

Supplementary Material

Threshold-Calibrated Explainable LightGBM for Feature-Level EEG Hand Open–Close Decoding

Nashwa Mosaad Othman^{1*}, Khalid A. Elshafey¹, Mohamad K. Refai¹ and Basim M. Ayoub²

¹ Systems and Computers Engineering Department, Faculty of Engineering, Al-Azhar University, Cairo, Egypt

² Neurosurgery Department, Kasr Al-Aini Faculty of Medicine, Cairo University, Cairo, Egypt

Supplementary Figure S1. Selected-feature correlation matrix.

The matrix was used to examine redundancy among the retained EEG descriptors. Some correlations were expected because ratio- and difference-based features were mathematically related to their primary components.

Supplementary Figure S2. Top 20 selected EEG features.

Supplementary Figure S3. Learning curve.

The learning curve summarizes training and validation behaviour of the final model across increasing training-set sizes.

Supplementary Table 1 S1. Feature set ablation study.

Supplementary Table 2 S2. Baseline model comparison.

Supplementary Table 3 S3. SHAP-ranked features.

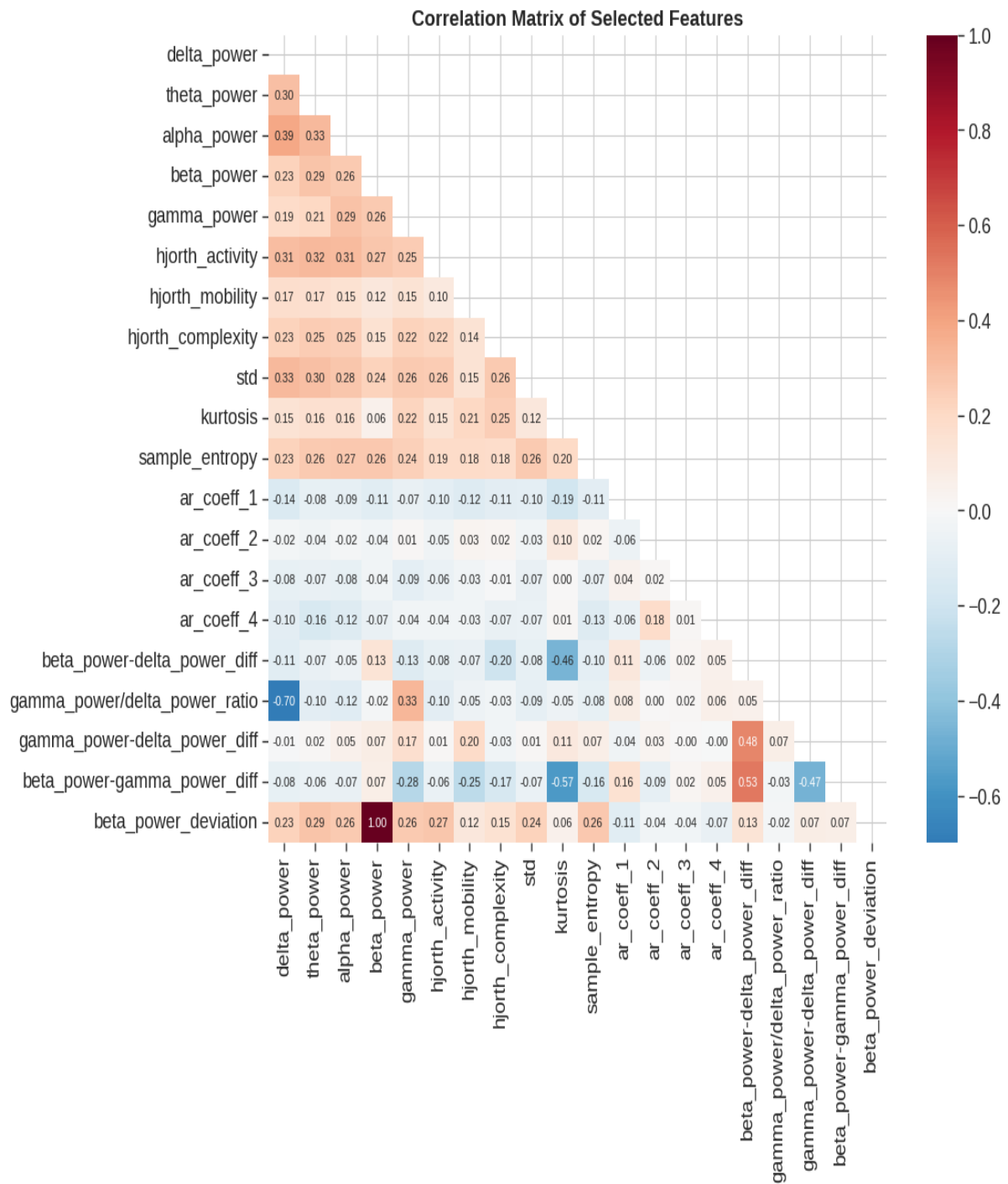


Figure 1: Selected-feature correlation matrix.

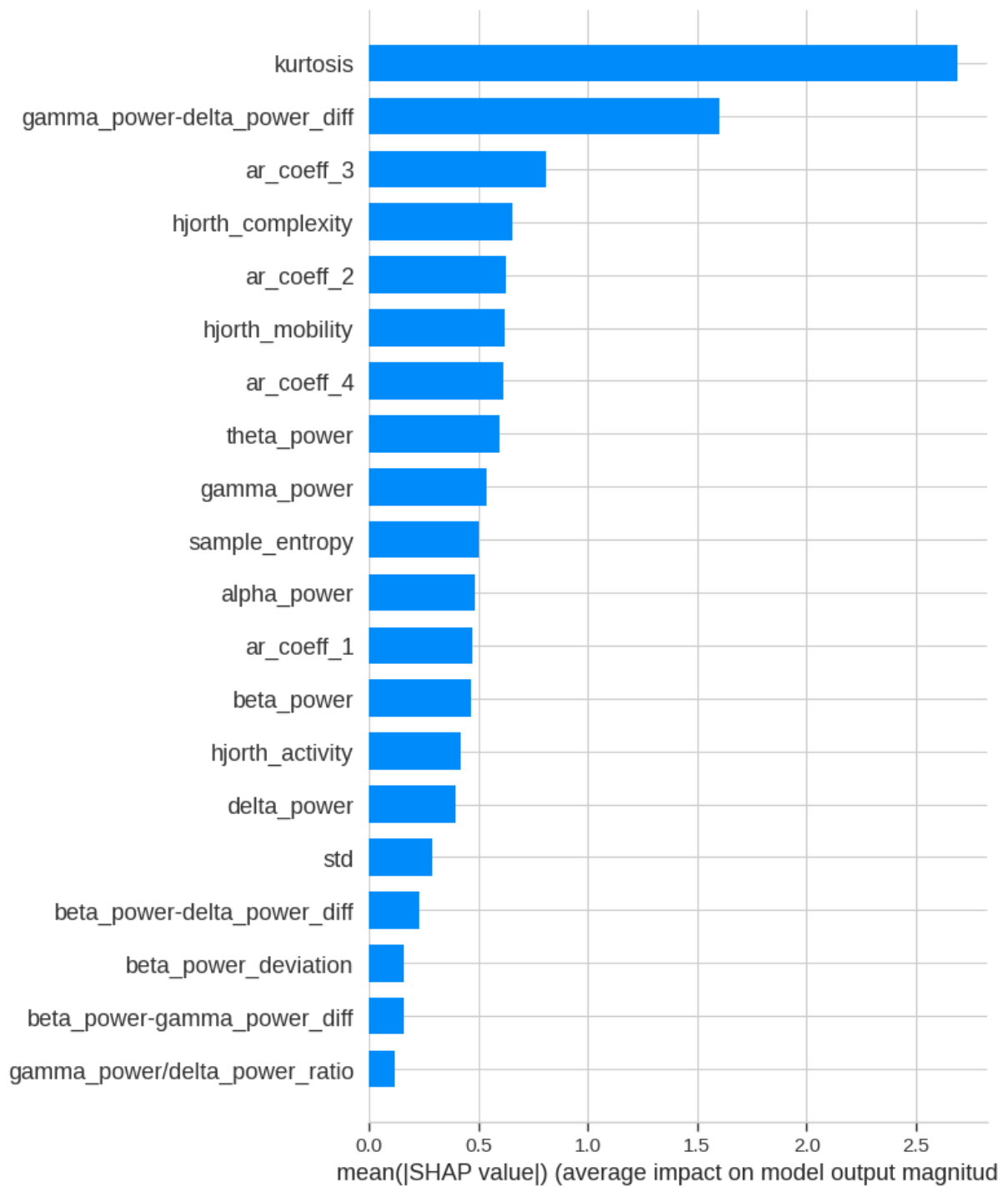


Figure 2: Top 20 selected EEG features.

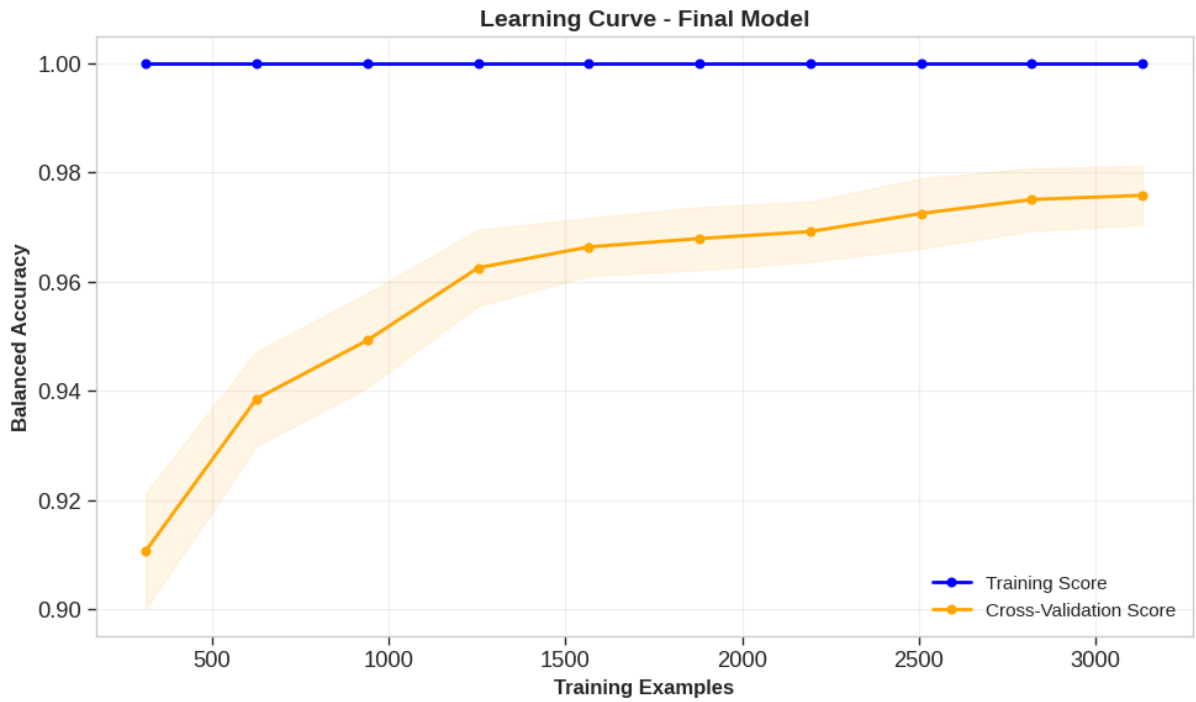


Figure 3: Learning curve.

Table 1. feature set ablation study.

Experiment No.	Feature set	Model	Threshold	Balanced accuracy	ROC-AUC	Close F1
E1	Base16	LightGBM	0.50	0.9750	0.9973	0.9749
E2	Base16 + SMOTE	LightGBM	0.50	0.9726	0.9971	0.9725
E3	Full features	LightGBM	0.50	0.9738	0.9973	0.9736
E4	Full features + SMOTE	LightGBM	0.50	0.9762	0.9973	0.9760
E5	Selected20	LightGBM	0.50	0.9750	0.9974	0.9749
E6	Selected 20 + SMOTE	LightGBM	0.50	0.9774	0.9971	0.9773
E7	Selected 20 + SMOTE	LightGBM	0.585	0.9786	0.9971	0.9785
E8	Selected20	XGBoost	0.585	0.9750	0.9966	0.9750

Table 2. Baseline model comparison.

Model	Accuracy	Balanced accuracy	ROC-AUC	Close recall	Close F1
Logistic regression	0.6786	0.6790	0.7340	0.5154	0.6165
SVM	0.7667	0.7669	0.8397	0.6841	0.7461
Random Forest	0.9786	0.9786	0.9936	0.9691	0.9784
XGBoost	0.9750	0.9750	0.9966	0.9739	0.9750
LightGBM	0.9786	0.9786	0.9971	0.9715	0.9785

Table 3. SHAP-ranked features.

Rank	Feature	Mean absolute SHAP
1	kurtosis	2.6904
2	gamma_power-delta_power_diff	1.6033
3	ar_coeff_3	0.8092
4	hjorth_complexity	0.6530
5	ar_coeff_2	0.6281
6	hjorth_mobility	0.6226
7	ar_coeff_4	0.6120
8	theta_power	0.5957
9	gamma_power	0.5347
10	sample_entropy	0.5035