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A novel stacking-based ensemble learning model for drilling efficiency prediction in earth-rock excavation

Key words: Drilling efficiency; Prediction; Earth-rock Excavation; Stacking-based ensemble learning; Improved cuckoo search optimization algorithm (ICSO); Five-fold cross-validation experiments; Rock-fill dam construction

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Framework



Drilling efficiency

Location

Elevation

Depth

……

Recorded data



Temperature

Sunny

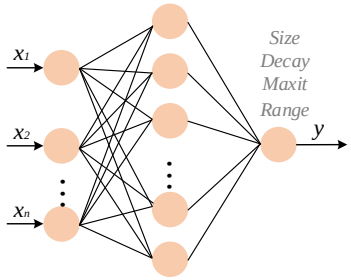
Cloudy

……

Mornitoring date

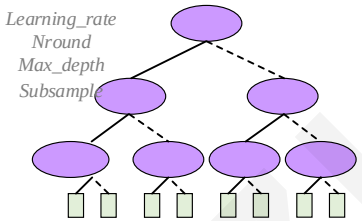
Base learners

Back Propagation Neural Network



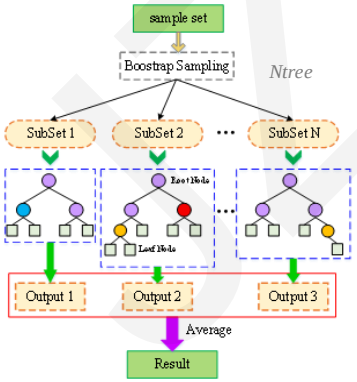
Predicted result 1

eXtreme Gradient Boosting



Predicted result 2

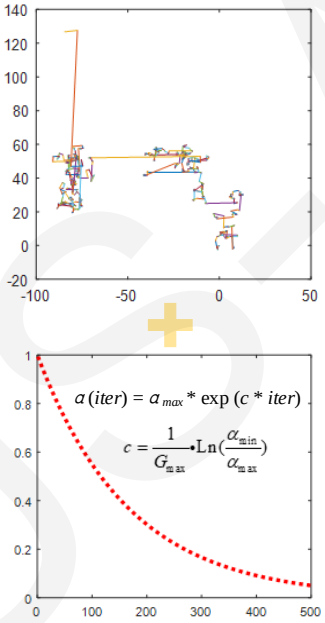
Random Forest



Predicted result 3

Optimized

Improved Cuckoo Search Algorithm

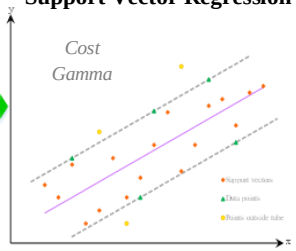


Parameter optimization

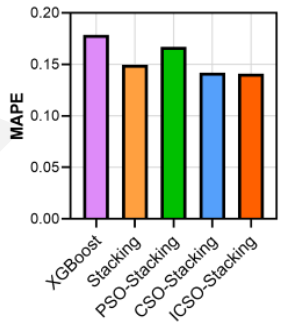
Optimized

Support Vector Regression

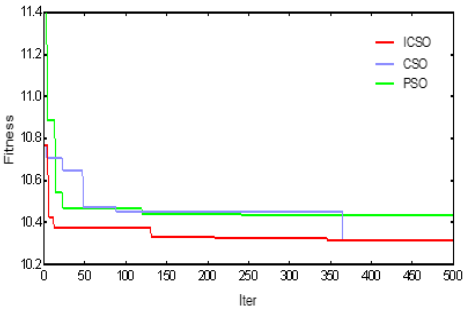
Input



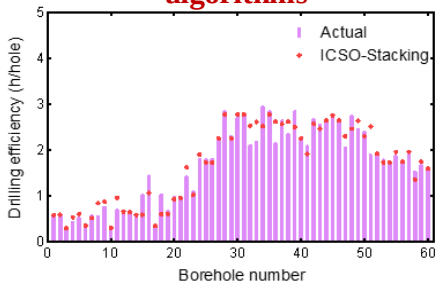
Meta-learner



Comparison of prediction algorithms



Comparison of optimization algorithms



Predicted drilling efficiency

Data Acquisition

Model Construction

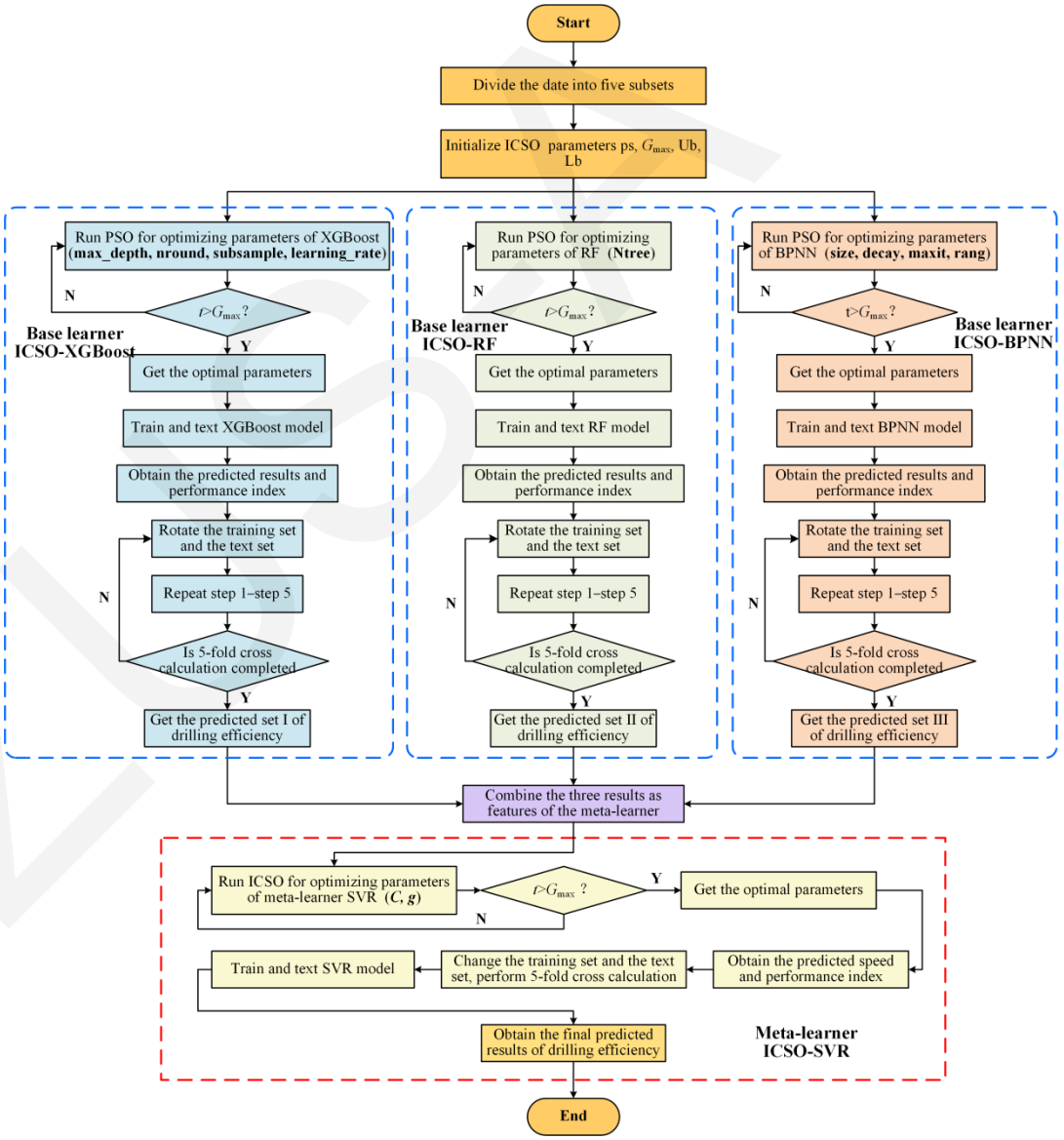
Case Study

The stacking prediction model

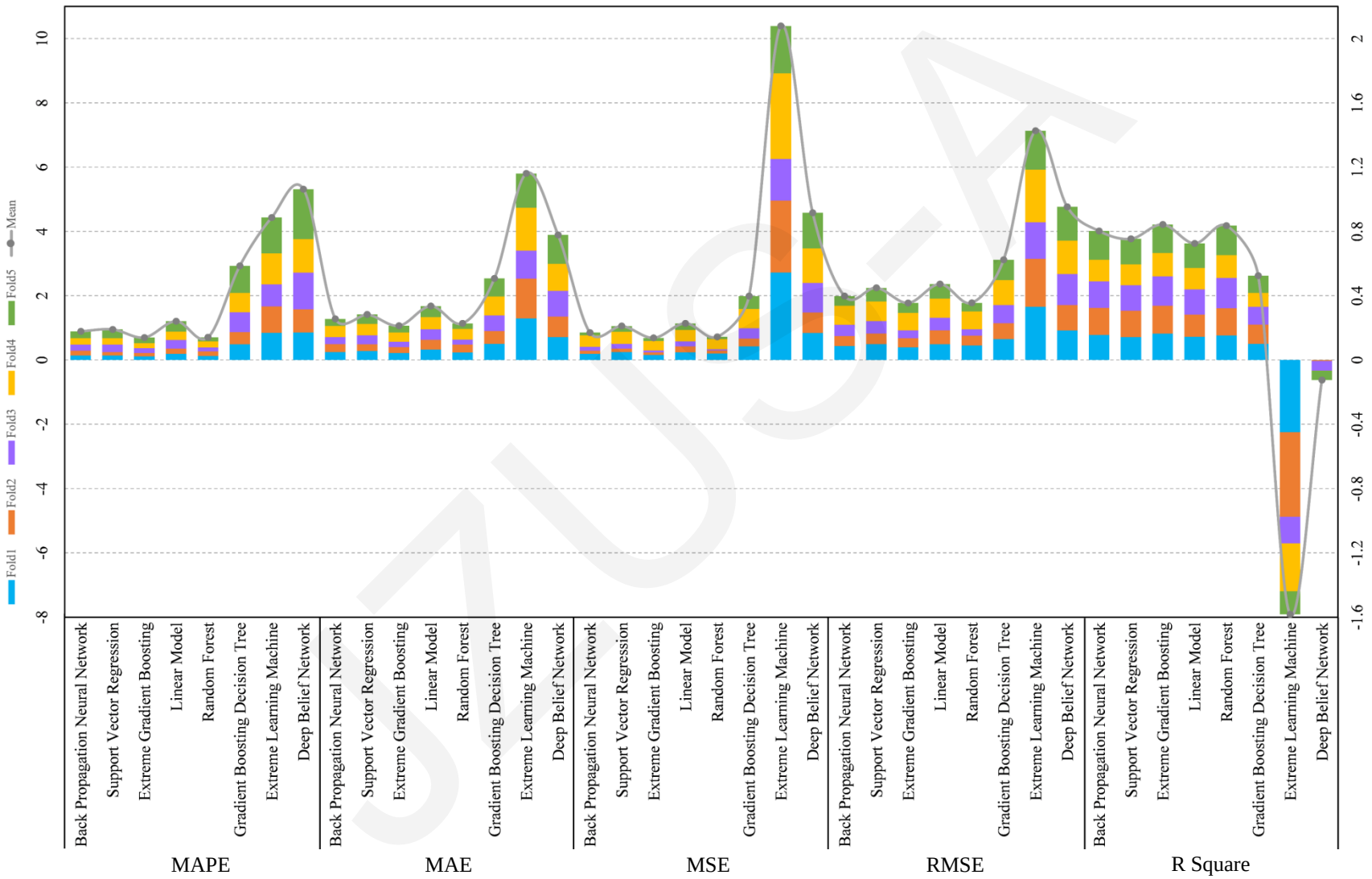
The pre-processed dataset is divided into five parts and the parameters of the ICSO are initialized

Three base learners are trained and tested, each providing an independent prediction result of drilling efficiency

The newly generated prediction results are taken as the input to train and test the meta-learner

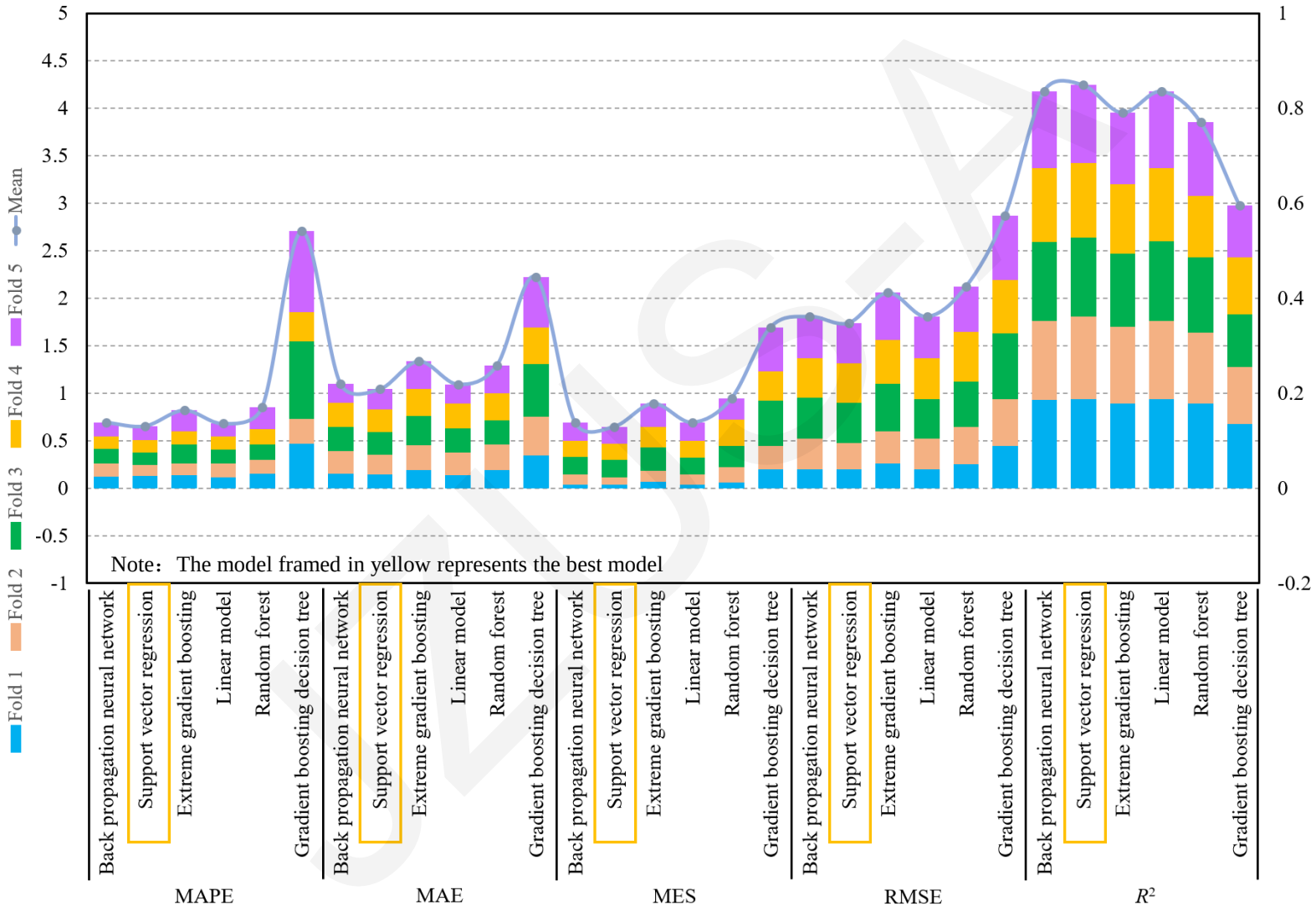


Selection of the base learners



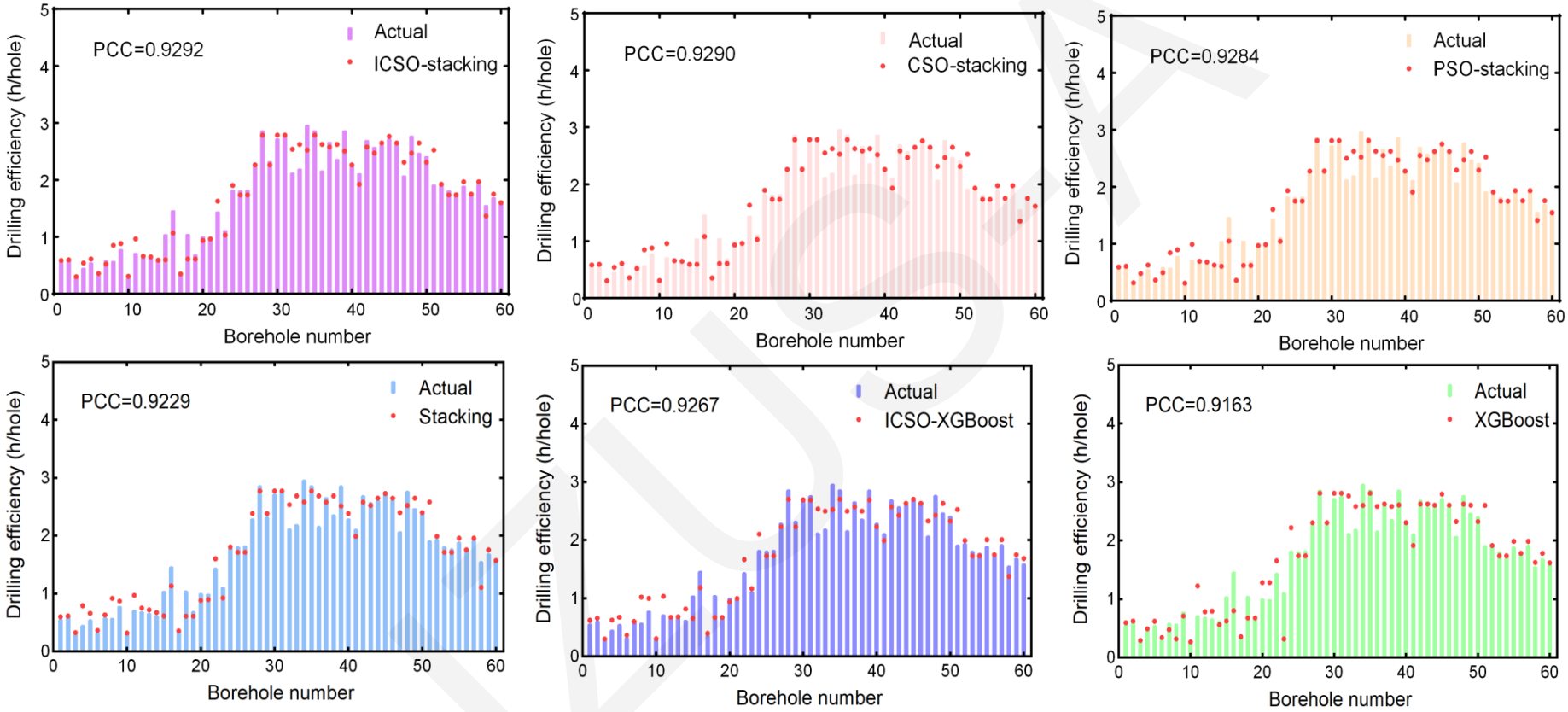
Prediction performance of eight single ML models for base learner

Selection of the meta-learner



Prediction performance of different single ML models as meta-learner

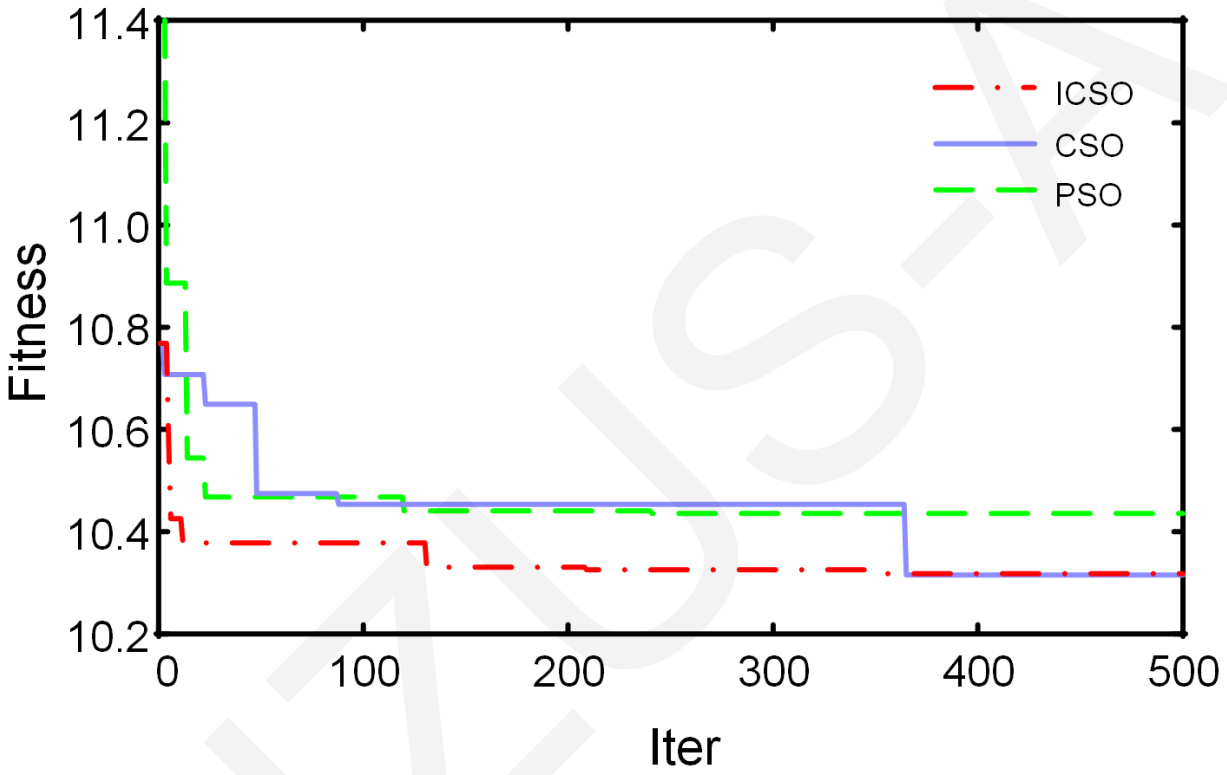
The prediction results



Prediction results of the proposed model and alternative prediction models

The PCC of ICSO-stacking ensemble learning is the largest amongst all the models. It demonstrates that the prediction results of the proposed ICSO-stacking ensemble learning model are closer to actual samples than those of the alternative models.

Comparison of optimization algorithms



The ICSO could find the optimal solution earlier with a better convergence speed as well as displaying more effective performance and smaller prediction error compared with the standard CSO and PSO.

Conclusions

- A novel stacking-based ensemble learning model is proposed for drilling efficiency prediction in earthwork excavation. The extensive experimental results with different combinations of varying types and numbers of base learners demonstrate that the model achieved the best prediction performance when XGBoost, RF, and BPNN were used as the base learners, and SVR was used as the meta-learner.
- Compared with the XGBoost and PSO-stacking methods, our ICSO-stacking ensemble method reduced the MAPE by 16.43% and 4.88%, respectively, proving that the proposed method could provide more reliable decision support for drilling procedures and excavation scheduling.