

Supplementary File (2): Hybrid Feature Selection Methods' Settings

Table A1: Hybrid (LASSO+GA)

Stage	Parameter	Setting
General	Software function	MATLAB ga
General	Random-number initialization	rng(2026)
LASSO	Function	lassoglm
LASSO	Distribution	Binomial
LASSO	Alpha	1
LASSO	Standardization argument	False; predictors standardized before LASSO
LASSO	Cross-validation folds	5
LASSO	Primary lambda	Index1SE
LASSO	First fallback	IndexMinDeviance if fewer than two predictors were retained
LASSO	Second fallback	Top 20 absolute coefficients if no predictors were retained
GA	Decision variables	Binary integer variables
GA	Lower and upper bounds	0 and 1
GA	Population size	80
GA	Maximum generations	100
GA	Selection function	selection tournament
GA	Tournament size	MATLAB default
GA	Crossover fraction	0.8
GA	Crossover function	MATLAB problem-dependent default
GA	Mutation function	mutation uniform
GA	Mutation rate	0.05
GA	Elite count	4
GA	Maximum stall generations	20
GA	Function tolerance	(10^{-4})
GA	Parallel processing	Disabled
Fitness	CV folds	5
Fitness	Classifier	Bagged Ensemble
Fitness	Learning cycles	100
Fitness	Performance measure	Mean AUC
Fitness	Complexity coefficient	0.01
Fitness	Empty-subset penalty	Objective value of (10^6)
Final fallback	Empty GA subset	Strongest absolute LASSO coefficient retained

Table A2: Hybrid (mRMR+PSO)

Component	Parameter	Setting
mRMR	Initial feature-selection method	Minimum Redundancy Maximum Relevance
mRMR	Candidate-feature rule	Highest-ranked mRMR predictors retained for PSO optimization
PSO	Implementation	Custom binary Particle Swarm Optimization
PSO	Particle representation	Binary position: 1 = selected; 0 = excluded
PSO	Swarm size	50 particles
PSO	Maximum iterations	100
PSO	Initial inertia weight	0.72
PSO	Inertia damping factor	0.99
PSO	Cognitive coefficient, (c_1)	1.49
PSO	Social coefficient, (c_2)	1.49
PSO	Velocity range	−6 to +6
PSO	Transfer function	Sigmoid
PSO	Fitness evaluation	Mean five-fold cross-validated AUC using a bagged Ensemble classifier
PSO	Fitness function	Mean CV-AUC − 0.01 × selected predictors/mRMR candidates
PSO	Complexity penalty	0.01
PSO	Stopping criterion	Maximum of 100 iterations
PSO	Random seed	2026
Fitness	Internal validation	Five-fold cross-validation
Fitness	Classifier	Bagged Ensemble
Fitness	Performance criterion	Mean cross-validated AUC
Fitness	Complexity penalty	0.01
Fitness	Objective	Mean CV-AUC − 0.01 × selected predictors/mRMR candidates
Stopping	Maximum iterations	100
Reproducibility	Random seed	2026
Output	Feature-importance normalization	Divided by the maximum nonzero importance score