Tidal water level prediction based on machine learning and empirical mode decomposition.

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ABSTRACT

In water level prediction, Tidal level is a part that satisfies tidal laws, and the residual water level caused by environmental factors is non-deterministic and time-varying. The difficulty of its prediction lies in the inability to quantify short-term meteorological factors such as wind, air pressure, and precipitation, and the increase and decrease of water caused by seasonal climate factors. This is the main reason that restricts the accuracy of traditional water level prediction models. With the development of artificial intelligence, neural networks and fuzzy logic reasoning are gradually applied to marine hydrologic factor prediction. Empirical modal decomposition is a method for handling non-stationary signals that can decompose the different scale fluctuations in the signal step by step.

Optimization of residual water level sample data by using empirical modal decomposition method can effectively improve the approximation and prediction ability of the model in machine learning. Based on the above analysis, this paper uses the combined model of Empirical Modal Decomposition and Long Short-Term Memory to separate the data from the residual water level sequence and use machine learning training and prediction to improve the short-term prediction accuracy of the residual water level. Then the predicted residual water level and the harmonic analysis water level are superimposed, that is, the predicted water level. The results show that this method can improve the prediction accuracy of tidal water level to a certain extent and can be used in tidal level prediction.

KEY WORDS: Tidal, Water level prediction, Empirical modal decomposition, Residual water level, Machine learning training.

INTRODUCTION

Tide is one of significant dynamic phenomena in about port and harbor activities, and it is also an important factor affecting marine economic activities. With the development of the world economy, trade between countries is becoming more and more frequent. As one of the important transportation modes, maritime shipping occupies a dominant position in the world's transportation industry due to its large capacity and low cost. In recent years, China's shipping industry has made great progress. The leading role of shipping in foreign trade and transportation has become increasingly prominent. The number and types of ships entering and leaving the port have continued to increase. Real-time and accurate water level prediction can provide safety guarantee for large ships entering and leaving ports and diving operations, and also provide a basis for decision-making for shipping establishment. Taking advantage of the strong time correlation of water level changes, accurate water level prediction can reduce the number of tide detection stations and expand the prediction range, thereby saving costs.

In the water level forecast, the tide level is the part that meets the tidal law, and the remaining water level caused by environmental factors is uncertain and time-varying. The difficulty in forecasting is that it is impossible to quantify short-term meteorological factors such as wind, air pressure, precipitation, and seasonal climate. The increase or decrease of water caused by these factors is the main reason that restricts the accuracy of traditional water level prediction models. With the development of artificial intelligence, neural networks and fuzzy logic reasoning are also gradually applied to marine hydrological element forecasting.

Artificial neural network has always been an important method for tide forecasting, but due to the shortcomings of BP (Back Propagation) neural network, its development in tide forecasting business has been restricted to some extent. In recent years, the significant development of artificial neural networks in time series has made a major breakthrough in tidal business. In time series analysis, future data is related to past data, but ordinary BP neural networks cannot reflect this correlation, and LSTM (Long Short-Term Memory) networks that have appeared in recent years can reflect this correlation well. In addition, there have been significant applications in areas such as natural language learning, speech recognition, and automatic composition of music. There are also precedents for coastal wind speed forecasting with LSTM combined with CNN (Convolutional Neural Networks) in the tidal ocean field. Studies have also shown that models established through LSTM neural networks can effectively forecast the 24-hour and 72-hour hourly temperature, humidity and wind.

In recent years, especially after the Resnet neural network in 2013, deep learning technology has developed rapidly. LeCun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998) invented the Convolutional Neural Network (CNN) in 1998. Hinton, G. E., and Salakhutdinov, R. R. (2006) "Deep Belief Network" concept in 2006. Their research laid the foundation for the development of neural networks. At the same time, Recurrent Neural Network (RNN) has also been widely used in time series such as speech recognition and automatic translation. Long short-term memory network (LSTM) was proposed by Hochreiter & Schmidhuber (1997). It is an RNN algorithm that incorporates...