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A data-driven approach for modeling and predicting the thrust force of a tunnel boring machine

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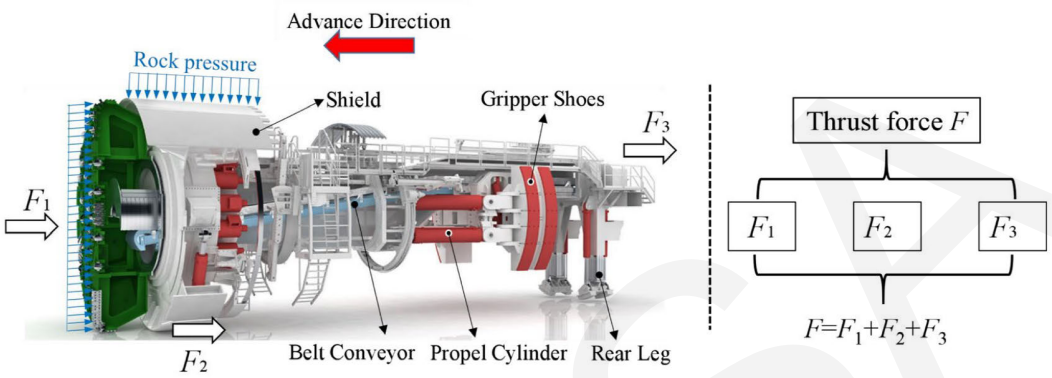
The challenge of thrust modeling



1. Cutterhead advance speed
2. Cutterhead torque
……
21. The left shield pressure

◆ Structural parameters of TBM

1. Geological condition
2. Rock stripping process
3. The contact position and quantity of tool and rock

◆ Random factor

F

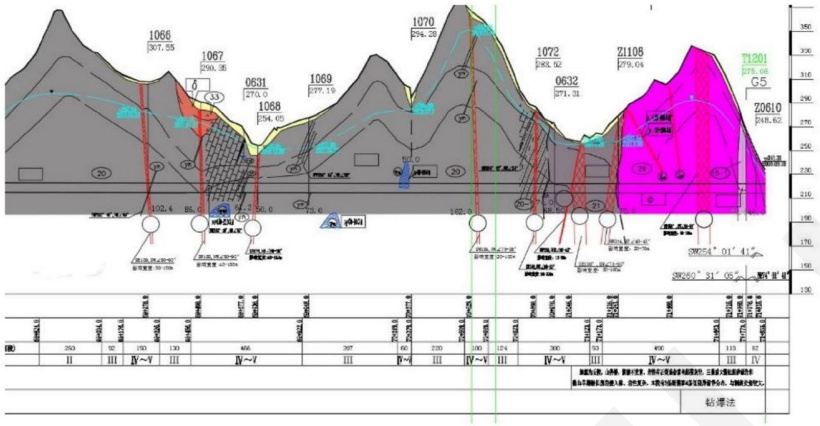
1. The normal force between the cutterhead and the rock F_1
2. The frictional force on the shield F_2
3. The traction force of the backup device F_3

Challenge

1. **Many parameters and no clear correspondence.**
2. **Random conditions increase the difficulty of modeling**

Innovation 1:The combination of field record data and agent model technology

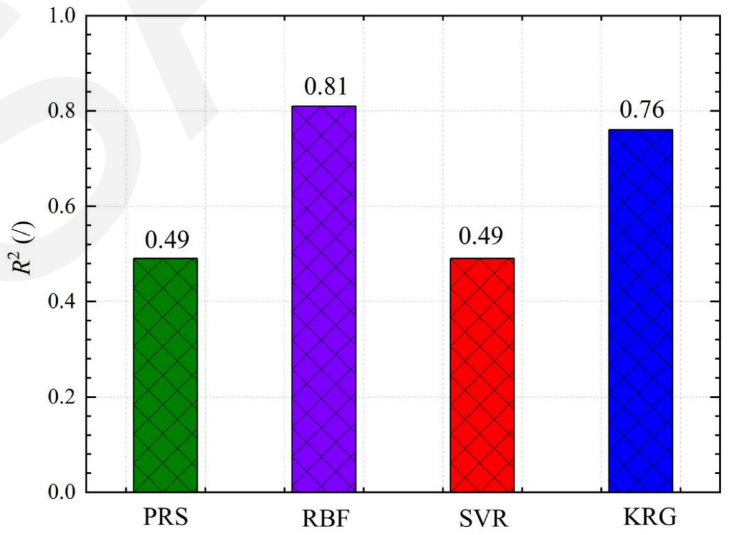
Recording data on site



surrogate model technology

1. Cubic polynomial response surface method
2. Kriging model
3. Support vector regression model
4. Radial basis functionmodel

Prediction model



Screen factors to improve its accuracy

Innovation 2：Morris method main factor screening to improve the modeling accuracy

21 possible influencing parameters

Morris method

5 key parameters

1.Cutterhead advance speed

2. Cutterhead torque

……

21. The left shield pressure

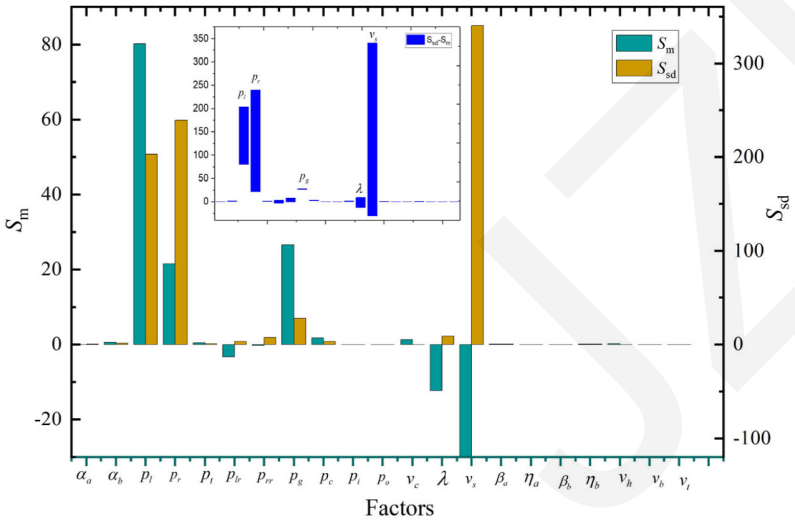
1.The left shield pressure

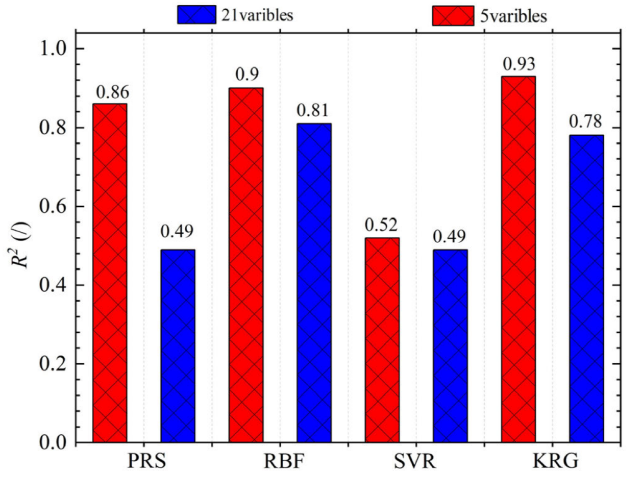
2. The right shield pressure

3. The pressure gripper shoes

4. The penetration

5. The cutterhead advance speed

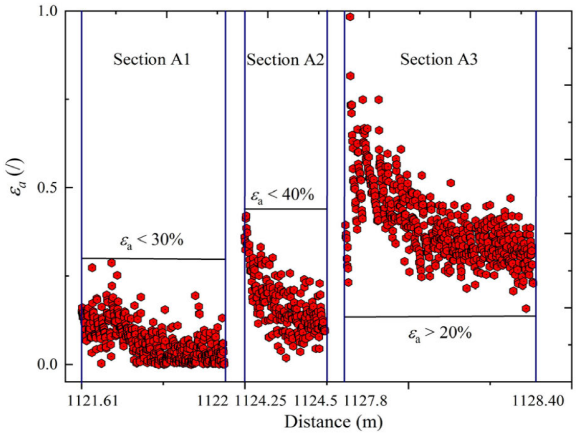




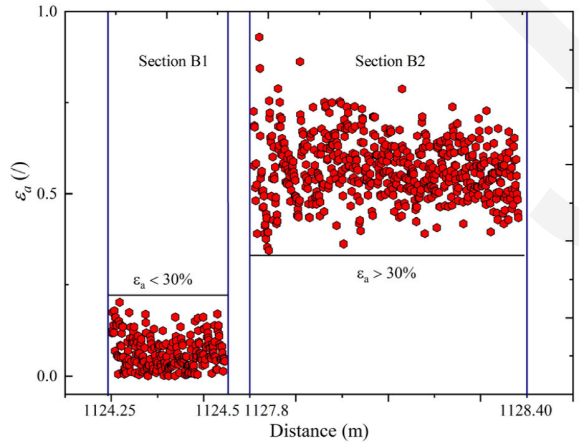
The Kriging model is selected for thrust modeling

Innovation 3：Modeling similar working conditions and appropriately increasing modeling samples can effectively improve the prediction accuracy of TBM thrust.

Model A



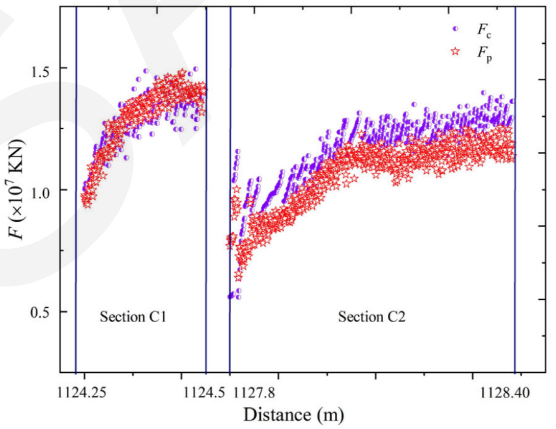
Model B

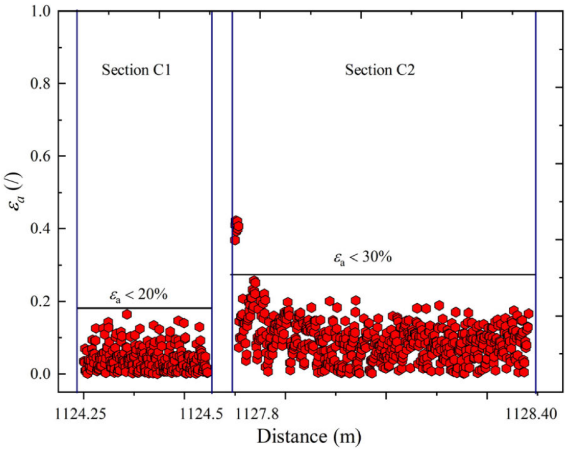


Similar working conditions

Increasing modeling samples

Model C





Conclusions

- The high-precision prediction model constructed by the combination of field record data and surrogate model technology provides a feasible way for the modeling and prediction of TBM thrust under complex working conditions.

- After the main factor screening by Morris method, the accuracy of the surrogate model is effectively improved.

- The use of similar working conditions modeling and reasonable increase in modeling costs can effectively improve the accuracy of prediction, and the data-driven TBM thrust prediction model can be used as an important basis for controlling thrust during tunneling.