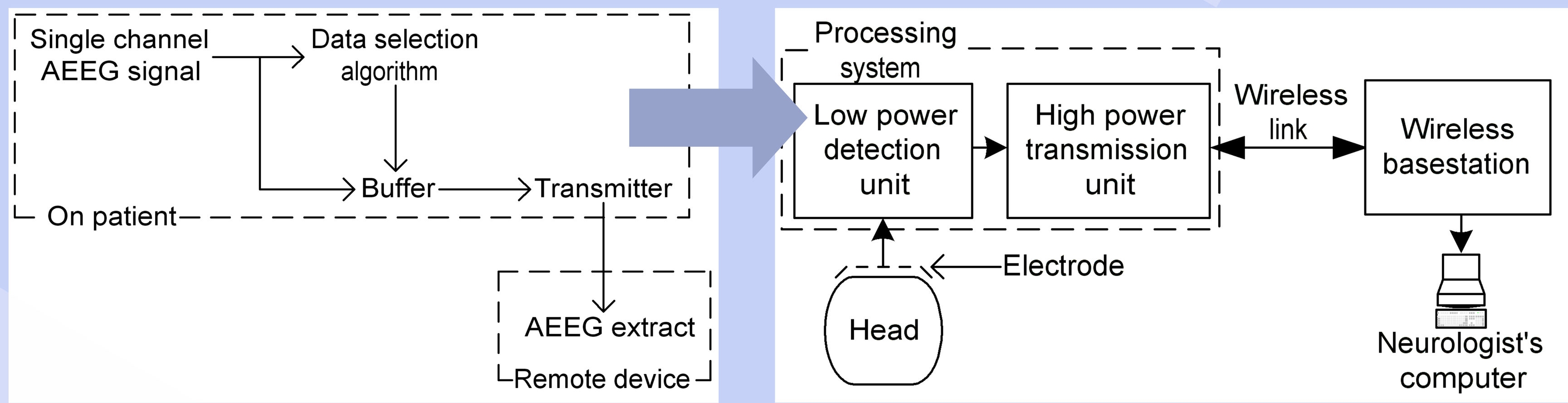
- Discontinuous monitoring of the EEG can offer significant power and analysis time savings for AEEG units.
- A low power algorithm based on the CWT has been proposed for this.
- Results show that this achieves a very satisfactory level of performance, 90% of expert marked events are recorded while transmitting less than 50% of the raw data.
- Future work will look at the hardware implementation in detail.

3 Proposed system

- The proposed system is discussed in detail in [2, 3].
- By detecting candidate epileptic activity and recording only the relevant sections significant data reduction can be achieved.

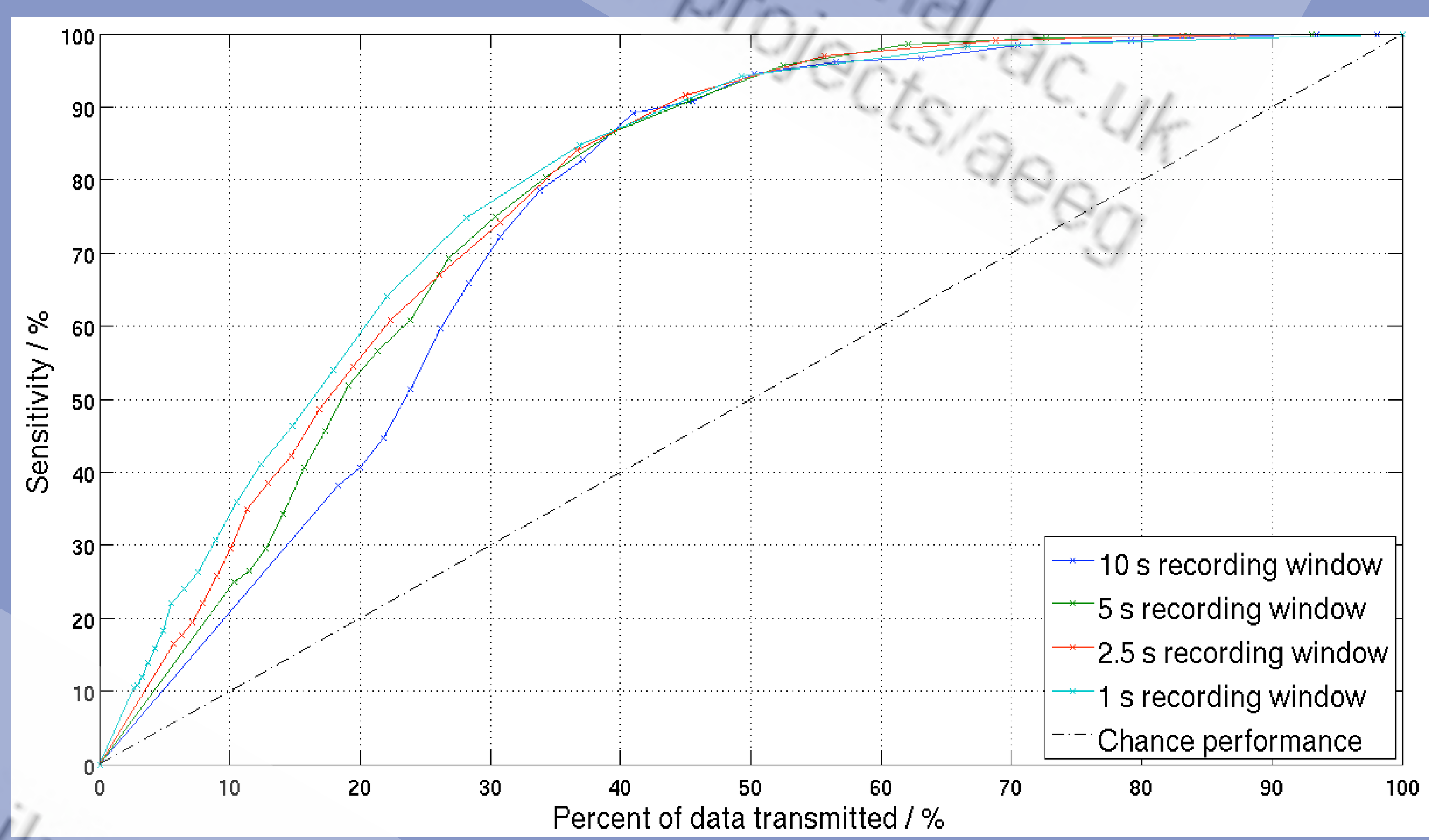


- This simultaneously reduces the data for both transmission and analysis.
- Provided that all events are detected, and some data reduction is achieved, false detections are not significant as they are rejected by the neurologist who interprets the data.
- The method is termed data selection to differentiate it from quantification methods where minimising false detections is critical [2].
- The principle is similar to that carried out by Gotman [4] but for online implementation the algorithm power consumption is key.
- This is a classic example of adding intelligence to the sensor node.
- The required system:



5 Results

- 959 expert marked interictal events in 20 hours of EEG data are analysed.
  - Events include spikes, spike-and-waves and other potential features of interest.
- Events are deemed to be successfully recorded if a detection occurs no more than 4 s, 2 s, 1 s or 0.4 s away from the marked position for the 10 s, 5 s, 2.5 s, and 1 s recording windows respectively.
- Different detection thresholds and recording periods in response to a detection can be used to control the algorithm's performance:



- Over 90% of the expert marked events can be recorded while transmitting less than 50% of the raw data.
- This offers a very significant system level power saving, increasing the battery life and decreasing the analysis time without important features being lost.

[1] D. C. Yates and E. Rodriguez-Villegas, "A key power trade-off in wireless EEG headset design," in IEEE EMBS conference on neural Engineering, Hawaii, May 2007.
[2] A. J. Casson and E. Rodriguez-Villegas, "Data reduction techniques to facilitate wireless and long term AEEG epilepsy monitoring," in IEEE EMBS conference on neural Engineering, Hawaii, May 2007.
[3] A. J. Casson, D. C. Yates, S. Patel, and E. Rodriguez-Villegas, "Algorithm for AEEG data selection leading to wireless and long term epilepsy monitoring," in IEEE Eng. Med. Biol. conference, Lyon, August 2007.
[4] J. Gotman, J. R. Ives, P. Gloor, L. F. Quesney, and P. Bergsma, "Monitoring at the Montreal Neurological Institute," in Long-term monitoring in epilepsy, J. Gotman, J. R. Ives, and P. Gloor, Eds. Amsterdam: Elsevier, 1985, pp. 327–340.
[5] A. J. Casson, D. C. Yates, S. Patel, and E. Rodriguez-Villegas, "An analogue bandpass filter realisation of the continuous wavelet transform," in IEEE Eng. Med. Biol. conference, Lyon, August 2007.