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Positioning error prediction and compensation for the multi-boom working mechanism of a drilling jumbo

Key words:

Multi-boom rock-drilling jumbo; Kinematic model; Neural network optimization; Positioning error prediction

The error of the inverse kinematics calculation for the drilling boom is estimated.

Input: position and attitude matrix (T), population (p), iteration times (t), inertia factor (w), objective function (f)

Output: joint variables $(\theta_1, \theta_2, d_3, \theta_4, \theta_5, \theta_6)$

Step 1: Determine the initial position xi and its velocity vi.

Step 2: Calculate particle fitness and update individual extremum (p_{best}) and global extremum (g_{best}).

Step 3: Update particle velocity: $v_i = wv_i + c_1 n_{r1}\left(p_{best,i} - x_i\right) + c_2 n_{r2}\left(g_{best,i} - x_i\right)$.

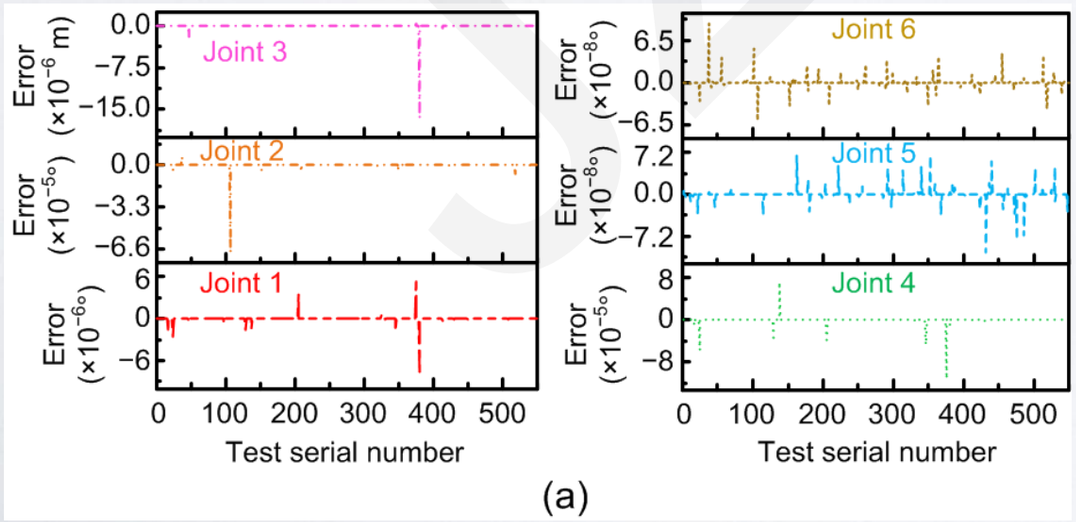
Update particle position: $x_i = x_i + v_i$.

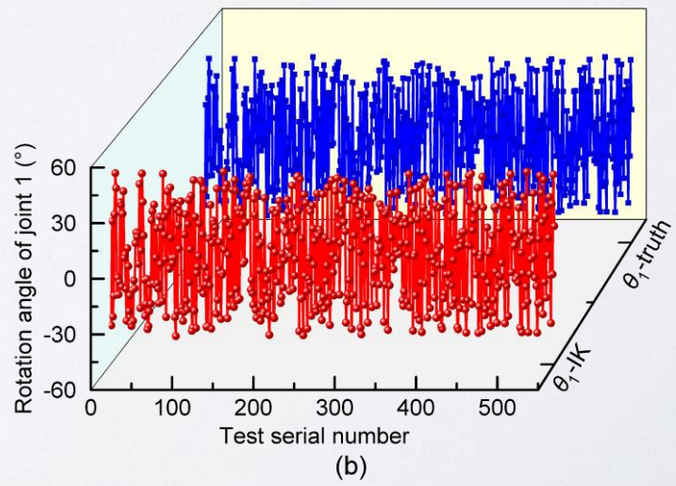
Step 4: Output search points after iteration.

Step 5: Use global search to solve the equation at a given initial point.

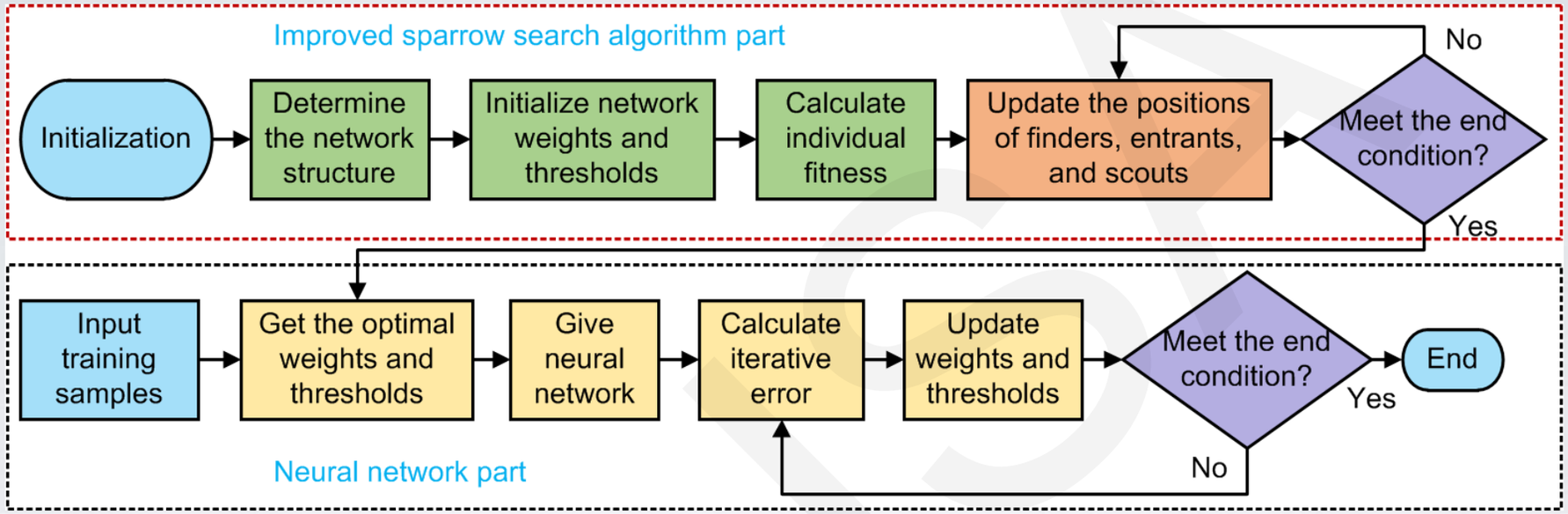
Step 6: Global search algorithm generates test points, initializes thresholds and counters, and starts the main loop.

Step 7: Output the result when the end condition is met.





Process of BP neural network optimized by the ISSA



Input: training data; number of hidden layer nodes (h_1, h_2), number of input layer nodes (m), number of output layer nodes (n), maximum evolutionary algebra (G_{max}), population (p), Alboom value (R_A)

Output: the best individual (F_{best})

Step 1: Initialize the network structure.

Step 2: Establish the function of fitness:

$$F(i)=\frac{1}{\frac{1}{2}\sum_{i=1}^{n}\left(o_i-r_i\right)^2}.$$

Step 3: Rank individual sparrows according to fitness function values.

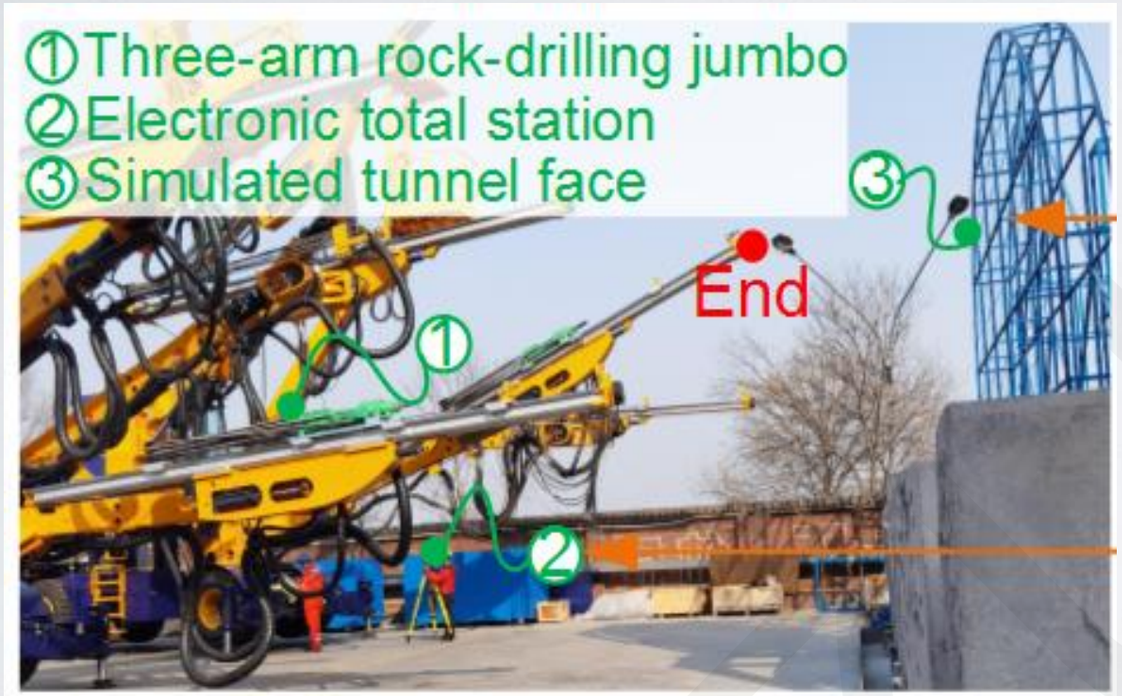
Step 4: Update provider, scrounger, and scout locations.

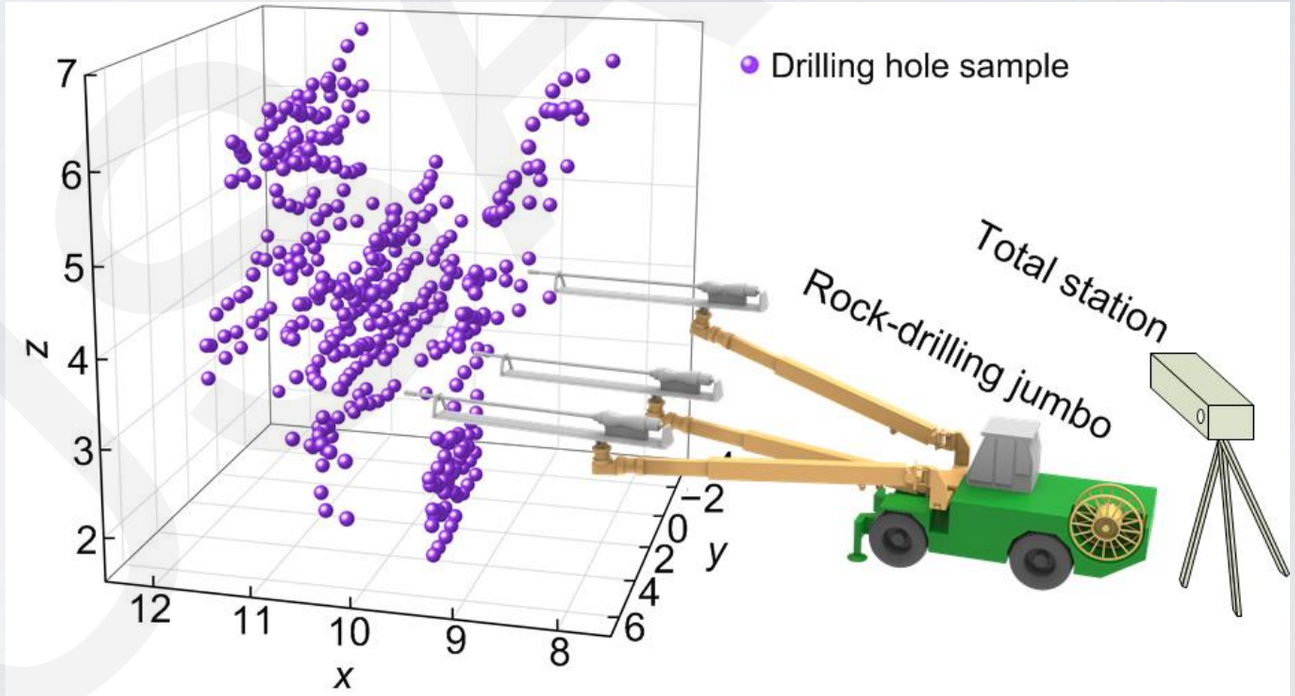
Step 5: Calculate fitness and update position.

Step 6: Cycle through steps 3 to 5 to get the best individual (F_{best}).

Step 7: The optimal weights and thresholds obtained by the ISSA are given to the network.

Experimental positioning error compensation process for a drilling boom





Model	Direction	Deviation (cm)		
		Max	Mean	Standard
BP	X	0.96	0.34	0.28
	Y	2.77	0.76	0.81
	Z	2.73	0.72	0.58
ISSA -BP	X	0.74	0.31	0.19
	Y	1.71	0.70	0.49
	Z	1.66	0.65	0.47

Perspectives and Research Priorities

Research Priorities:

- The error of the inverse kinematics calculation for the drilling boom is estimated.
- The positioning error of the drilling booms is predicted based on ISSA-BP.
- The average drilling-positioning error was reduced from 9.79 to 5.92 cm, and the error was reduced by 39.5%.

Rock-drilling jumbos are the most widely used tunneling equipment in coal-energy exploitation and underground tunnel construction. The positioning accuracy of rock-drilling booms is an important factor affecting excavation efficiency and section-forming quality in the mining of roadways and engineering tunnels. The self-weight, strong coupling, complex structure, and long boom length of a three-boom drilling jumbo can easily cause excessive positioning error, which significantly hinders the efficiency of roadway excavation. Therefore, accurate prediction and compensation of positioning error for the drilling mechanism of three-boom rock-drilling jumbos is key to improving drilling performance.