A look into the Preprocessing techniques for EEG

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Introduction

The original code included the flt_eog function which took care of removing the artifacts (EOG) for us.

What is flt_eog?

This is an online filter that operates on continuous data, and removes artifacts using a regression technique, if artifact channels (e.g., EOG or EMG) are present (using recursive least squares)

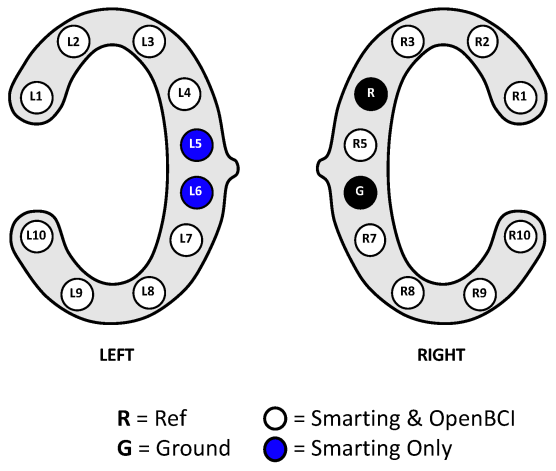

Fig. EEG collected from channels in the ears

Overall summary of the methodology used by flt_eog:

```
% get the current EEG samples s(n)
s_n = X(eeg,n);
% calculate e(n/n-1)
e_nn = s_n - (r_n' * H_n)';
% update H(n)
H_n = H_n + K_n * e_nn';
% calculate e(n), new cleaned EEG signal
e_n = s_n - (r_n' * H_n)';
% write back into the signal
X(eeg,n) = e_n;
```

FIG. Snippet of code from from BCILAB of flt_eog

As stated previously it is an adaptive filter which changes its filter parameters with every . The terms are expained in the code.

Filter Coefficients:

```
% calculate K(n)                                    % Eq. 25
K_n = R_n * r_n / (ffact + r_n' * R_n * r_n);
% update R(n)                                      % Eq. 24
R_n = ffact^-1 * R_n - ffact^-1 * K_n * r_n' * R_n;
```

K(n): is called the kalman gain and is used to update the filter coefficients that estimate the contribution of artifacts. It helps adjust the filter weights to minimize the difference between the estimated artifact contribution and the actual artifact present in the EEG signal.
R(n): represents the covariance between the artifact reference channels' history and itself.

H(n) is the EOG filter.

ffact stands for "forgetting factor." The forgetting factor is a parameter that controls the influence of past observations on the adaptive filter's updates. It determines the rate at which the filter "forgets" or gives less weight to older observations as new observations arrive.

Why RLS was chosen?

- Superior stability
- Fast convergence.

Independent component analysis :

1. This has also been proposed
2. requires a large number of channels
3. success dependent on identifying the type of noise

Reference:

- P. He, G.F. Wilson, C. Russel, "Removal of ocular artifacts from electro-encephalogram by adaptive filtering" Med. Biol. Eng. Comput. 42 pp. 407-412, 2004

Thank you!!!

Conclusion

EEG signals are a powerful tool for studying the human brain. They can provide insights into brain activity and are used in a variety of applications, from diagnosing neurological disorders to controlling prosthetic devices. While interpreting EEG signals can be challenging, advances in signal processing techniques are making it easier to extract meaningful information from these signals.

Thanks!

Do you have any questions?
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