Interpretable Machine Learning of PET Imaging for Individualized Predictions of Seizure Outcomes after Temporal Lobe Epilepsy Surgery

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Introduction

Background

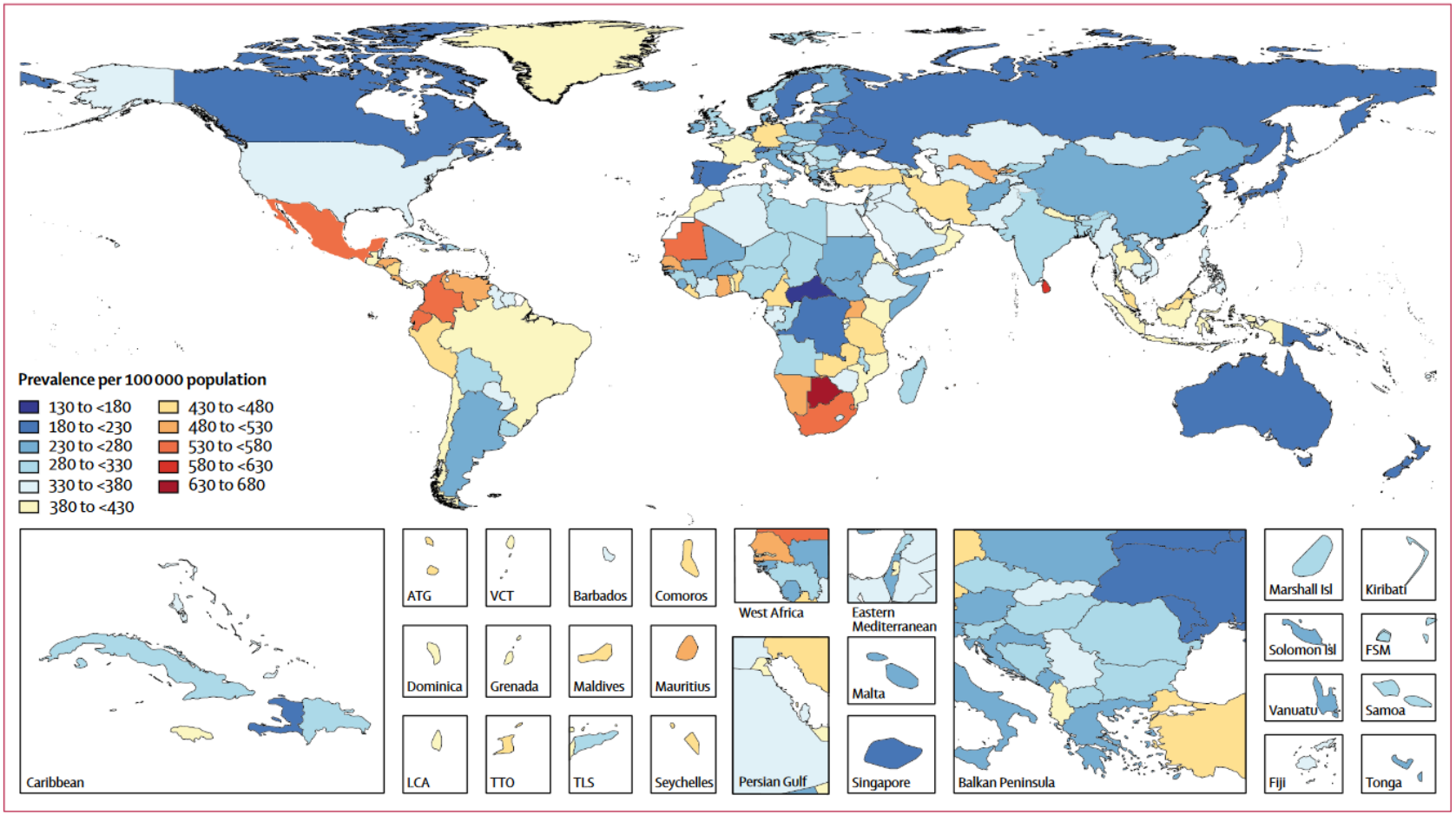

Figure 1: Epilepsy epidemiology

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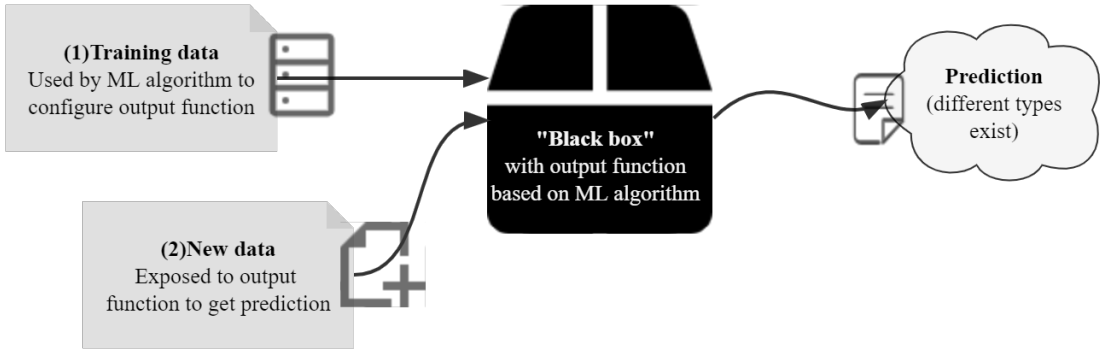
Aims



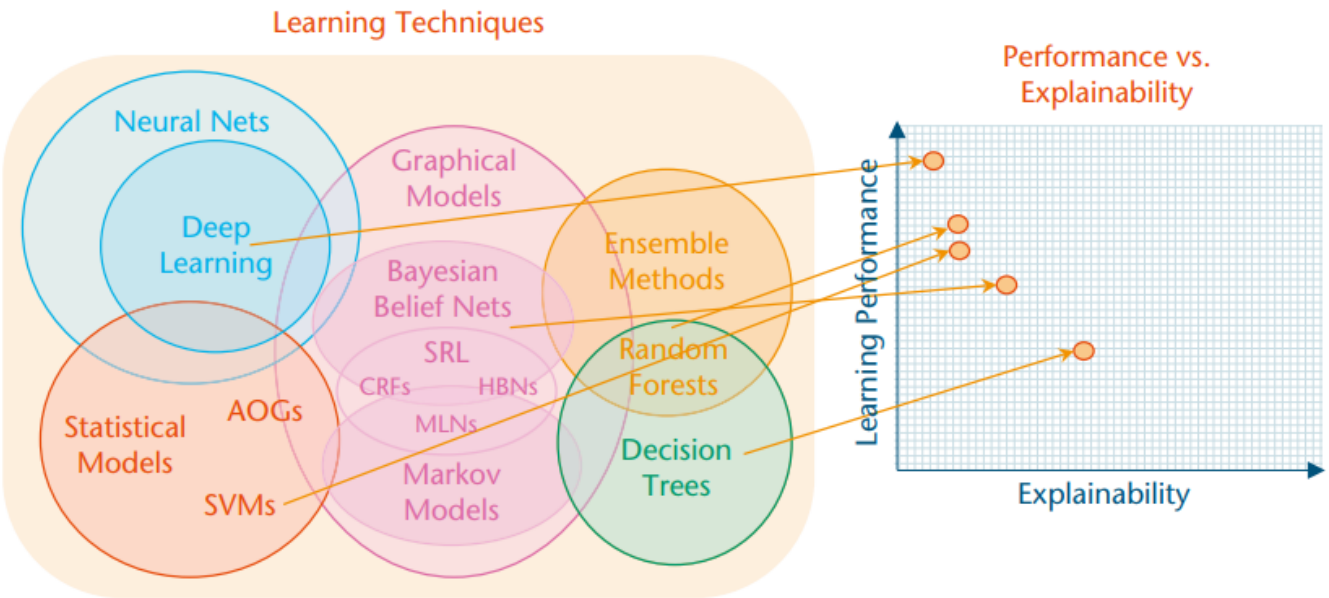


Figure 2: Focuses on interpretability of ML

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Scheme

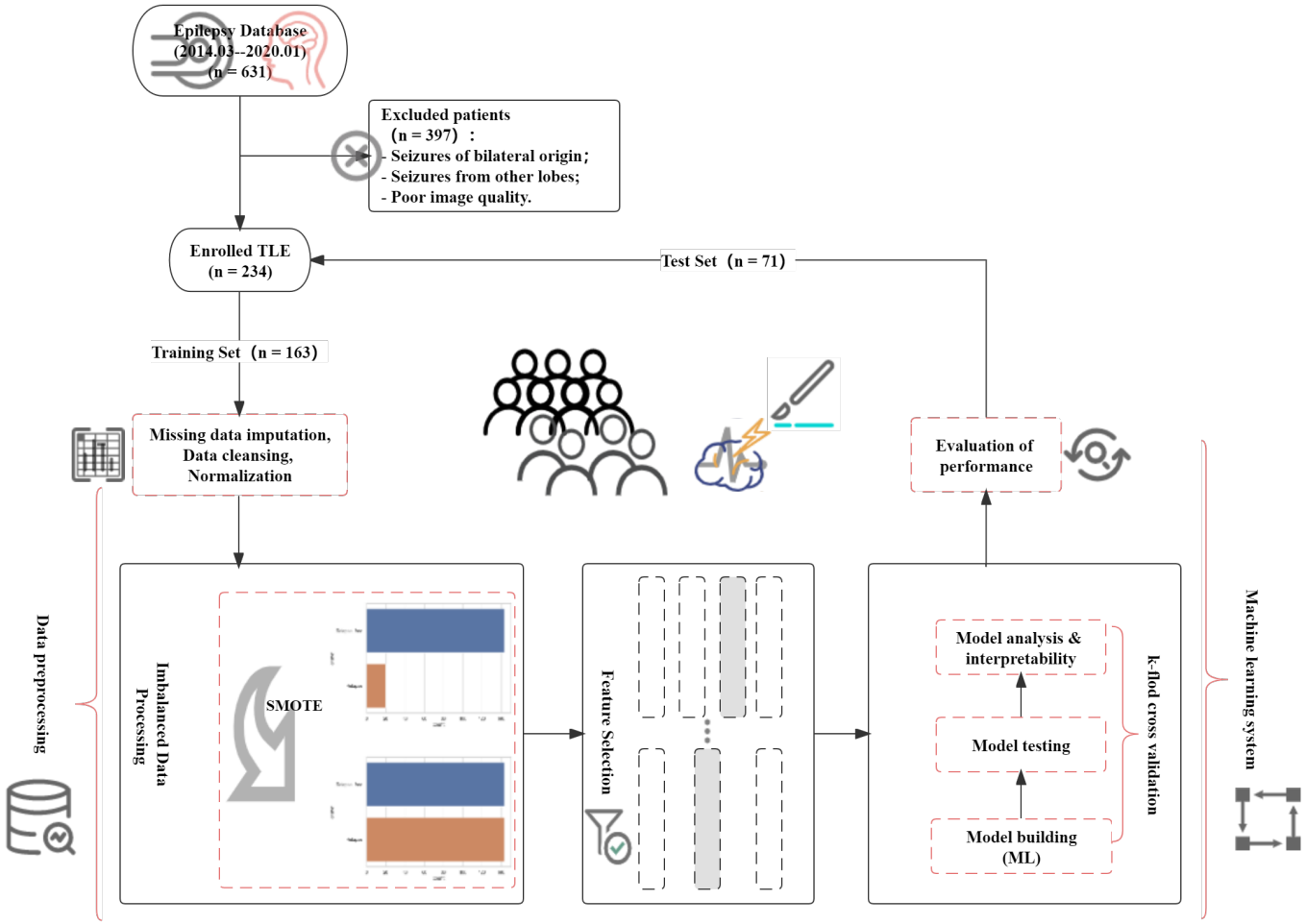

Figure 3: Flowchart of TLE postsurgical IML

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The Data

Combined of PET Radiomics and Clinical Features

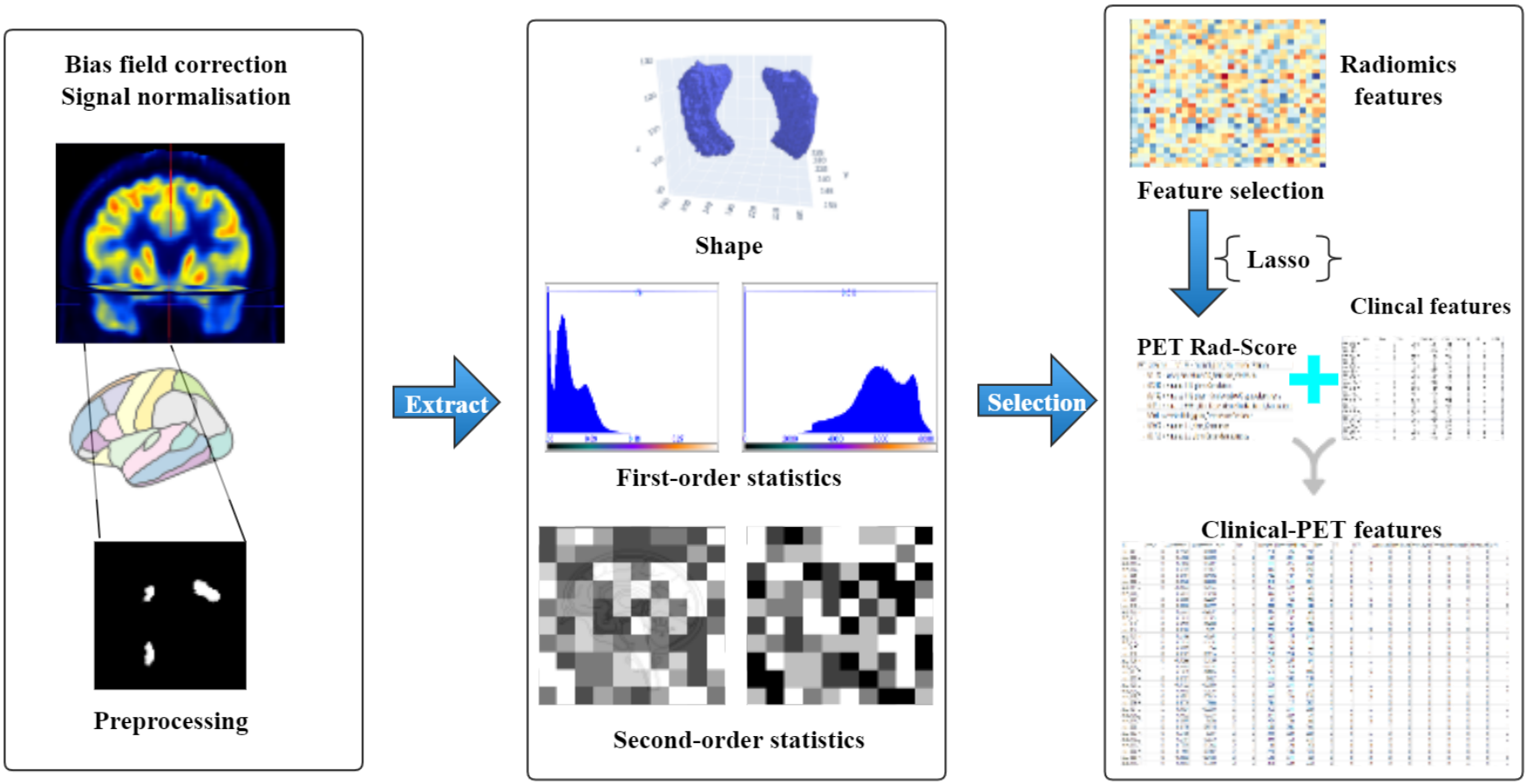

Figure 4: PET radiomics score and clinical-PET features

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Exploratory Data Analysis

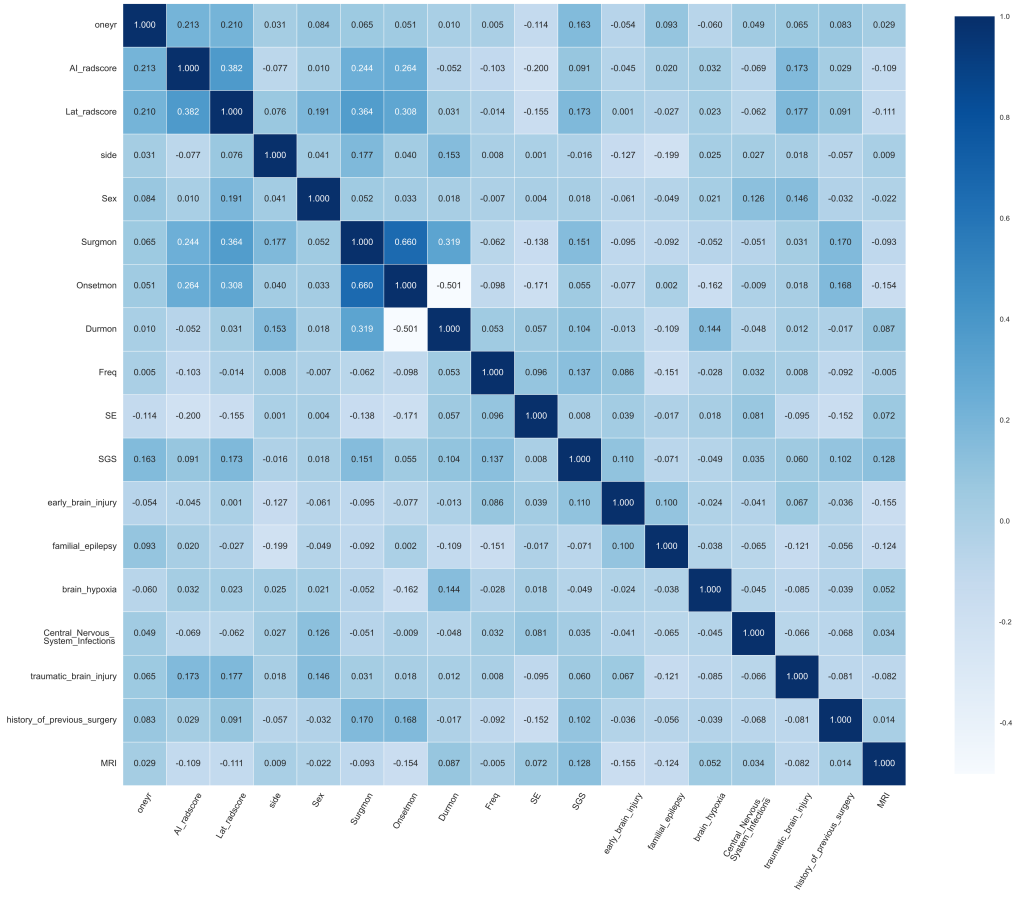

Figure 5: Heatmap of Clinical-PET Features

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The Model

Benchmark

Table 1: Performance Comparison Eleven ML algorithms and K-folds Cross-validation of the Selected AdaBoost

Model	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC
Ada Boost Classifier	0.883	0.789	0.400	0.433	0.393	0.345	0.357
Extreme Gradient Boosting	0.884	0.777	0.300	0.400	0.333	0.287	0.295
Random Forest Classifier	0.884	0.763	0.200	0.350	0.250	0.217	0.230
Gradient Boosting Classifier	0.890	0.762	0.350	0.483	0.390	0.346	0.360
Light Gradient Boosting Machine	0.859	0.749	0.250	0.325	0.267	0.211	0.221
Logistic Regression	0.878	0.669	0.050	0.100	0.067	0.055	0.059
Extra Trees Classifier	0.884	0.662	0.100	0.200	0.133	0.118	0.127
K Neighbors Classifier	0.865	0.646	0.200	0.200	0.183	0.140	0.149
Linear Discriminant Analysis	0.884	0.642	0.100	0.200	0.133	0.119	0.128
Naive Bayes	0.251	0.586	0.900	0.129	0.226	0.014	0.072
Decision Tree Classifier	0.798	0.584	0.300	0.264	0.259	0.158	0.167

Folds\Tuned_Ada	Accuracy	AUC	Recall	Prec.	F1	Kappa	MCC	APC
1	0.882	0.733	0.000	0.000	0.000	0.000	0.000	0.361
2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	0.824	0.550	0.000	0.000	0.000	-0.085	-0.091	0.183
4	0.875	0.893	0.000	0.000	0.000	0.000	0.000	0.500
5	0.938	0.929	0.500	1.000	0.667	0.636	0.683	0.750
6	0.938	0.964	0.500	1.000	0.667	0.636	0.683	0.833
7	0.875	0.554	0.000	0.000	0.000	0.000	0.000	0.321
8	0.938	0.964	0.500	1.000	0.667	0.636	0.683	0.833
9	0.938	1.000	0.500	1.000	0.667	0.636	0.683	1.000
10	0.938	0.679	0.500	1.000	0.667	0.636	0.683	0.591
Mean	0.914	0.827	0.350	0.600	0.433	0.410	0.432	0.637
Std	0.047	0.172	0.320	0.490	0.367	0.368	0.384	0.200

AdaBoost Algorithm

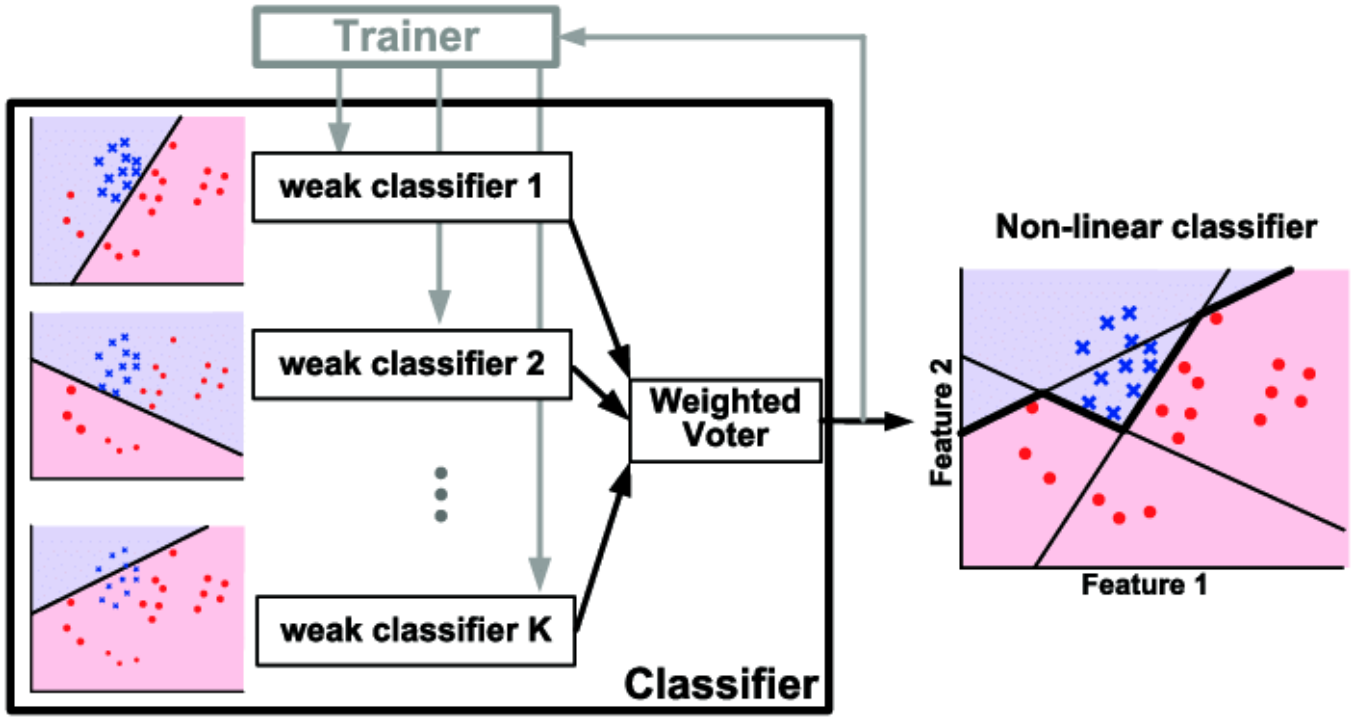

Figure 6: Illustration of AdaBoost Algorithm

- `AdaBoostClassifier(algorithm='SAMME', base_estimator=None, learning_rate=0.2, n_estimators=230, random_state=123)`

The Explanation

Permutation Importance

Weight	Feature
0.0394 ± 0.0329	AI_radscore
0.0197 ± 0.0138	Lat_radscore
0.0085 ± 0.0138	Durmon
0.0085 ± 0.0138	SGS
0.0028 ± 0.0113	Onsetmon
0 ± 0.0000	Freq
0 ± 0.0000	side
0 ± 0.0000	Sex
0 ± 0.0000	MRI
0 ± 0.0000	history_of_previous_surgery
0 ± 0.0000	early_brain_injury
0 ± 0.0000	familial_epilepsy
0 ± 0.0000	brain_hypoxia
0 ± 0.0000	Central_Nervous_System_Infections
0 ± 0.0000	traumatic_brain_injury
0 ± 0.0000	SE
-0.0028 ± 0.0113	Surgmon

Figure 7: Permutation Importance of AdaBoost