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From tunnel boring machine to tunnel boring robot: perspectives on intelligent shield machine and its smart operation

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Introduction

- Traditional shield machine industry confronts immense challenges arising from the construction environment and manual operations.
- Growing need for intelligent shield machines that can operate intelligently, adapt to changing geological conditions, and improve construction efficiency and safety.

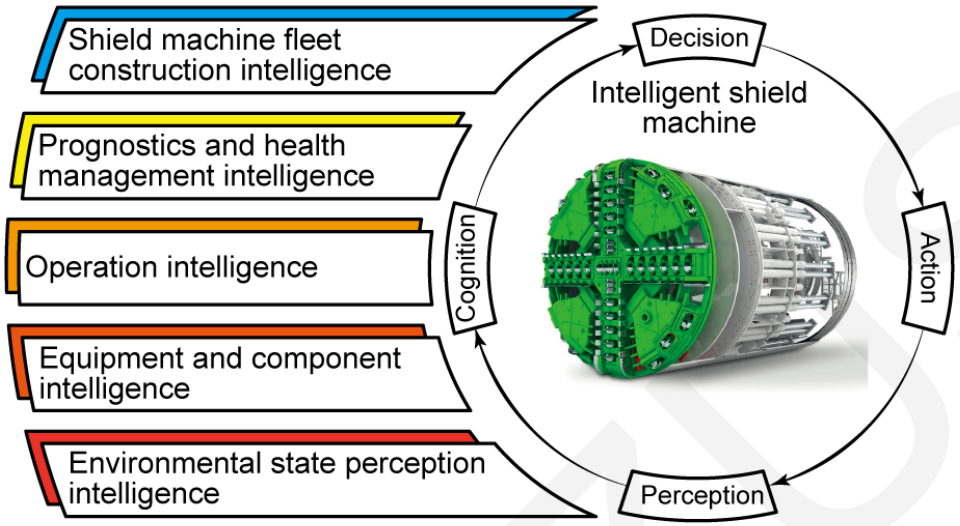






Fundamental issues of intelligent shield machines

Contents of shield machine intelligence



- The level of intelligence of an intelligent shield machine increases with its degree of autonomy.

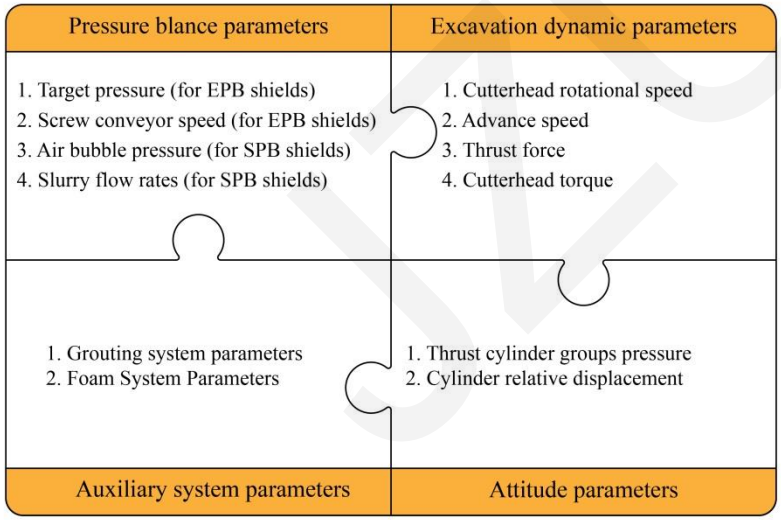
Long-term development goal

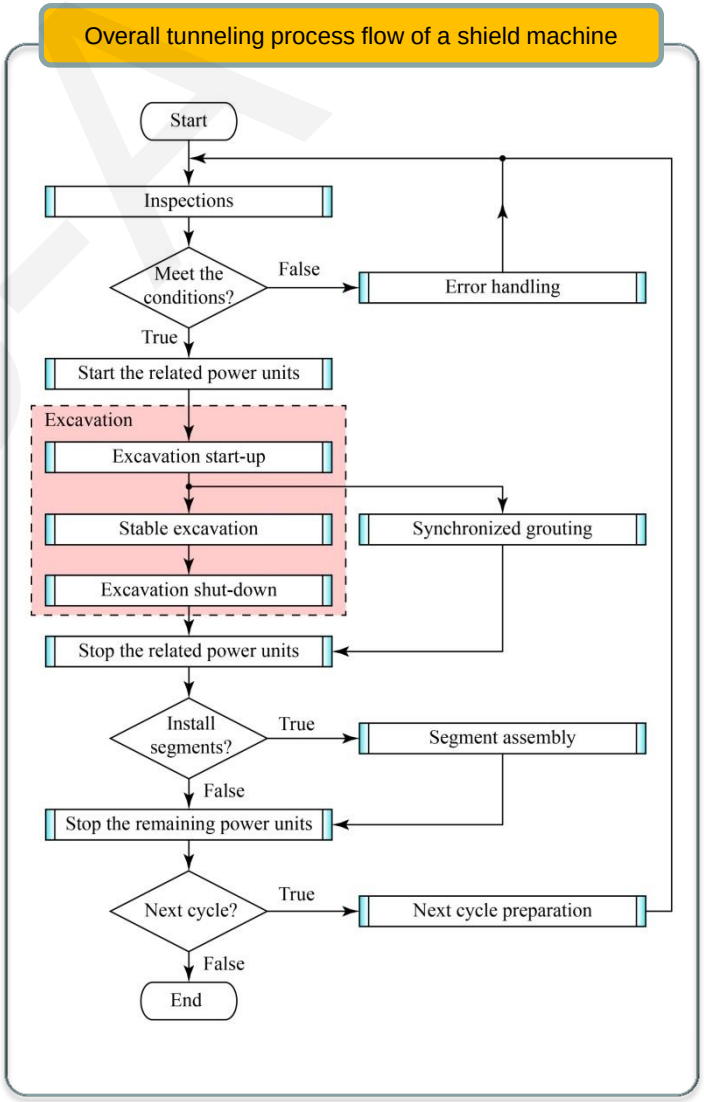
- Attain a certain degree of autonomous construction.
- Outperforming manual operation.

Autonomous operation framework

Analysis of the tunneling operation process

- Processes that require decision-making or continuous adjustment of analog quantities require intelligence.
- The stable excavation operation can be broken down into the adjustment of four groups of parameters.

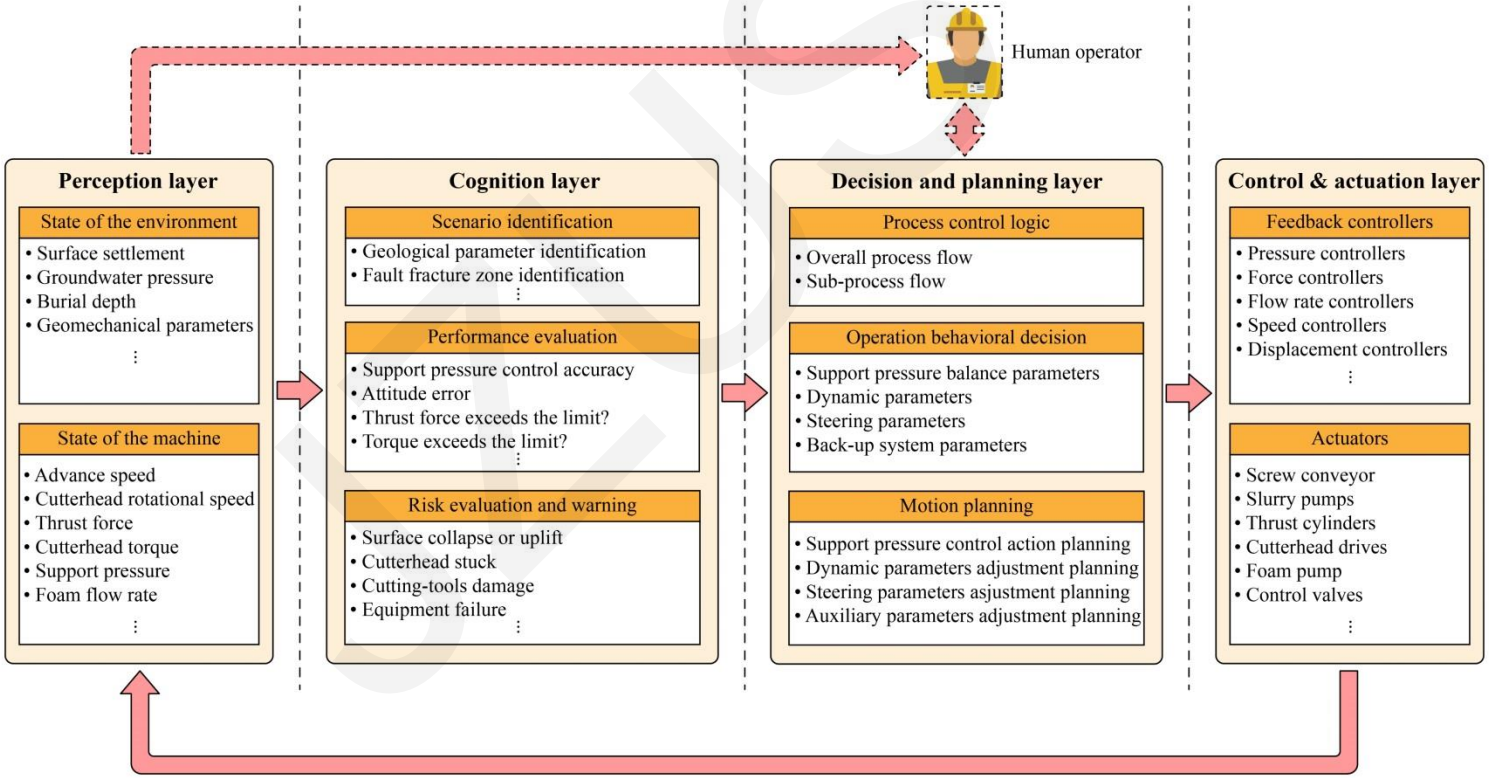




Autonomous operation framework

Stand-alone-level autonomous operation architecture

- Each layer employs a modular design, with upper modules utilizing information from lower modules to make decisions.
- The closed loop of information represents fully autonomous excavation



Autonomous operation framework

Autonomous operation architecture of shield machine fleet level

- A coordinated "cloud-edge-device" autonomous operation architecture

