An Oxygen Forecasting Strategy for Waterless Live Fish Transportation Based on IPSO-GRU Method

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Introduction

To improve the prediction accuracy and efficiency for short-term oxygen concentration trends during the process of waterless live fish transportation, a kind of short-term oxygen consumption prediction model is proposed by using the gated recurrent unit (GRU) neural network, and its parameters are optimized by improved particle swarm optimization technology (IPSO). By comparing the prediction accuracy and efficiency of prediction fusion algorithms IPSO-GRU, IPSO-LSTM, GRU, and LSTM (Long Short-Term Memory), it is concluded that the time-series prediction model IPSO-GRU has higher predicting accuracy in short-term oxygen forecasting, and its efficiency has been significantly improved. Through experimental comparison, the accuracy of IPSO-GRU is improved about 45.9%,9.16% when it compares with GRU by error criteria MAPE and RMSE respectively, and also improved about 54.1%,15.3% than LSTM. In addition, the time cost of IPSO-GRU is greatly reduced in a predicting operation when it compares with LSTM and GRU methods. Therefore, the method IPSO-GRU provides an effective prediction and early-warning functions for oxygen consumption prediction management during fish waterless keep-alive transportation.

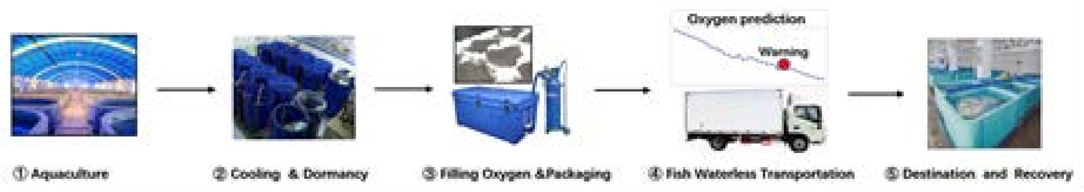


Figure 1 Waterless Live Fish Transportation

Methods

Step1. The training oxygen concentration data and test data were constructed, and the oxygen concentration data were preprocessed to obtain the historical oxygen consumption sequence for the fish keep-alive transportation.

Step2. The parameters of the GRU are optimized by IPSO to construct the optimal short-term oxygen prediction model. The specific modeling steps are as follows:

Step 2.1. The parameters of particle swarm optimization and GRU neural network are initialized. The parameters of particle swarm optimization include population size, population layers, iterations, learning factors, and the limited interval of particle position and velocity. The initial values of particle position and velocity are random. The parameters of the GRU neural network mainly include the number of neurons in each layer and the number of hidden layers.

Step 2.2. Calculate the fitness value of each particle. The fitness value of each particle in the population is calculated and the population hierarchy is constructed. The fitness function of particles in a population is defined as:

$$fit_i = \frac{1}{n}\left[\sum\left(Oxygen\_sample_i - Oxygen\_real_i\right)^2\right], i = 1, 2, \cdots, n$$

Where n is the population size, is the forecasted sample output value, is the actual output value.

Step 2.3. Update the velocity and position of particles according to equations (3) and (4).

Step 2.4. If the end of iteration condition (good enough position or the maximum number of iterations) is reached, the iteration will end; Otherwise, the iteration will continue in Step 2.

Step3. According to the optimal model IPSO-GRU, the short-term oxygen concentration is predicted, and the actual prediction results are output.

Figure 2 Comparison of test function optimization process

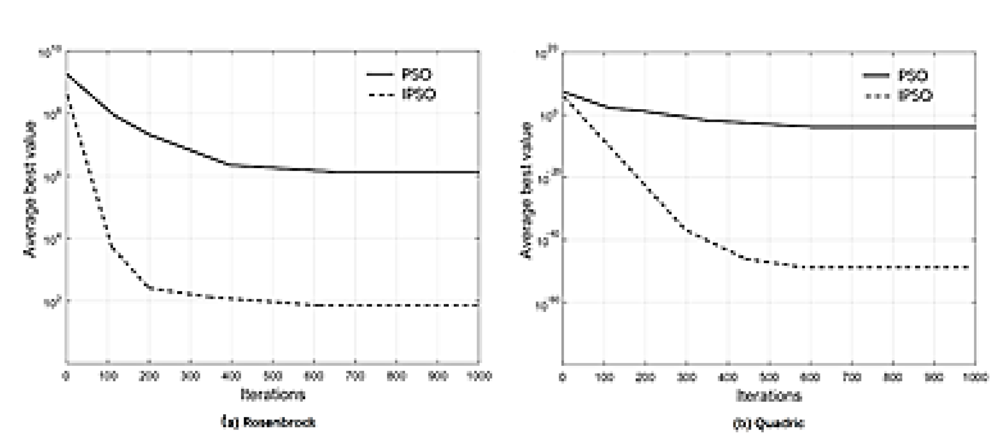
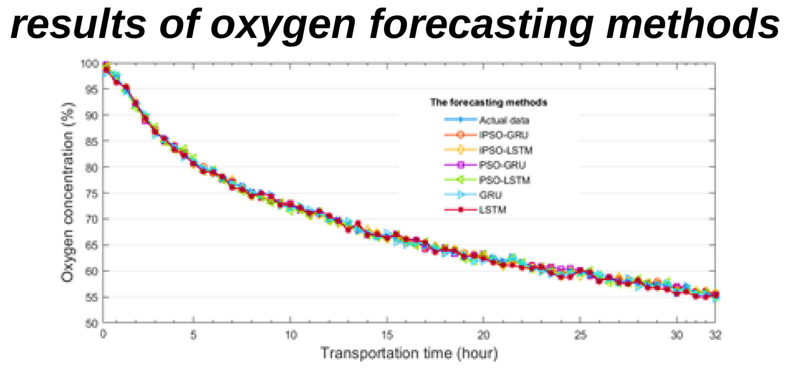


Figure 3 Comparison curve of prediction results of oxygen forecasting methods

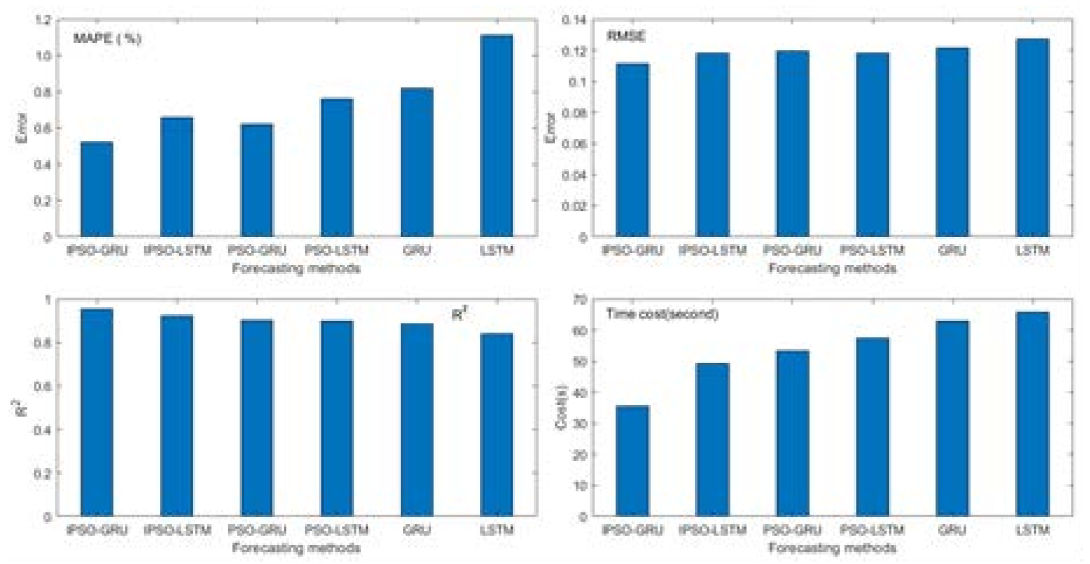


Results

Our research and experiments are implemented by Python 3.9. All of the data monitoring and processing in this study is conducted by the Numpy, Pandas, and Scikit-Learn packages of the Python software. The deep learning methods, LSTM, GRU, PSO, IPSO-LSTM, and IPSO-GRU, are developed by Keras that is based on TensorFlow.

Figure 3 shows the comparison curve of the prediction results of the prediction algorithms IPSO-LSTM, PSO-GRU, PSO-LSTM, GRU, and LSTM, and Figure 4 demonstrates the comparison statistics of the prediction error results of these time-series forecasting algorithms. Compared with the GRU neural network based on PSO optimization, the prediction criteria RMSE, MAPE, R2, and time cost of IPSO-GRU are proposed in this paper are improved about 6.7%, 15.7%, 4.3%, and 38.1% respectively. The running performance of the intelligent oxygen concentration prediction method IPSO-GRU is also improved about 5.9%, 24.2%, 7.4%, and 46.6% respectively when it compares with the PSO-LSTM model according to the above same criteria orders.

Figure 4 Comparison of prediction error and performance results



Conclusions

This paper proposes the optimized IPSO-GRU method, which has improved by the improved particle swarm optimization than traditional PSO algorithms. In the process of updating the speed and position of particles in IPSO, the factors of mutual attraction between particles are taken into account, which overcomes the defects of the PSO algorithm and improves the speed and accuracy of the algorithm. IPSO algorithm can quickly and efficiently find the optimal parameters of the GRU neural network. Through the experiment, the measured oxygen time series is predicted and evaluated. It can be concluded from the experimental results that the IPSO-GRU model can better fit the data in the dynamic prediction of oxygen concentration. Moreover, the forecasting error is decreased greatly when it compares with IPSO-LSTM, PSO-GRU, PSO-LSTM, GRU, and LSTM methods. The experimental results show that the GRU neural network model based on IPSO optimization has higher prediction accuracy and significantly improved the prediction efficiency in the prediction for oxygen consumption in live fish waterless transportation.

Bibliography

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