A Solvers and Machine Learning Models Portfolio

Table 7 lists the solvers included in our portfolio, along with the corresponding version or commit used to ensure reproducibility.

Table 7. Solver versions

Solver	**Version**	**Commit**
RoundingSat	pb24-log	01be2c2d
NaPS	v1.03a2	125435e0
Mixed-Bag	-	d144418
SCIP	SCIP Optimization Suite 9.2.1	-
Gurobi	10.0.0	-

Table 8 reports the main Python libraries and their versions used to implement the meta-solver pipeline and to extract features from PBO instances.

Table 8. Python libraries used for training models and feature extraction.

Library	**Version**
scikit-learn	1.3.0
joblib	1.3.2
PySCIPOpt	4.3.0

Table 9 shows the best hyperparameters found for each machine learning model (Random Forest, Gradient Boosting, and KNN) when trained as classifiers, regressors, and multilabel models. These hyperparameters were selected based on cross-validation on the training set. Additionally, the hybrid meta-solver was trained using the best configurations identified for the regression and multilabel models.

Table 9. Hyperparameters for classifier, regressor, and multilabel versions of the models.

Model	**Classifier**	**Regressor**	**Multilabel**
Random Forest	n_estimators=200, max_features="sqrt", criterion="gini"	n_estimators=200, max_features="sqrt", criterion="squared_error"	n_estimators=200, max_features="sqrt",
Gradient Boosting	n_estimators=200, learning_rate=0.1, max_depth=3, max_features="sqrt"	n_estimators=200, learning_rate=0.1, max_depth=3, max_features="sqrt"	-
KNN	n_neighbors=21	n_neighbors=21	-