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# EEG Artifact Attenuation with Artifact Subspace Reconstruction for Android

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## Introduction

- We implemented a procedure for online EEG artifact attenuation running on Android smartphones
- Our method is based on Artifact Subspace Reconstruction (ASR) [1], an adaptive procedure which computes a principal component analysis on covariance matrices of the channel data to detect artifacts in the component subspace
- We integrated JavaASR into our BCI application SCALA [2], which receives data via the LabstreamingLayer (LSL) [3], classifies the data online and provides a feedback to the user

## Methods

- We use EEG data from 11 subjects, seated and walking outdoors for validation. Data were recorded with mobile EEG hardware on a smartphone
- The JavaASR algorithm is implemented in a Java library and was used on a PC for the analyses. It receives raw EEG data and returns cleaned data with a short processing delay of 50 samples
- We validate the sensitivity and specificity of JavaASR by looking at blink artifact correction and the amplitude of N100 signals before and after cleaning

## Framework

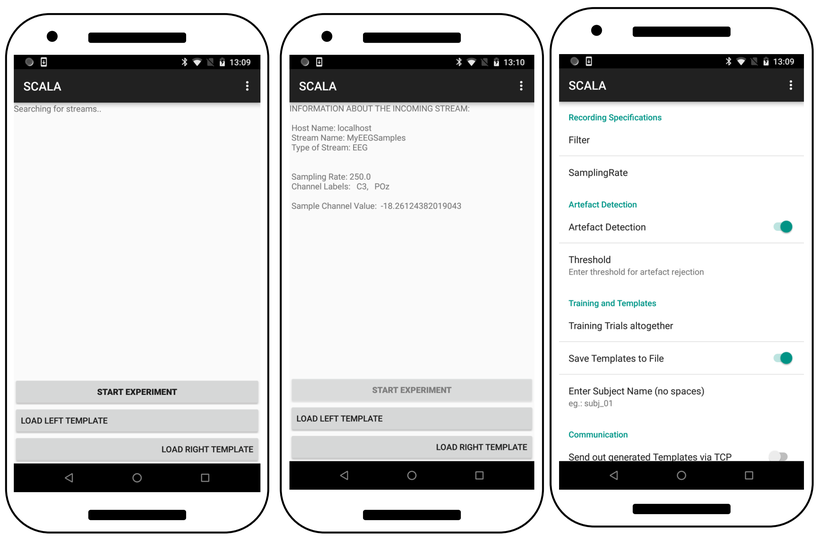



**Figure 1:** Three screens of the signal processing application SCALA [2]. SCALA is an Android application which accepts time series data of any type via LSL, preprocesses the data and classifies them.

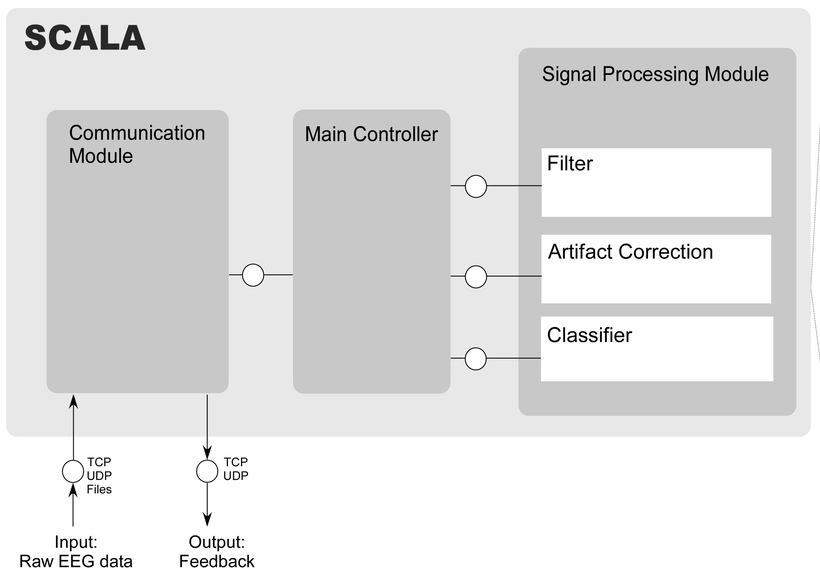



**Figure 2:** SCALA architecture and functional connections illustrated as a fundamental modelling concepts diagram [4]. Connections with overlaying bullet points indicate bidirectional communication channels.

## Procedure

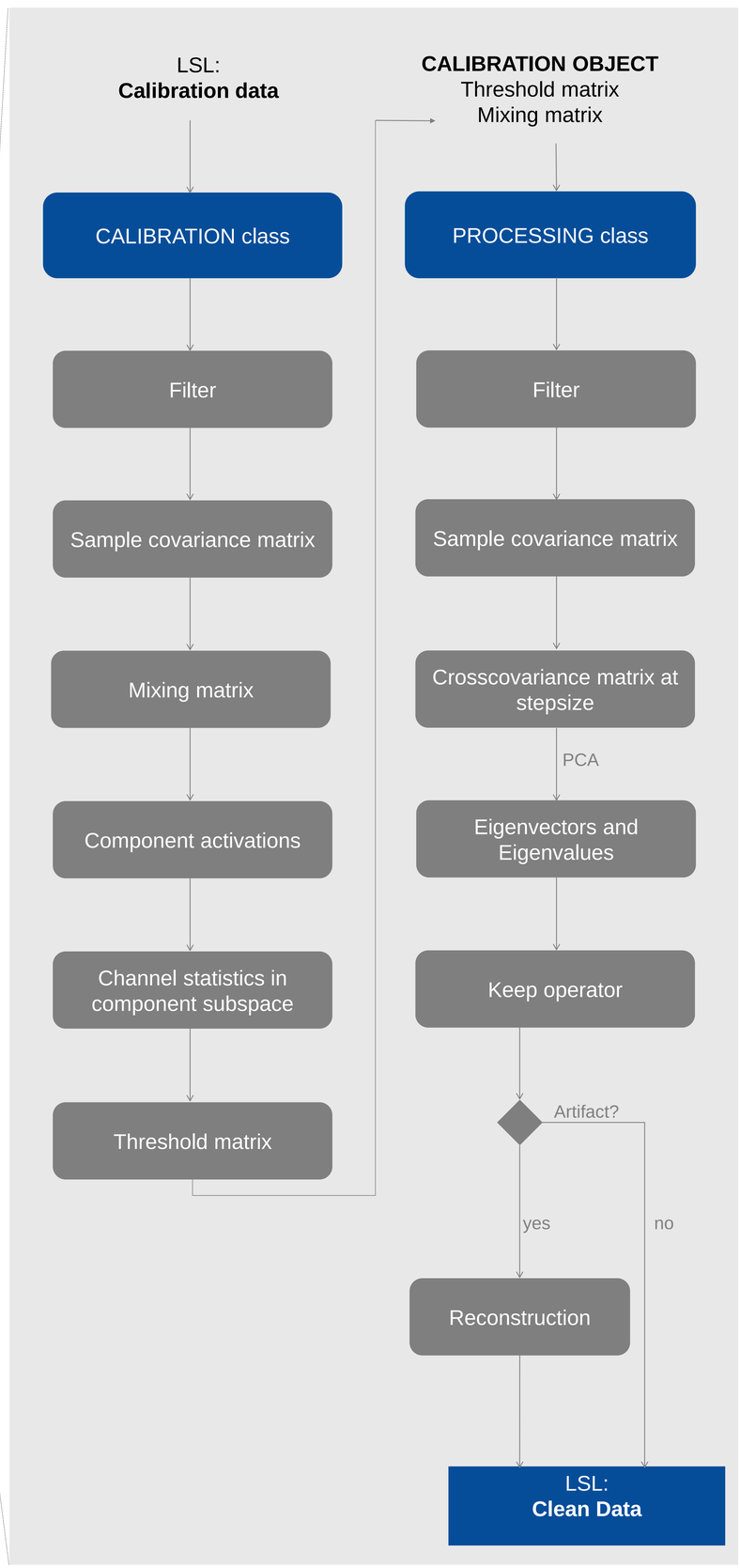
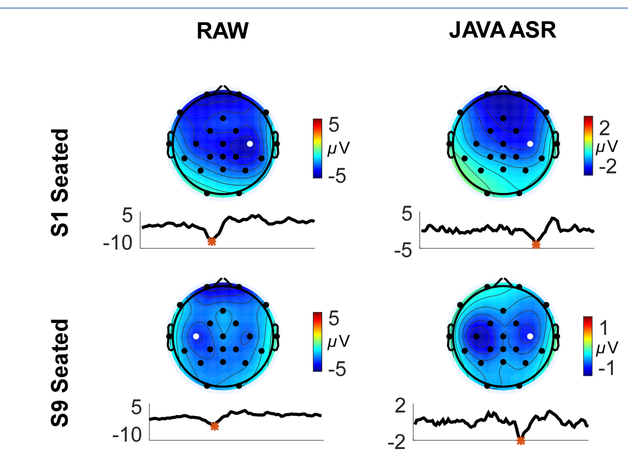



**Figure 3:** JavaASR calibration and processing classes. Dataflow from top to bottom through the ASR classes.

## Validation

### N100 Potential




### Blink Artifact

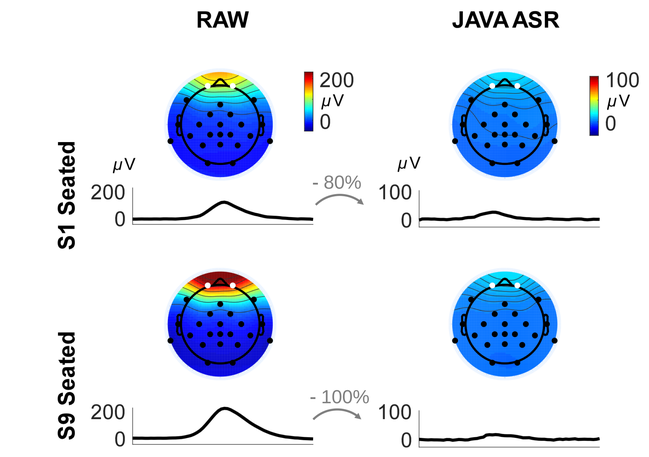



**Figure 4:** Single subject EEG data from seated and walking subjects. **Upper Figure:** N100 potential. **Lower Figure:** Blink artifact

## Conclusion

- JavaASR can be used in mobile BCI systems to attenuate artifacts during an experiment
- JavaASR is robust towards movement-related artifacts and therefore suitable for mobile recording settings
- JavaASR is an efficient and objective method for the online correction of multi-channel EEG data acquired during mobile conditions on smartphones

## References

**[1] T. R. Mullen et al**., “Real-time neuroimaging and cognitive monitoring using wearable dry EEG“, in IEEE Transactions on Biomedical Engineering, vol. 62, no. 11, pp. 2553-2567, Nov. 2015
**[2] S. Blum, S. Debener, R. Emkes, N. Volkening, S. Fudickar, and M. G. Bleichner**, “EEG Recording and Online Signal Processing on Android: A Multiapp Framework for Brain-Computer Interfaces on Smartphone,” BioMed Research International, vol. 2017, Article ID 3072870, 12 pages, 2017.
**[3] Swartz Center for Computational Neuroscience and C. Kothe**, Lab Streaming Layer (LSL), https://github.com/sccn/labstreaminglayer.

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