ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199

Research on Blind equalization method of variable step size neural network in underwater acoustic communication

Canghao Gao

Harbin Engineering University

gao497627595@163.com

Abstract: In the construction and development of modern society, how to ensure the high efficiency and safety of underwater communication is the main issue discussed by researchers. Among them, the underwater acoustic channel as a very complex variable parameter channel, the actual frequency band is limited, the signal fluctuation and fading is more serious, which directly affects the efficiency and quality of underwater information transmission. As one of the effective methods to solve this problem, channel equalization technology is the main content of the empirical analysis of scholars. Therefore, on the basis of understanding the theory of underwater acoustic communication and blind equalization technology, this paper compares and analyzes the convergence performance of the traditional constant mode blind equalization algorithm and the new variable step constant mode blind equalization algorithm. The final research results show that the improved algorithm has higher convergence than the traditional algorithm, and can reduce the transmission error and improve the quality of aquatic communication.

Keywords: Aquatic communication; Neural network; Blind equalization; convergence

1. Introduction

The traditional adaptive equalization technology needs to periodically send to the known training sequence at the receiver, which further improves the reliability of data transmission, but reduces the severely limited communication bandwidth, thus affecting the application efficiency of the channel. Blind equalization algorithm has the advantages of no training sequence, and can achieve higher equalization than traditional adaptive equalization technology under certain conditions. Therefore, it is of great significance to systematically study the theory and algorithm of blind equalization in aquatic communication. Nowadays, the development of social construction has entered the information age, communication as the overall development of the most rapid, is also one of the most harvest content of the industry, land and air communication field contains the two most active and active branches, that is, the Internet network and mobile communication network, while the development of maritime communication is more in the initial stage. With the coming of the ocean century, the ocean covering a large area of the earth has gradually become a new field and research hotspot of human activity space, and underwater communication technology has also been paid attention to by scholars of various countries. [1.2.3]From the perspective of traditional technology research, communication technologies in the land field are mainly electromagnetic waves, but such forms decay very fast in water and can travel a relatively small distance. At present, acoustic wave is the only information carrier that can carry out long-distance communication in seawater medium, and it is also the main content of current scientific research. Among them, aquatic communication is one of the effective means of underwater wireless long-distance communication.

In essence, underwater acoustic communication is the use of sound waves of mechanical vibration, using the way of wave transmission in the water. Compared with radio communication, there are many problems in high-speed data transmission over underwater acoustic channel. The reason for this phenomenon is that the frequency band of underwater acoustic channel is limited because the sound propagation loss in seawater changes with temperature, distance, frequency and other factors. At the same time, because the interface reflection and scattering of acoustic waves are often affected by a variety of random factors, the acoustic signals acquired in seawater will have multi-path effects and have time-varying properties. These adverse factors will cause serious intersymbol interference and lead to incorrect coding of received data when realizing underwater

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199
acoustic high-speed communication. Used in the traditional sense of the underwater acoustic channel, adaptive equalization technique balance in practice can effectively solve the problem of intersymbol interference, but require known symbol sequence continuously to filter the weight value of periodic training, thus reducing the efficiency of channel application, is not suitable for high-speed communication in the limited bandwidth of the underwater acoustic channel. Nowadays, research scholars put forward fanaticism in practice to explore the identification and blind equalization method, does not need to filter parameters cycle training, use only receive prior information to balance to the characteristics of sequence, make the output sequence, as close as possible to send to effectively compensate the non-ideal properties of channel, overcome the intersymbol interference, error control coding, Ensure the quality and efficiency of channel communication. Therefore, current researchers put forward the rational use of blind equalization technology in underwater acoustic communication system.[4.5]

The underwater acoustic wireless communication system first appeared in 1914. The development of the underwater acoustic telegraph system was applied to the cruiser by the British Navy. Since then, a large number of underwater information transmission and communication equipment have been paid attention to in the military field. However, due to the limitations of the technical conditions at that time, many researches have not been applied in practice. It was not until the 1970s that underwater acoustic communication entered a relatively rapid development stage. In the rapid development of underwater acoustic communication technology, other technologies also show the characteristics of increasing salary, which greatly promotes the innovation and exploration of underwater acoustic communication. Nowadays, the world's major universities and research institutions gradually strengthen the research of underwater acoustic communication technology, and achieved excellent results in the practice exploration, underwater is one of the most popular network, it is mainly consists of gas sensor, autonomous underwater route, to the surface of the sea of guild wars, etc, and control center to communicate ashore. Nowadays, the development direction of underwater acoustic communication between nodes is based on the network for remote control and video signal data exchange network of autonomous underwater sampling, whether fixed or mobile, will install underwater equipment, such as cameras, seismographs and hydrophone, remote users can take advantage of the wireless network and to realize data exchange with the center of the surface buoy network node, To get more underwater information.

Blind equalization technology is a new adaptive equalization technology which can realize the equalization channel characteristics and make the output sequence of equalizer as close as possible to the transmitted sequence according to the prior information of the received sequence without the help of the training sequence. Therefore, in the data communication system, the performance efficiency can be improved without sending sequence. At the same time, blind equalization technology also has stronger equalization performance, so it is the main content of data communication technology research at the present stage, and has important application value in geological exploration, control engineering, communication radar and other fields.[6.7]

2. Method

2.1 Underwater acoustic channel

The communication quality is directly related to the physical characteristics of the channel, so the study of underwater acoustic channel characteristics is an important link to understand underwater acoustic communication technology. As the only important medium for long-distance information transmission, underwater acoustic communication has a positive impact in the Marine environment. Multipath effect is the most serious interference in underwater acoustic channel. The reason for this phenomenon is that during the transmission of acoustic waves through aquatic channels, they encounter undesirable phenomena such as scattering and reflection of various undesired reflectors, and the relevant signal will interact with the direct signal at the receiving port. In underwater acoustic channel, when there is always more than one transmission path at both ends

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199
of the transmitter and receiver, multipath effect may occur in any case, which is a common phenomenon in long-distance communication. The formation of multipath is directly related to the Marine environment and symbol frequency. The mechanism of multipath formation can be divided into two conditions: on the one hand, in the shallow channel, it is caused by the reflection of the seabed, sea surface and target; On the other hand, in the deep channel, it is caused by the bending of sound lines with different emission angles during propagation. In a certain region, the phase of multiple acoustic lines is consistent, which can form a cluster region. The multipath effect of underwater acoustic channel will lead to serious inter-symbol interference phenomenon in underwater acoustic communication system after receiving short messages, which will lead to error coding and reduce the reliability of system operation. This phenomenon will not only affect the design quality of underwater acoustic communication system, but also limit the application performance of underwater acoustic communication system.

2.2 Channel Model

As a typical time-varying and space-varying channel, underwater acoustic channel has special transmission characteristics in practical applications. It is impossible to express the characteristics of ocean underwater acoustic channel with accurate mathematical models, but approximate models can be constructed. Among them, the most striking feature of mathematical communication systems is that there are only two definite states: 0 and 1. Only when the system can accurately judge the two states at the sampling point can the communication be ensured smoothly. Therefore, the digital communication system only focuses on the value range of the signal at the sampling point, and does not consider the signal value at the flying sampling point. It can be seen that the aquatic communication channel model can be built on a certain sampling interval, which is regarded as a discrete channel, so the discrete channel model is constructed.

2.3 Blind equalization technology

This technique refers to a method to balance the channel characteristics only according to the prior information of the received sequence without the help of the training sequence, and the output sequence should be as close as possible to the transmitted sequence. From the perspective of practical application, blind equalization technology can effectively compensate the non-ideal characteristics of the channel, control the coding error rate, and improve the communication quality. The technical principle of blind equalization is shown in Figure 1 below:

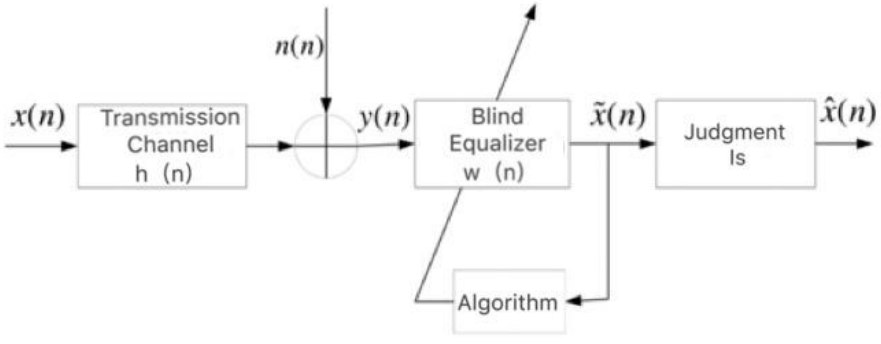

FIG. 1 Schematic of the blind equalization technique

At present, the blind equalization algorithm will choose finite-length tapped transverse filter as the specific structure is shown in Figure 2 below:

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199

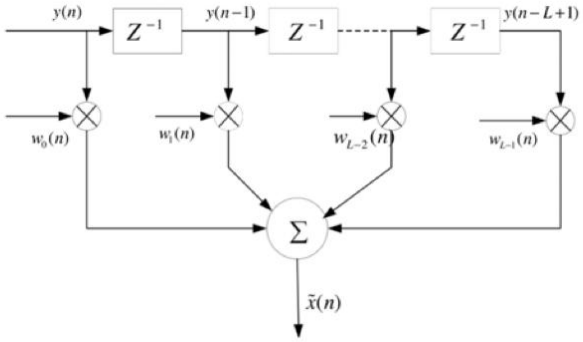

FIG. 2 Structure diagram of transverse filter

2.4 Basic algorithm

On the one hand, the least mean square algorithm (LMS). This algorithm is a very effective and simple gradient estimation method, which has been widely used in the early 1960s. The biggest advantage is that the number of calculations is small, the practical operation is convenient, and the off-line calculation is not needed. As long as the input signal and reference response are determined at each iteration of the adaptive linear combinator, this algorithm can be used for computational analysis. On the other hand, recursive least squares algorithm (RLS). The key of this algorithm is to replace the least mean square criterion of the least mean square algorithm by the minimization criterion of the time average of the two squares. In other words, the square of all the errors from the initial time to the current time should be averaged to ensure that it is minimized.[9.110]

The flow of the backpropagation algorithm in the blind equalization method of neural network algorithm studied in this paper is shown in Figure 3 below:

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199

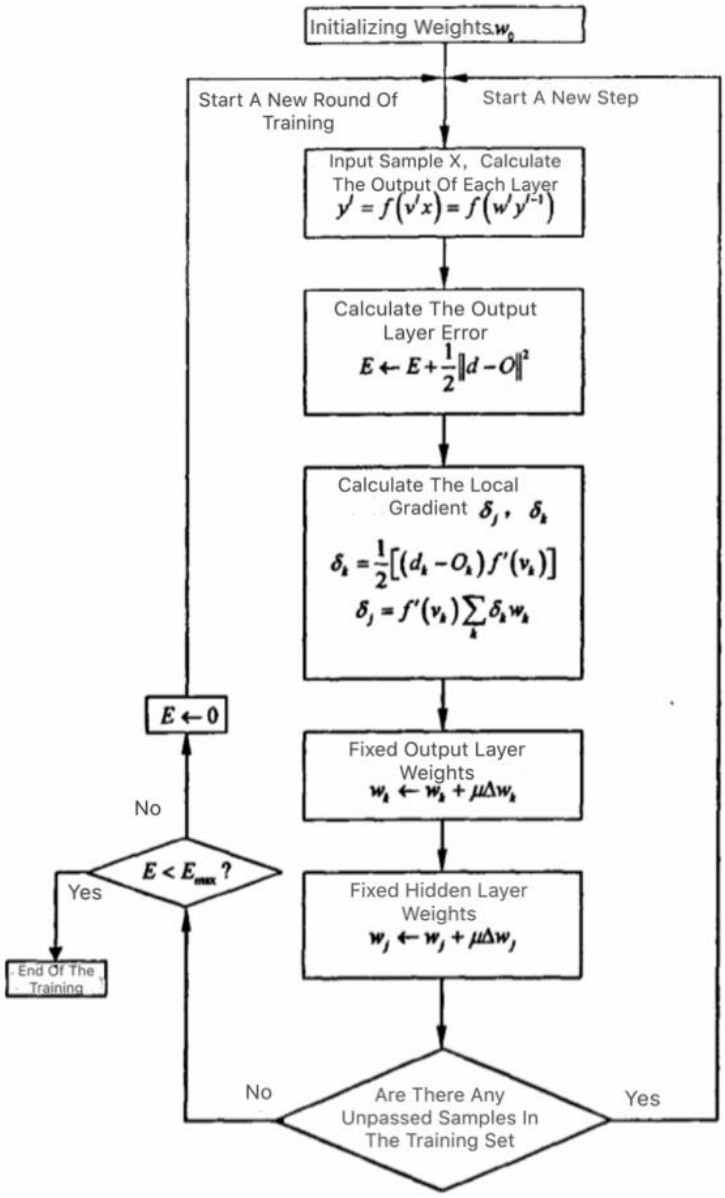

FIG. 3 Flowchart of the backpropagation algorithm

3. Result analysis

This paper starts from two aspects. On the one hand, in order to ensure the good convergence performance of the applied algorithm, the influence of the parameter variation on the composition of convergence performance of the constant modulus blind equalization algorithm based on the Rayleigh step variable step size is analyzed. First, the uniform noise generator in the software is used to generate 3000 random numbers, and then 4QAM modulation is carried out, and the generated 4QAM signal is passed through the channel. When the parameters are fixed, the convergence performance of different numerical algorithms also has different changes. The final experimental results show that when α is equal to 0.5 and β is equal to 0.08, the convergence performance of the proposed algorithm reaches the best, the practice convergence speed is fast, and the overall application accuracy is high.

On the other hand, the constant mode algorithm and the blind equalization method based on BP neural network algorithm are compared and analyzed, and the two modulation methods of 4QAM and 4PSK are used, and the central tap initialization is used to pass through the underwater acoustic

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199
channel respectively. Among them, the principle of constant modulus algorithm is shown in Figure 4 below, and the principle of blind equalization method of BP neural network algorithm is shown in Figure 5 below:

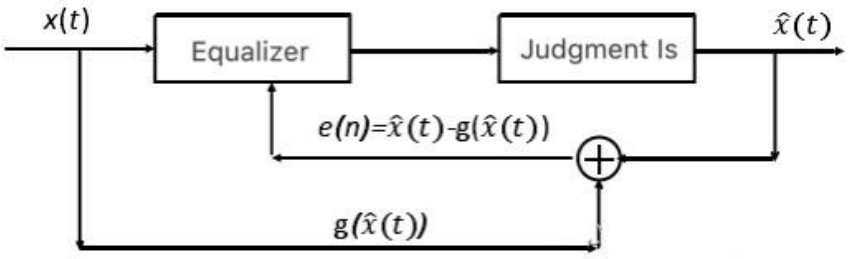

FIG. 4 Schematic diagram of constant modulus algorithm

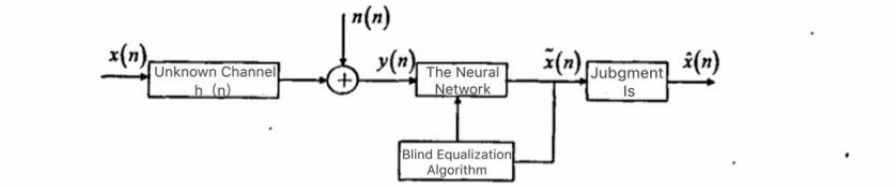

FIG. 5 Schematic diagram of BP neural network blind equalization method

The final experimental results show that, according to the contradiction between convergence speed and convergence accuracy of BP neural network blind equalization algorithm, the variable step size theory of adaptive equalization is applied to the neural network blind equalization algorithm. Under the same steady-state error, the improved algorithm has faster proficiency speed. Therefore, Chinese researchers have gradually strengthened the application of blind equalization algorithm in underwater acoustic communication.

4. Conclusion

To sum up, on the basis of understanding various concepts, according to the shortcomings of the traditional constant modulus algorithm in convergence speed and steady-state residual error, this paper proposes a constant modulus blind equalization algorithm with Rayleigh stepwise variable step size as the core, and focuses on the influence of the parameters in the algorithm on the convergence curve. The final experimental results show that the improved algorithm improves the application performance of the traditional algorithm and meets the application requirements of underwater acoustic communication technology in the new era.

Reference

[1] Yanan Zhao, Wenfeng Du, Yingqi Wang, et al. Research on Intelligent shape Finding of Tree Structures based on BP neural network algorithm [J]. Journal of Building Structures, 2022, 43(4):9.

[2] Di Gao, Bo Wen. Research on Document information Management based on BP Neural Network algorithm. Journal of Hebei North University: Natural Science Edition, 2021, 37(5):6.

[3] Lingyun Zhu, Yujuan Zhuang. Research on Traffic Prediction based on Neural Network Algorithm in SDN Environment [J]. Network Security Technology and Application, 2020(3):3.

[4] Hang Yin, Tian Tian, Shijun Feng, et al. Research on Modulation Pattern Recognition of underwater acoustic Communication based on BP Neural network [J]. Electroacoustic Technique, 2020, 44(9):6.

[5] Junjun Zhang. Research on the application of information fusion technology based on Convolutional neural network [J]. Information Recording Materials, 2022, 23(7):3.

[6] Qiuju Yang. Predictive control method based on CPSO-RBF Neural Network algorithm [J]. Journal of Guiyang University: Natural Science Edition, 2021, 16(3):5.

[7] Tong Xin, Liu Zhi, Siyuan Gao. Cma-lms equalization algorithm with Variable step size in space laser communication [J]. Optical Communication Technology, 2020, 44(7):4.

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.199
[8] Danyang Hong, Wei Wang, Chengyang Zhou, et al. Doppler Estimation and Compensation method of orthogonal frequency Division Multiplexing underwater acoustic Communication based on non-uniform Fast Fourier Transform [J]. Chinese Journal of Scientific Instrument, 2021, 42(4):8.

[9] Yongbin Li, Bin Wang, Gaoping Shao, et al. A denoising method for underwater acoustic communication Signals Based on RCGAN [J]. Acta Electronica Sinica, 2022, 50(1):9.

[10] Qian-li Liu, Jing Xie. Development status and trend of MIMO-OFDM underwater acoustic communication system [J]. Communications Technology, 2021, 54(5):10.