

Results of Radiomics Using Metaheuristic Feature Selection Techniques for HNC

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Classifiers vs Feature Selection Techniques

Implemented the following 49 classifier-feature selection combinations (7 classifiers × 7 feature selection techniques):

Classifiers to Evaluate:

1. Logistic Regression
2. Naive Bayes
3. Linear Support Vector Machine (Linear SVM)
4. Radial Basis Function Kernel SVM (RBF SVM)
5. Decision Tree
6. Random Forest
7. Voting Classifier

Selected Feature Selection Techniques:

1. SelectKBest (Univariate statistical selection)
2. Least Absolute Shrinkage and Selection Operator (LASSO)
3. Particle Swarm Optimization (PSO)
4. Whale Optimization Algorithm (WOA)
5. Grey Wolf Optimizer (GWO)
6. Genetic Algorithm (GA)
7. Simulated Annealing (SA)

All combinations have been successfully implemented and tested. Results were evaluated using ROC AUC and Accuracy on both training and test data..

Selected Feature Techniques: Least Absolute Shrinkage and Selection Operator (LASSO)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.69	0.68	0.35	0.63
Naive Bayes	0.63	0.68	0.70	0.68
Linear Support Vector Machine (Linear SVM)	0.61	0.65	0.73	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.64	0.66	0.68	0.63
Decision Tree	0.87	0.80	0.27	0.47
Random Forest	0.99	0.92	0.33	0.53
Voting Classifier	0.99	0.82	0.48	0.63

Selected Feature Techniques: Particle Swarm Optimization (PSO)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.63	0.54	0.57	0.59
Naive Bayes	0.77	0.51	0.58	0.42
Linear Support Vector Machine (Linear SVM)	0.87	0.65	0.48	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.87	0.64	0.44	0.63
Decision Tree	0.84	0.82	0.64	0.63
Random Forest	0.99	0.95	0.49	0.47
Voting Classifier	0.99	0.82	0.48	0.63

Hybrid Feature Selection Approach: **Bootstrap LASSO + Particle Swarm Optimization (PSO)**

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.70	0.70	0.61	0.68
Naive Bayes	0.80	0.72	0.70	0.58
Linear Support Vector Machine (Linear SVM)	0.78	0.66	0.51	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.78	0.66	0.51	0.63
Decision Tree	0.90	0.85	0.65	0.63
Random Forest	0.98	0.95	0.80	0.84
Voting Classifier	0.99	0.95	0.54	0.53

Selected Feature Techniques: Whale Optimization Algorithm (WOA)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.64	0.53	0.58	0.63
Naive Bayes	0.78	0.53	0.45	0.53
Linear Support Vector Machine (Linear SVM)	0.87	0.65	0.49	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.13	0.65	0.67	0.63
Decision Tree	0.85	0.77	0.56	0.58
Random Forest	0.99	0.93	0.48	0.47
Voting Classifier	0.99	0.82	0.47	0.63

Date: 8th May, 2025

Hybrid Feature Selection Approach: **Bootstrap LASSO + Whale Optimization Algorithm (WOA)**

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.69	0.73	0.58	0.63
Naive Bayes	0.77	0.69	0.82	0.63
Linear Support Vector Machine (Linear SVM)	0.36	0.65	0.63	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.75	0.65	0.61	0.63
Decision Tree	0.92	0.88	0.57	0.53
Random Forest	0.97	0.91	0.52	0.58
Voting Classifier	0.99	0.95	0.54	0.53

Date: 8th May, 2025

Selected Feature Techniques: Grey Wolf Optimization Algorithm (GWOA)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.66	0.57	0.58	0.63
Naive Bayes	0.80	0.54	0.48	0.53
Linear Support Vector Machine (Linear SVM)	0.87	0.65	0.37	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.87	0.65	0.38	0.63
Decision Tree	0.85	0.76	0.52	0.47
Random Forest	0.99	0.95	0.56	0.53
Voting Classifier	0.99	0.82	0.48	0.63

Date: 9th May, 2025

Hybrid Feature Selection Approach: Bootstrap LASSO + Grey Wolf Optimization Algorithm (GWOA)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.71	0.68	0.48	0.47
Naive Bayes	0.77	0.73	0.73	0.74
Linear Support Vector Machine (Linear SVM)	0.73	0.65	0.54	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.76	0.65	0.40	0.63
Decision Tree	0.93	0.85	0.50	0.47
Random Forest	0.97	0.95	0.80	0.84
Voting Classifier	0.99	0.95	0.54	0.53

Date: 9th May, 2025

Selected Feature Techniques: Genetic Algorithm (GA)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.63	0.58	0.71	0.68
Naive Bayes	0.78	0.51	0.65	0.53
Linear Support Vector Machine (Linear SVM)	0.15	0.65	0.74	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.82	0.65	0.68	0.63
Decision Tree	0.79	0.80	0.54	0.53
Random Forest	0.99	0.95	0.56	0.47
Voting Classifier	0.99	0.82	0.48	0.63

Date: 12th May, 2025

Hybrid Feature Selection Approach: **Bootstrap LASSO + Genetic Algorithm (GA)**

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.60	0.69	0.87	0.63
Naive Bayes	0.72	0.69	0.93	0.68
Linear Support Vector Machine (Linear SVM)	0.64	0.65	0.89	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.46	0.65	0.11	0.63
Decision Tree	0.93	0.85	0.80	0.79
Random Forest	0.91	0.89	0.90	0.79
Voting Classifier	0.99	0.95	0.54	0.53

Date: 12th May, 2025

Selected Feature Techniques: Simulated Annealing (SA)

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.60	0.60	0.88	0.74
Naive Bayes	0.73	0.53	0.80	0.53
Linear Support Vector Machine (Linear SVM)	0.14	0.65	0.68	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.22	0.65	0.27	0.63
Decision Tree	0.84	0.74	0.77	0.74
Random Forest	0.99	0.96	0.60	0.47
Voting Classifier	0.99	0.82	0.48	0.63

Date: 12th May, 2025

Hybrid Feature Selection Approach: **Bootstrap LASSO + Simulated Annealing (SA)**

Classifier	Training ROC AUC	Training Accuracy	Test ROC AUC	Test Accuracy
Logistic Regression	0.60	0.70	0.90	0.63
Naive Bayes	0.72	0.70	0.94	0.63
Linear Support Vector Machine (Linear SVM)	0.65	0.65	0.91	0.63
Radial Basis Function Kernel SVM (RBF SVM)	0.68	0.65	0.12	0.63
Decision Tree	0.91	0.81	0.85	0.84
Random Forest	0.99	0.91	0.81	0.68
Voting Classifier	0.99	0.95	0.54	0.53

Date: 12th May, 2025