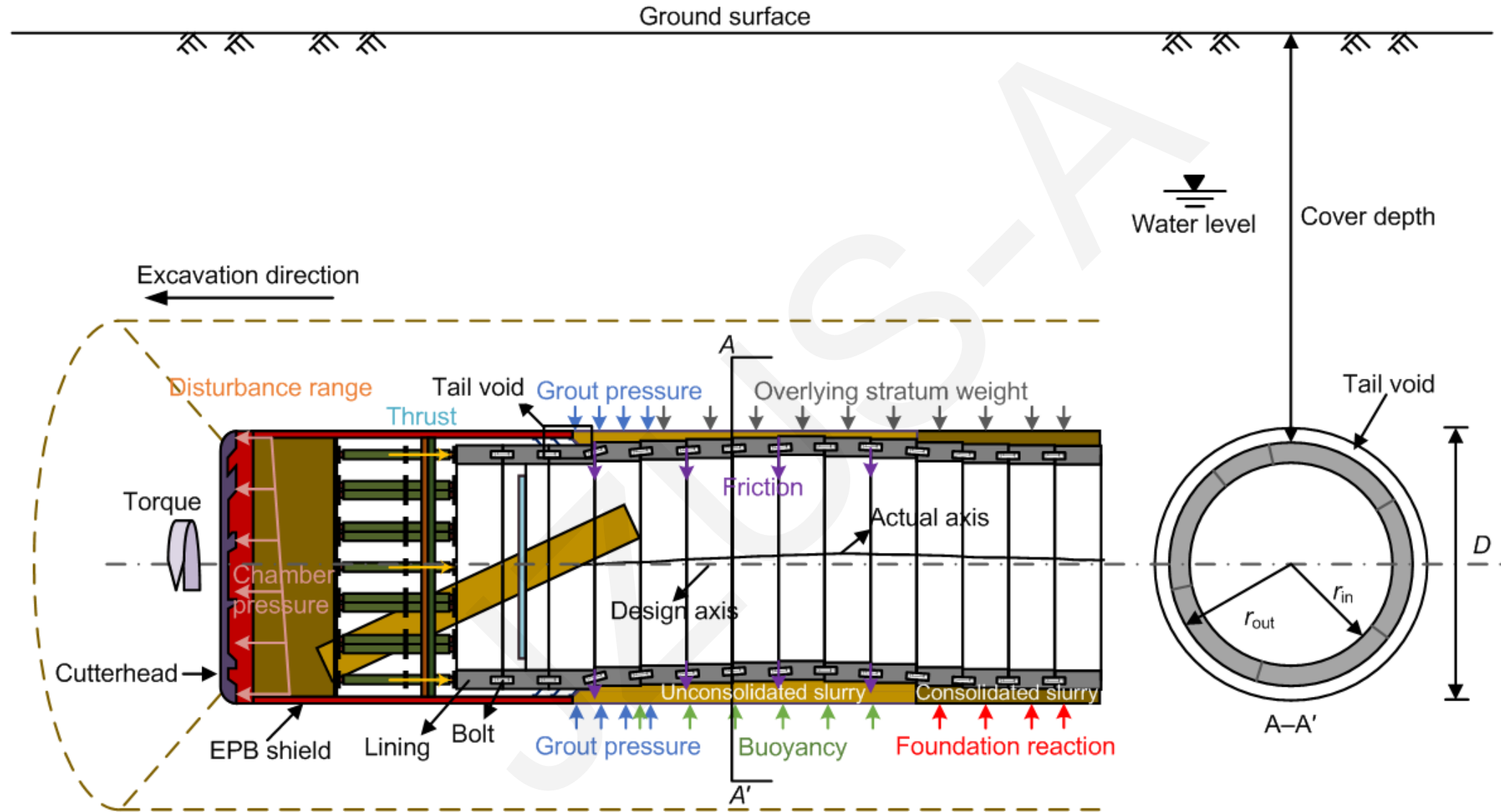


Prediction of maximum upward displacement of shield tunnel linings during construction using particle swarm optimization-random forest algorithm

Xiaowei YE, Xiaolong ZHANG, Yanbo CHEN, Yujun WEI, Yang DING

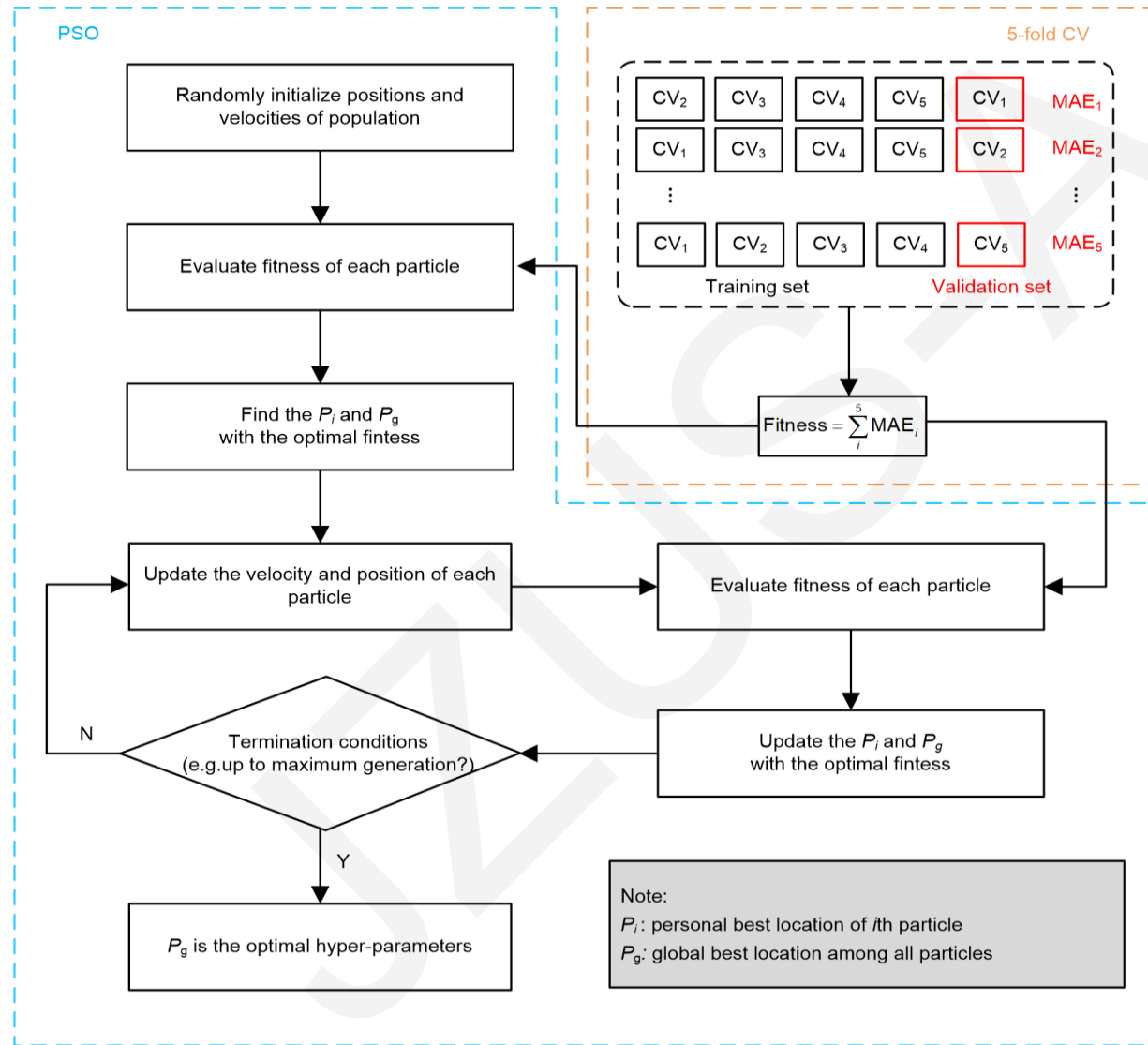
Cite this as: Xiaowei YE, Xiaolong ZHANG, Yanbo CHEN, Yujun WEI, Yang DING, 2024. Prediction of maximum upward displacement of shield tunnel linings during construction using particle swarm optimization-random forest algorithm. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(1):1-17. <https://doi.org/10.1631/jzus.A2300011>

Mechanism of upward movement of tunnel linings



Factors affecting the upward movement of a tunnel lining

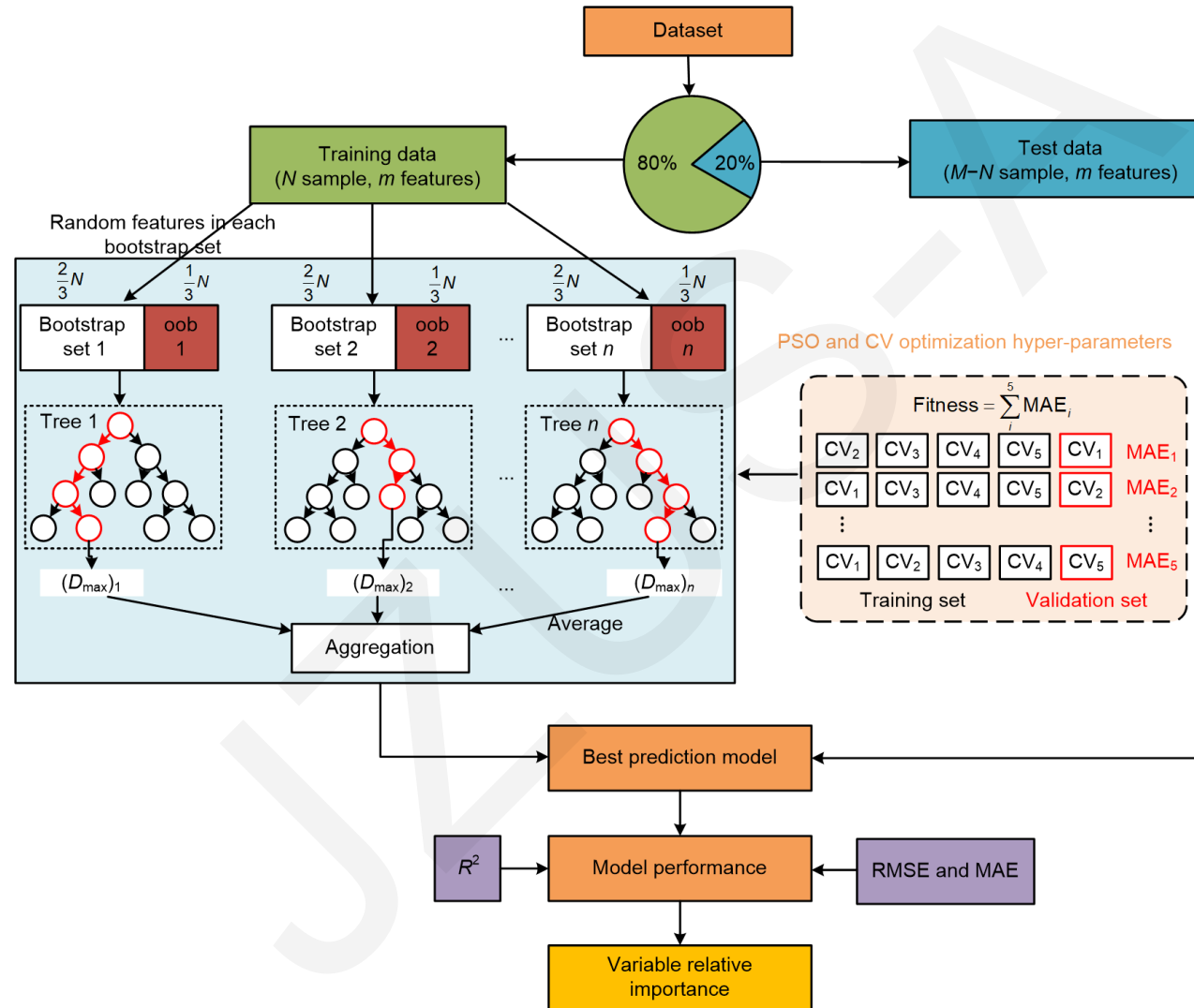
Proposed hybrid optimization algorithm



- This hybrid algorithm can effectively **avoid** the problem of **over- or under-fitting** in optimization and **improve** the **robustness and generalization** of prediction models

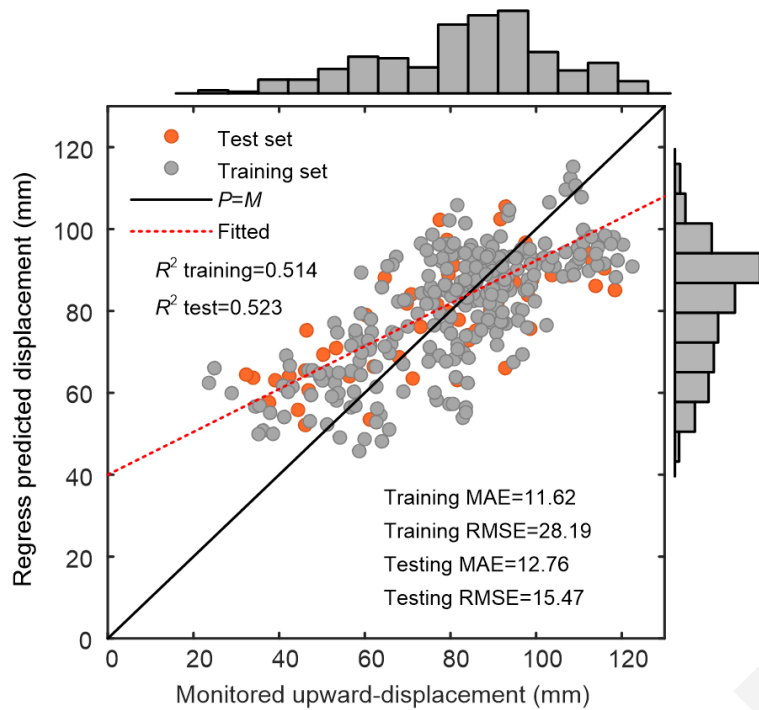
Flowchart of PSO and 5-fold CV hybrid optimization algorithm

Prediction model framework

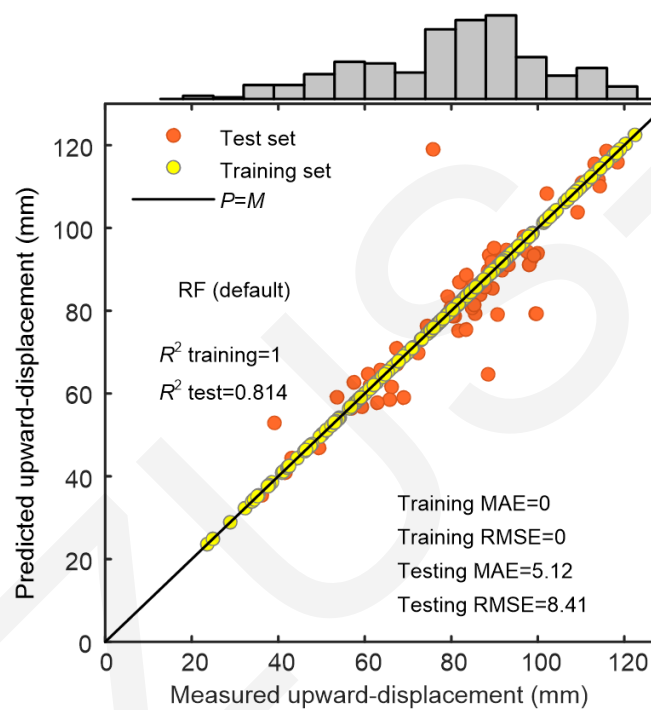


Flowchart of upward displacement prediction model using PSO-RF

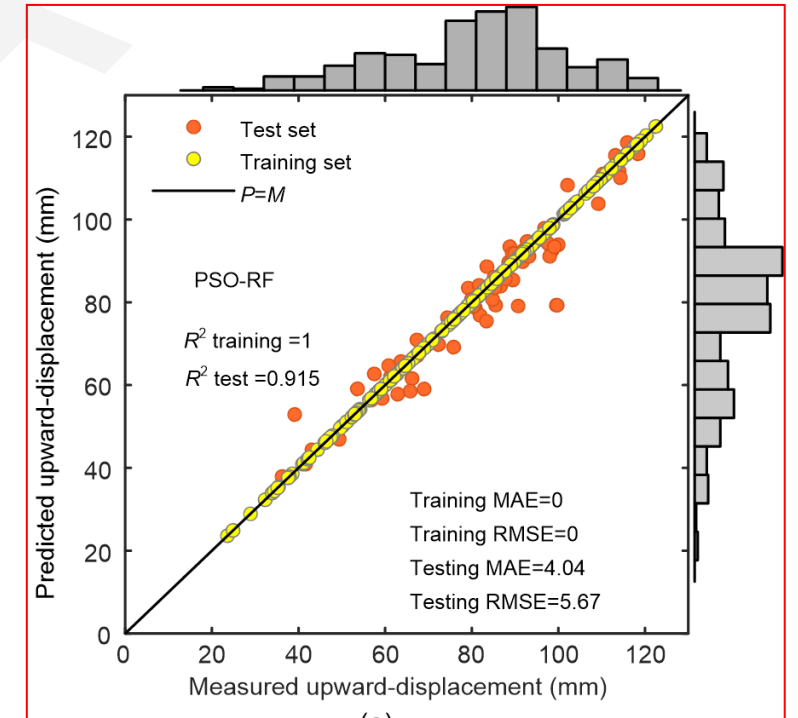
Excellent prediction performance



Multiple linear regression



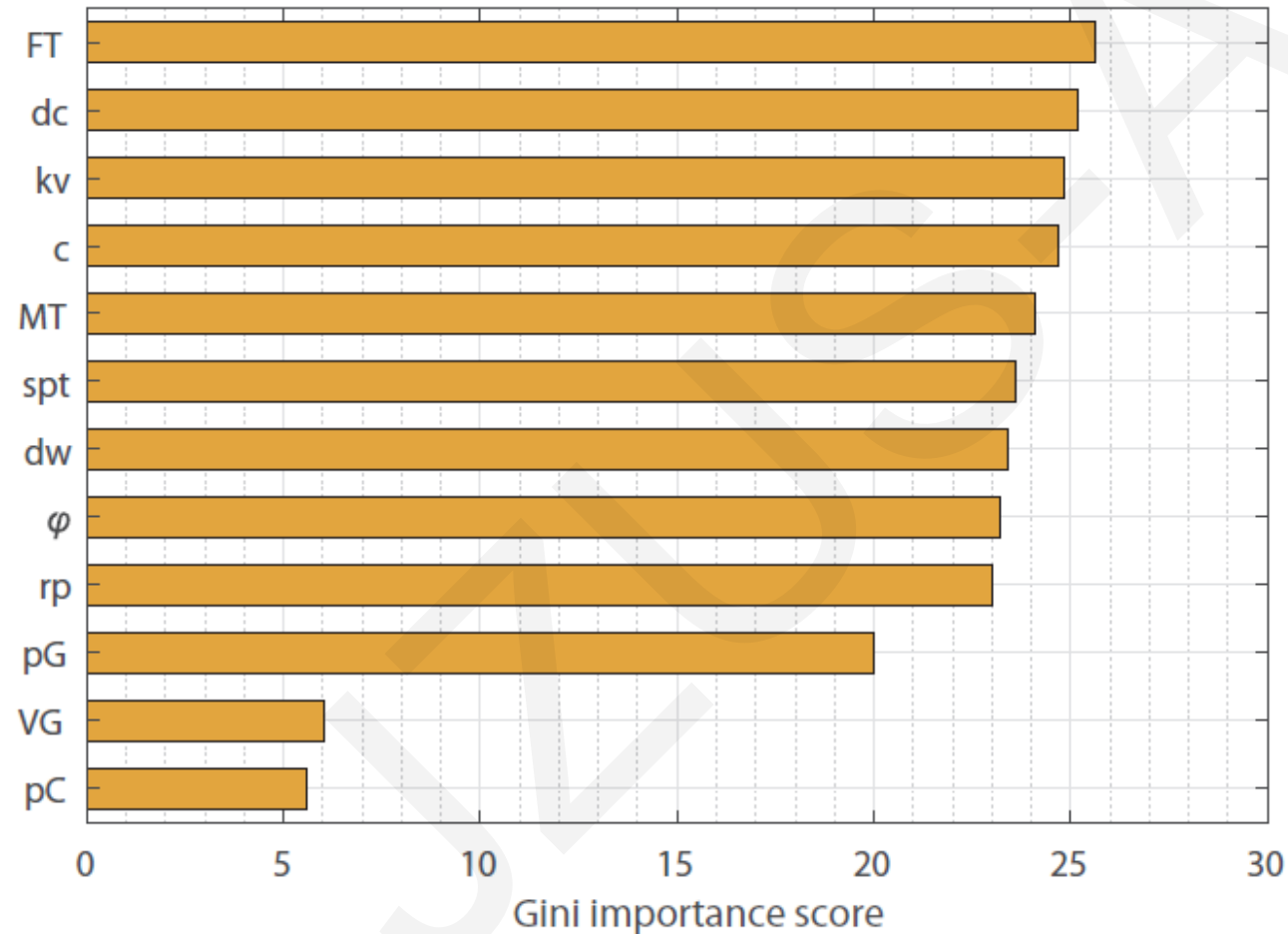
RF (default) model



PSO-RF model

Lower error (MAE=4.04, RMSE=5.67) and a higher correlation ($R^2=0.915$)

Relative importance of influencing factors



- The most important factors influencing tunnel lining floating were **thrust (FT)**, followed by **depth of tunnel (dc)**, **permeability coefficient (kv)** and **soil cohesion (c)**.

Gini importance scores of all influencing factors

Conclusions

- The mechanism of the upward movement of tunnel linings is that the tail void provides the **floating space** and the **upward external forces** affect the floating trend.
- The combination of PSO and CV effectively determines the optimal hyper-parameters and improves the prediction performance of the RF.
- The **PSO-RF model** successfully predicts the maximum upward displacement of linings with **a low error** (MAE=4.04, RMSE=5.67) and a **high correlation** (R²=0.915).
- The **thrust** and **depth of the tunnel** are the **most important** influencing factors for the PSO-RF based model to predict the upward displacement of linings.