UNIVERSITÄT
LEIPZIG

Evaluating the DoC-Forest tool for Classifying the State of Consciousness in a Completely Locked-In Syndrome Patient

ICISPC 2023

Oliver Kirsten, Sophie Adama, Martin Bogdan

Agenda

INTRODUCTION

Introduction

Robust EEG-based cross-site and cross-protocol classification of states of consciousness (2018) [1]
Introduced Machine Learning (ML) based method called DoC-Forest to classify Disorders of Consciousness (DoC), like the comatose state or the minimally conscious state, based on EEG data.

Our paper (2023)
Adapted the DoC-Forest to classify the state of consciousness in anesthesia patients and a Completely Locked-In Syndrome (CLIS) Patient. In CLIS (which isn't a DoC), the patient is fully paralyzed and therefore unable to communicate, but still conscious.

Data

Anesthesia Data [2]

- 26 patients
- Stereoelectroencephalography (sEEG)
- from being under anesthesia till after waking up
- labeled with propofol withdrawal and point of waking up

CLIS Data

- 1 patient
- Electrocorticography (ECoG)
- recorded over 24 hours
- 2 hours period when patient is known to be conscious

METHODS

Markers of Consciousness

Information Theoretic

Entropy and **Lempel-Ziv** based time series **complexity** measures have shown that brain activity is more complex in conscious patients.

Connectivity

The **Mutual Information (wSMI)** measure has shown that brain activity is more cross-correlated in conscious patients.

Spectral

Analysis of distribution of signal power across different frequency bands in the **Power Spectrum (PSD)**.

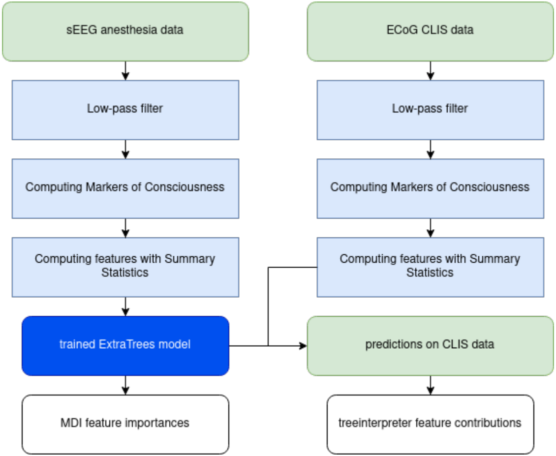

Figure 1: Features are calculated by applying the Mean and Standard Deviation across the markers' sensor dimension, and then a 15 minutes rolling Mean and Standard Deviation, respectively.

Explainable ML

Mean Decrease Impurity

Quantifies how important each feature is for the predictive power of a trained Decision Tree Ensemble.

Treeinterpreter

Decomposes a prediction $\hat{p}(x_t)$ of a Decision Tree into bias and contributions from each feature k, based on the Trees' nodes and the region in the feature space in which the sample lies.

$$\hat{p}(x_t) = bias + \sum_{k=1}^{K} contribution(x_t, k)$$

RESULTS

Cross Validation (CV) on the anesthesia data

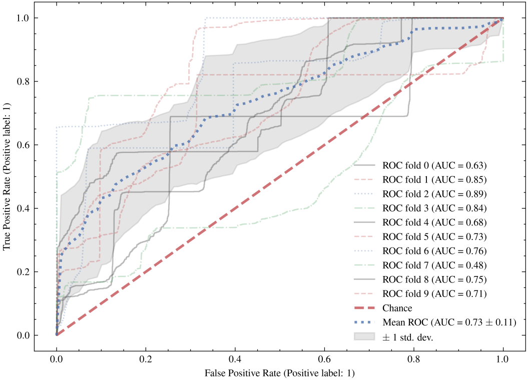

Figure 2: The receiver operating characteristic (ROC) curves for ten randomly selected Cross Validation (CV) train-test splits.

Applying the model to the CLIS data

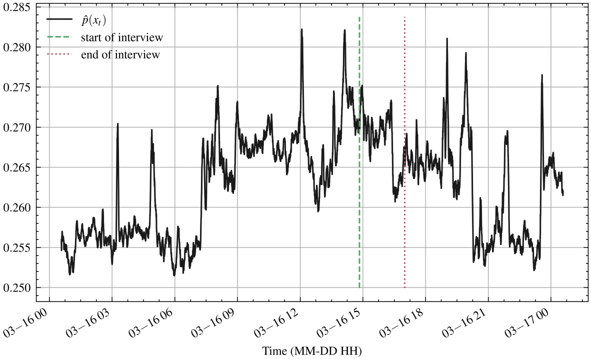

Figure 3: Predicted probabilities for the CLIS patient. Marked as start and end of interview is a period when the patient was able to communicate and therefore conscious.

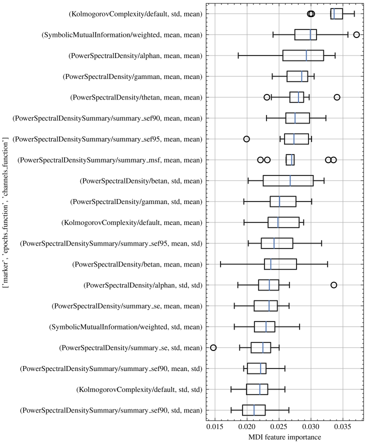

Figure 4: Top MDI features importances over the anesthesia data CV sets.

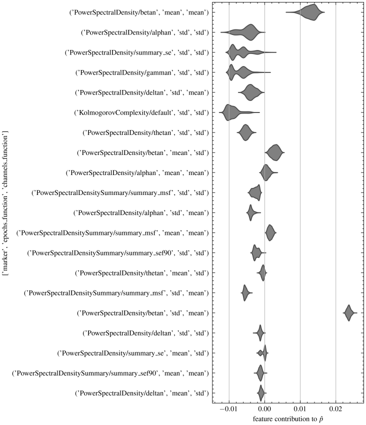

Figure 5: Top Treeinterpreter feature contributions as measured by their variance over all CLIS predictions.

CONCLUSION

Conclusion

- DoC-Forest method successfully adapted to predict consciousness over time in patients under anesthesia and CLIS.
- Feature importance measure and explanation tools used to identify key predictors for anesthesia and CLIS states.
- Approach can be used to assess generalizability of complex tree-based ML models to new datasets with varying characteristics.

UNIVERSITÄT
LEIPZIG

THANK YOU!

Oliver Kirsten, Sophie Adama, Martin Bogdan
Faculty of Mathematics and Computer Science

ok72muma@studserv.uni-leipzig.de
adama@informatik.uni-leipzig.de

REFERENCES

Denis A. Engemann et al.

Robust eeg-based cross-site and cross-protocol classification of states of consciousness.

Brain, 141(11):3179–3192, 2018.

S. Wan, F. Bao, C. Yao, F. Wang, B. Li, S. Mao, W. Yu, K. Zhang, Y. Kong, X. Zhang, X. Du, X. Cai, L. Fang, Y. Deng, Y. Yao, and Q. Dai.

Conscious-seeg-dataset.

OpenNeuro, 2021.