Machine learning enabled prediction of post-stroke functional recovery after rehabilitation from clinical data

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Objective & Design

Develop a multivariate predictive model for functional outcomes in post-stroke survivors undergoing intensive inpatient rehabilitation. Prospective observational study based on data from a multicenter dataset.

Setting

Data were collected from the **STRATEGY** study, which included patients from multiple intensive rehabilitation units in Italy, all following a standardized evidence-based rehabilitation pathway.

Main Outcome Measure

The modified Barthel Index, a measure of functional independence, was used as theprimary outcome at both 3- and 6-months post-onset.

Methods

Demographic, clinical/functional, and psycho-social data at admission were used to **predict functional outcomes at 3 and 6 months**. Machine learning models were trained, cross-validated and tested for both time frames prediction using admission data. Data preprocessing ensured robust analysis, addressing feature selection and handling of missing data. Performance metrics included median absolute error(MAE) and its interquartile range (IQR). Different models were compared by optimizing Lasso, LARS, HUBER, OMP, SVR, RF and CART based regressions.

Data preprocessing
- Imputation (KNN)
- Univariate screening by statistical methods

Nested cross validation
- Model comparison
- Hyperparameters optimization

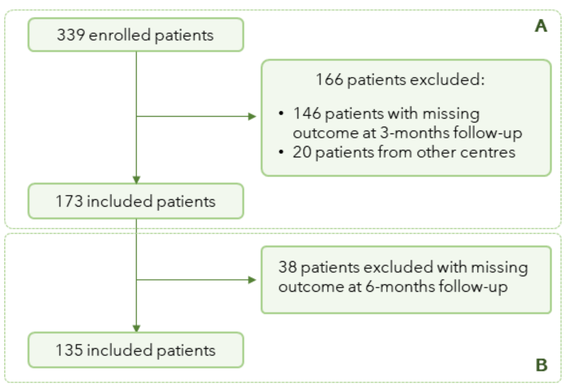
Error analysis and interpretability
- Verification of errors
- SHAP interpretability

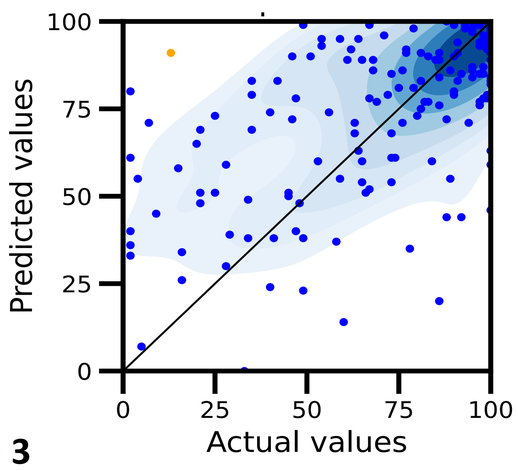
Variables at Admission	Mean (std)/ Median [IQR] or Frequencies (%)
Demographics	
Age	78.0 [17.0]
Sex (Women)	88 (50.9%)
Educational level	8.0 [8.0]
Cohabitation (Yes)	124 (71.7%)
Description of the event	
Aetiology (Ischaemic)	137 (79.7%)
Time from the event	16.0 [9.0]
Recurrent event (Yes)	20 (11.7%)
Side of the lesion	Right: 78 (49.4%) Left: 75(47.5%) Both: 5 (3.2%)
Area of the lesion	Unknown: 11 (6.4%) Sub-tentorial: 70 (40.5%) Supra-tentorial: 54 (31.2%) Both: 38 (22.0%)
Clinical assessment	
Reduced vigilance and coma (Yes)	0 (0.0%)
Clinical instability (Yes)	10 (5.9%)
Delirium (Yes)	3 (1.7%)
Acute infection (Yes)	10 (5.8%)
Depression (Yes)	34 (19.8%)
Dysphagia (Yes)	50 (29.1%)
Presence of anaemia (Yes)	21 (12.2%)
Malnutrition (Yes)	2 (1.2%)
SNG/PEG (Yes)	11 (6.4%)
Bedsores (Yes)	5 (2.9%)
Bladder catheter (Yes)	36 (20.9%)
Incontinence (Yes)	18 (12.9%)
Central venous catheter (Yes)	5 (2.9%)
Tracheostomy (Yes)	1 (0.6%)
Dialysis (Yes)	0 (0.0%)
Pain (Yes)	28 (16.4%)
CIRS_CCI	16.7 [11.1]
NIHSS	5.0 [6.0]
SDC	4.0 [1.0]
Psycho-social assessment	
MMSE	24.6 [6.0]
mFWC	6.0 [1.0]
FAI	28.0 [13.0]
Physiotherapy assessment	
mBI	47.0 [40.0]
TCT	61.0 [51.0]
FAC	1.0 [2.0]
mRS_anamnestic	4.0 [0.0]
mRS	0.0 [1.0]
SPPB	0.0 [1.0]
MAS_UL	0.0 [0.3]
MAS_LL	0.0 [0.0]
FMA_MI_UL	71.5 [37.0]
FMA_MI_LL	70.0 [33.0]

Results

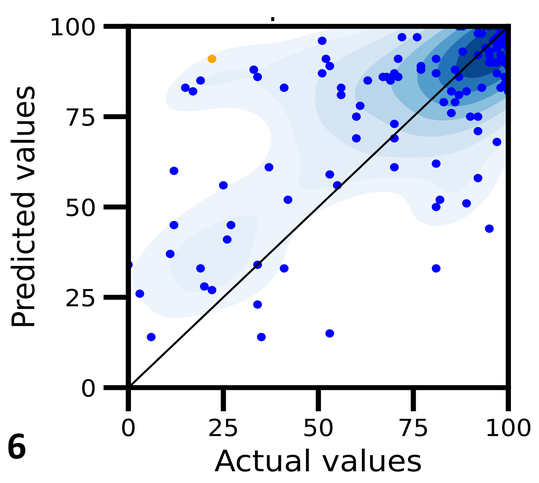
Out of the initial 339 patients, data from **173 patients** were analyzed for 3 months mBI estimate and **135** for 6 months.
In both cases, Support Vector Regression (SVR) obtained the best validation performance and a prediction error MAE[IQR] of **10.0[22.0] points at 3 months and 10.0[16.5] points at 6 months**.



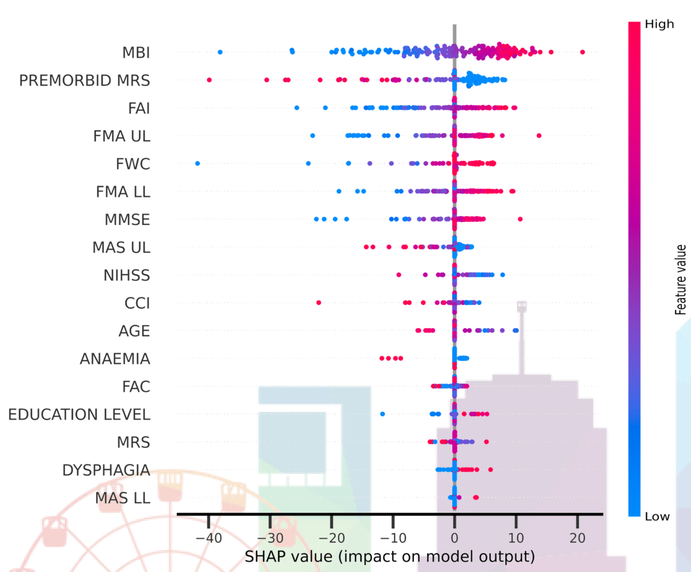


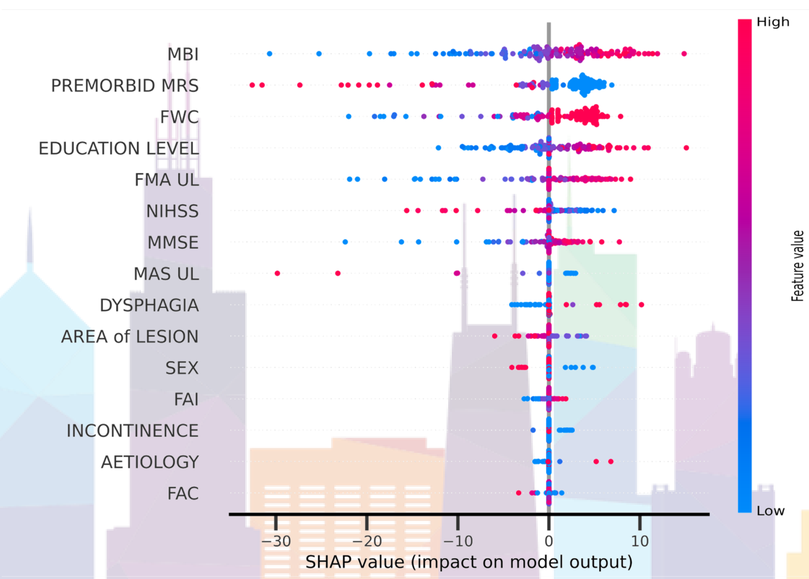


Month 3



Month 6





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