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INGÉNIEURS POUR LE MONDE

FACULTÉ LIBRE DE MÉDECINE

groupe Hospitalier de l'Institut Catholique de Lille

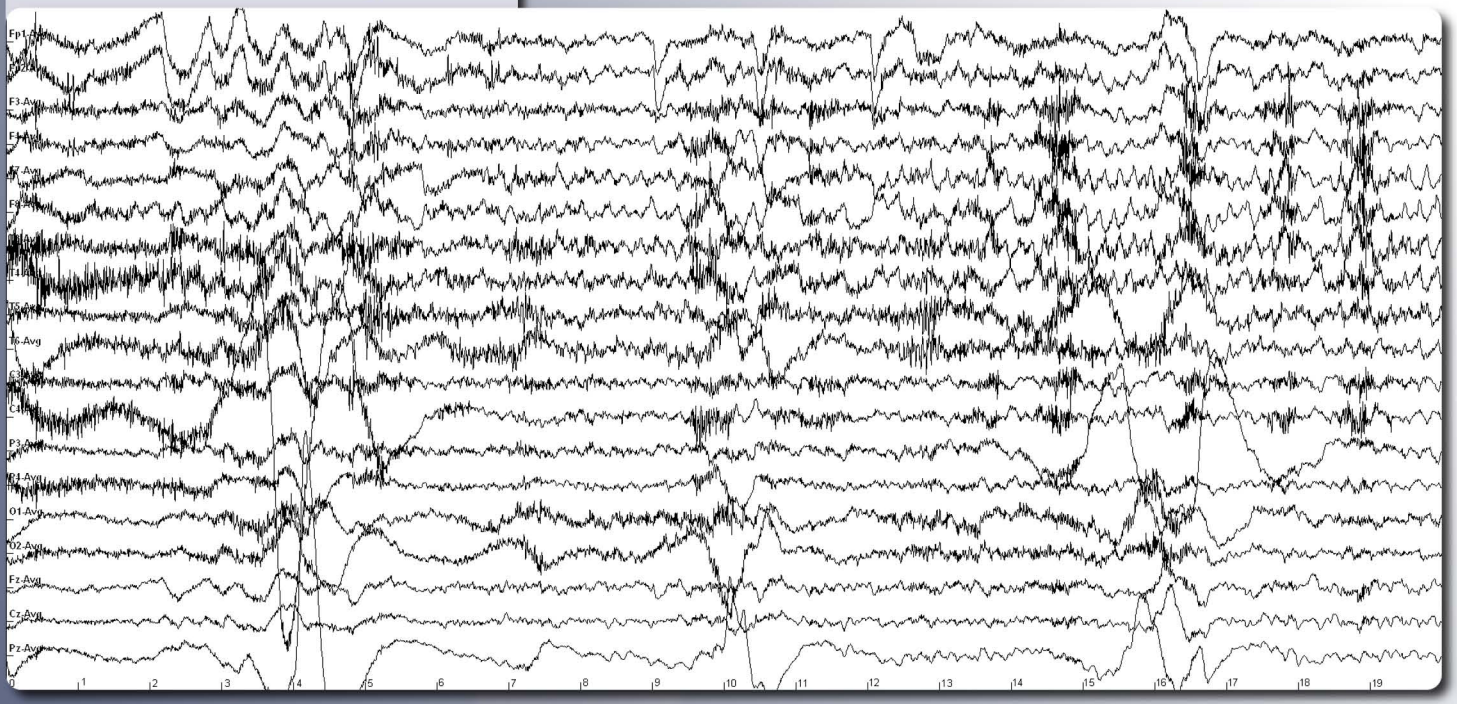
Adaptive Filtering by Optimal Projection

EEG filter which preserves pathologic signals

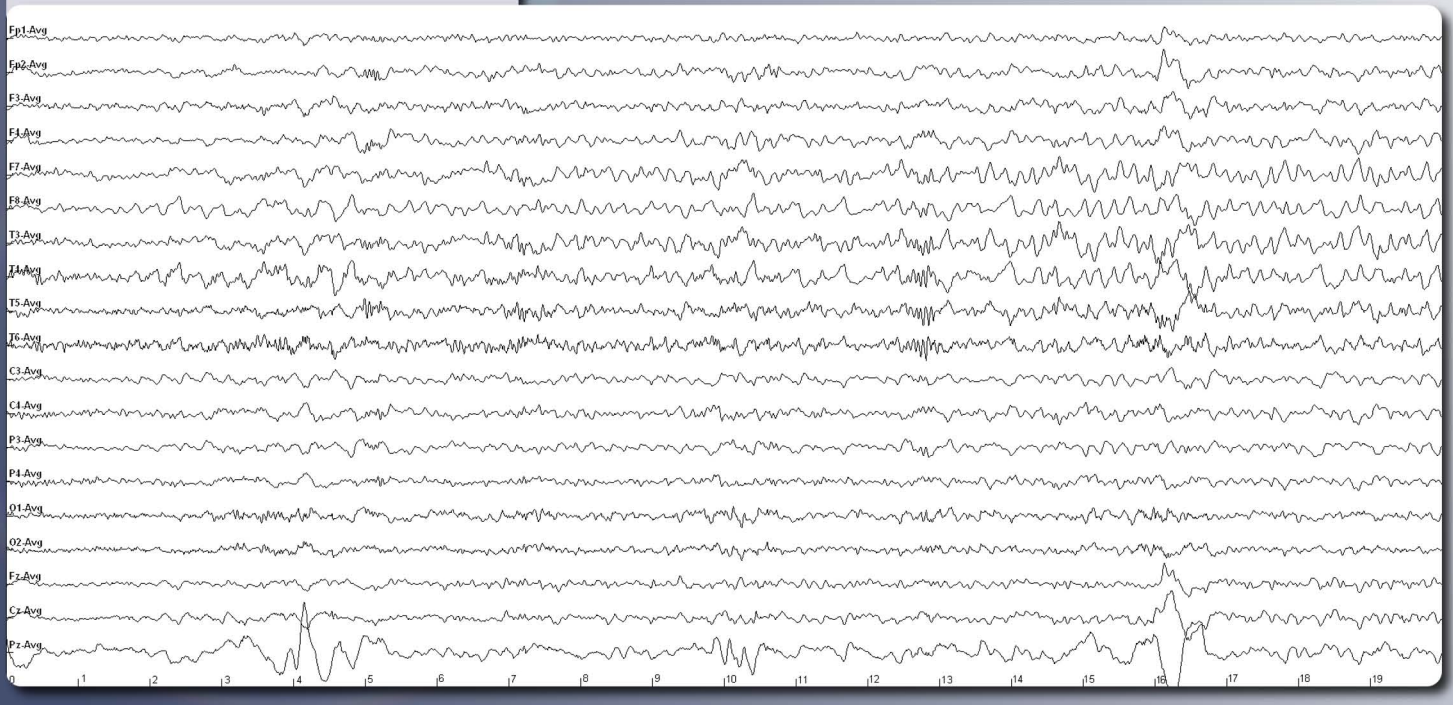
(patent pending)

Presentation and clinical evaluation

Before filtering



After filtering



The electroencephalogram (EEG) is a fundamental examination in neurology and particularly in epileptology. The signal investigation, especially during a seizure event, supplies the location and the characterization of the epilepsy disorder, thus providing a valuable guidance for eventual treatments or surgical operation.

Unfortunately, EEG activity can be easily contaminated by parasitic signals called artifacts, which makes the interpretation more difficult. The artifacts can have several origins like eyes, muscles, electrodes, galvanic skin responses, heart pulses.

The aim of the AFOP method is to automatically reduce all those artifacts while preserving the cerebral activity as much as possible.

1. The AFOP method

The AFOP method is a combination of frequential and spatial filters. It consists in dividing the various channels into time-frequency windows and in applying a different spatial filter to each of these windows.

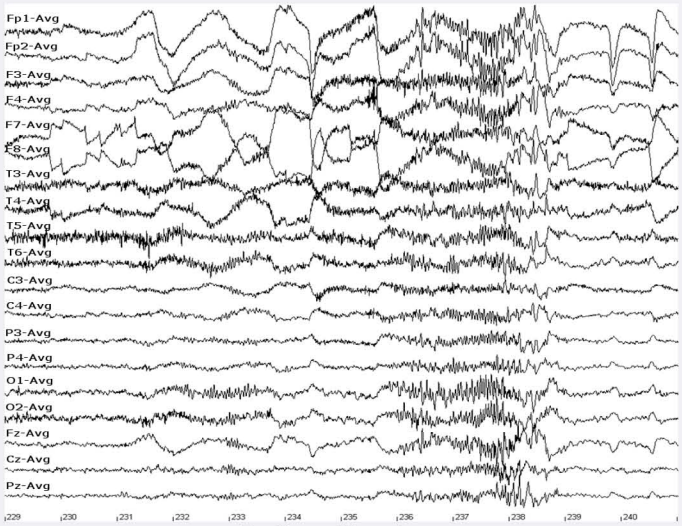
Each spatial filter is a combination of one or more of the following three processes:

- Removing the ocular artifacts thanks to a learning process of the standard spatial distribution of artifacts.
- Removing the electrode artifacts (electrode movement, galvanic skin response, head movement, pulse artifacts, …) thanks to the removal of the slowest components.
- Removing the muscular artifacts thanks to the removal of the fastest components.

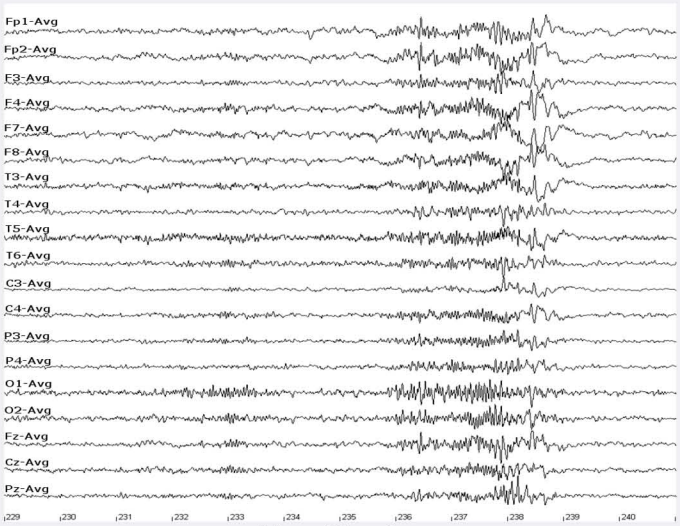
The final signal is the sum of all the spatially filtered windows.

2. Exemples

Exemples of epilepsy seizures with various artifacts:

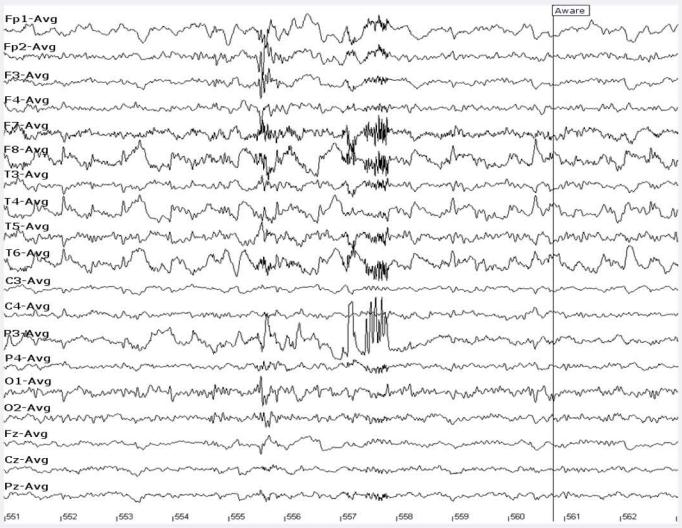


Before filtering



After filtering

Before filtering



After filtering

3. Evaluation method

An expert committee of three neurologists have evaluated the filtering results by pages of 20 seconds. The recordings corresponds to epileptic awake adults, acquired with the 10/20 system with 19 electrodes

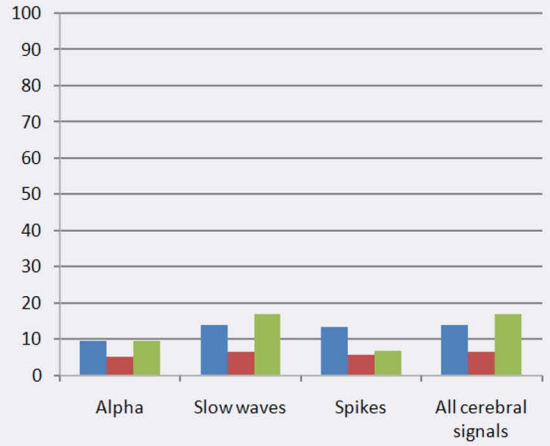
Data Collection:

- Number of recordings and subjects: 26 (5 of 72H, 21 of 20min)
- Number of examined pages: 133
- Number of studied seizures: 16 (42 pages)
- Number of studied signals: 346 (202 artifacts and 144 cerebral signals)

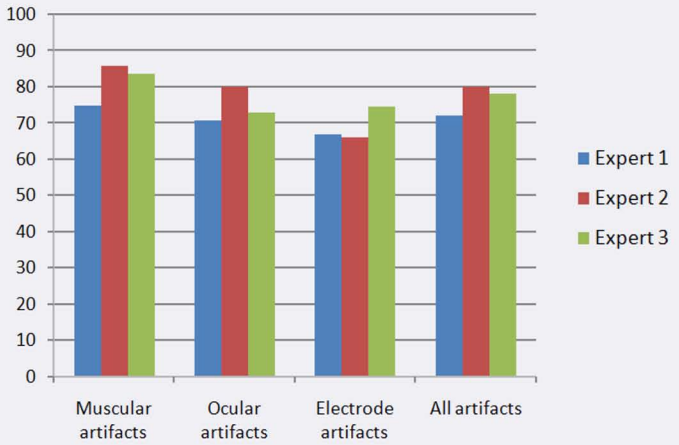
Evaluation method for each expert:

- Quotation of the artifact elimination ratios on a range from 0 to 4:
  (0: No reduction… 4: complete elimination)
- Quotation of the cerebral rhythms elimination ratios on a range from 0 to 4:
  (0: No visible modification… 4: Not identiable anymore)
- Quotation of the appreciation before and after filtering for each pages on a range from 0 to 4:
  (0 means cerebral rhythms not identifiable; 4 means no disturbance on the rhythm identification)

4. Results

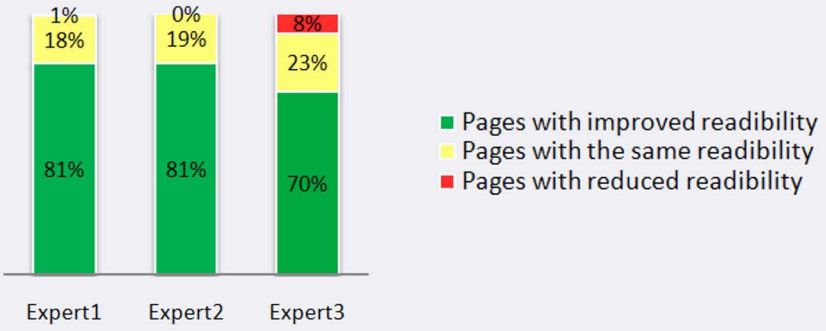


Estimation of the average ratios of cerebral signals removing



Estimation of the average ratios of artifacts removing

Pages with deleted cerebral rhythms : **1%**
(When the signals are very slow(<2Hz), it is possible that the rhythms will be removed. Particularly, the standard settings of the filter cannot be applied on slow-wave sleep.)



Readibility improvement ratios

When considering only epilepsy seizures, 98% of the pages were judged improved.

5. Discussion & Conclusion

The method AFOP provides noteworthy results for the reduction of all types of artifacts and for the conservation of both normal and pathologic cerebral signals. Particularly, there is not significant alteration of paroxistic activities: spike, spikes-waves,… It is only on the Delta band where the amplitude reduction can be noticed on some uncommon cases.

The interest of the method is obvious in epileptology where the artifact filtering reveals paroxistic activities, particularly on the beginning of seizure.

Since the filtering is entirely automatic, the using is particularly easy for medical practitioner; it just need one click to visualize the filtering result. Moreover, the computation time is neglecting. It is still recommended to visualize both the raw and the filtered recordings due to possible rhythm reduction and artifact transformation on some uncommon cases. A dual screen viewing can then be a comfortable solution for long duration recording analysis.

The clinical evaluation have proved that the filter can really improve the readability of artifacted EEG and particularly during seizures. It could represent a time saving for analyzing as well as a better interpretation.

6. Publications

[1] Boudet, S., L. Peyrodie, and P. Gallois, "**Procédé de traitement de données permettant le filtrage d'artefacts, adapté notamment à l'électroencéphalographie**" , PCT Patent n°PCT/FR2009/051340 apply the 07/07/2009.

[2] Peyrodie L., Boudet S, Szurhaj W., Barbaste P., Forzy G., Gallois P., "**Evaluation of automatic artifact filtering of clinical EEG by the AFOP method**" in redaction, will be submitted to Clinical Neurophysiology

[3] Boudet S, Peyrodie L., Szurhaj W., Forzy G., Gallois P., "**Dual Adaptive Filtering By Optimal Projection to filter muscular artifacts on EEG**", in redaction, will be submitted to IEEE trans on Biom Eng.

[4] Boudet S, Peyrodie L., Forzy G., Pinti A., Toumi H., Gallois P., "**Improvements of Adaptive Filtering by Optimal Projection to filter different artifact types on long duration EEG recordings**", Submitted to Comp. Meth & Prog. in Biomed.

[5] Boudet, S., "**Filtrage d'artefacts par analyse multicomposantes de l'électroencephalogramme de patients épileptiques**". PhD Thesis, Université de Lille 1, 07/2008.

[6] Boudet, S., L. Peyrodie, P. Gallois, and C. Vasseur, "**Filtering by Optimal Projection and application to automatic artifact removal from EEG**", Signal Processing, vol. 87, issue 8, no. 8, pp. 1978–1992, 2007.

[7] Boudet, S., L. Peyrodie, P. Gallois, and C. Vasseur, "**A robust method to filter various types of artifacts on long duration EEG recordings**", 2nd International Conference IEEE-ICBBE, pp. 2357 - 2360, 2008.

[8] Boudet, S., L. Peyrodie, P. Gallois, and C. Vasseur, "**A global approach for automatic artifact removal for standard EEG record**", Proceedings of 28th Annual International Conference of the IEEE-EMBS, pp. 5719–5722, 2006.

The method has been elaborated in the **Biomedical Signal Processing Unit (UTSB)** of Catholic University of Lille. This unit is a collaboration between 3 organizations: **HEI** (Hautes Etudes d'Ingénieur), **FLM** (Faculté Libre de Médecine) and **GHICL** (Groupe Hospitalier de l'Institut Catholique de Lille).

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