Intelligent Algorithm Based on OFDM Channel Estimation

Yuan Chuanlin, Xiao Jun

Dalian Neusoft University of Information, Liaoning Dalian, China

Keywords: OFDM; channel estimation; intelligent algorithm

Abstract: In the communication system, the error rate of signal transmission in the channel is high. The use of OFDM (Orthogonal Frequency Division Multiplexing) technology can reduce the bit error rate and improve the quality of signal transmission. Channel estimation algorithm, as a key technology in OFDM system, is particularly important. In this paper, three common channel estimation algorithms are analyzed, and the pilot channel estimation methods are emphatically studied. Their advantages and disadvantages are analyzed, and the future development prospects of this technology are prospected.

1. Introduction of OFDM

In the communication transmission system, the bandwidth of the channel can accommodate more than one signal. If a single channel is occupied by a single signal, the bandwidth will be wasted [1]. Therefore, in order to make full use of channel bandwidth, we usually use frequency division multiplexing technology to save bandwidth.

1.1 Principles of OFDM

The main principle of OFDM is to divide the broadband signal in a communication system into several parallel narrowband signals, that is, to divide a channel into several sub-channels. The frequency of each subchannel is f, and each subchannel is orthogonal. We can also understand that it decomposes a high-speed signal into multiple low-speed data streams, modulates each subchannel carrier, and then transmits the signal [2]. Finally, it separates these orthogonal signals by correlation demodulation technology at the receiving end, which reduces the interference between subchannels. In addition, in terms of signal bandwidth, the signal bandwidth transmitted by each subchannel is smaller than the correlation bandwidth of the channel, so each subchannel shows flatness attenuation and avoids inter-symbol interference [3]. Subchannel bandwidth only accounts for a small part of the original channel bandwidth, so it is easier to achieve channel equalization.

1.2 Composition of OFDM System

The block diagram of the OFDM system is shown in Figure 1. After the input signal is modulated, the serial signal is transformed into multiple parallel signals, and then the frequency domain signal is converted to city and signal through the change of IFFT Fourier norm. We add cyclic prefix to it, and the signal is sent to the channel for signal transmission through parallel-series conversion and D/A conversion. Then we use the demodulation processes of A/D conversion, parallel-series conversion, FFT, and equalization correction to transmit the orthogonal signals separately. This can reduce the inter-symbol interference, make the signal transmission more balanced, and improve the quality of signal transmission. Finally, we recover the transmitted signal by synchronization and coherent detection at the receiving end, so we can get the original transmitted information.

  DOI: 10.25236/iwmecs.2019.015

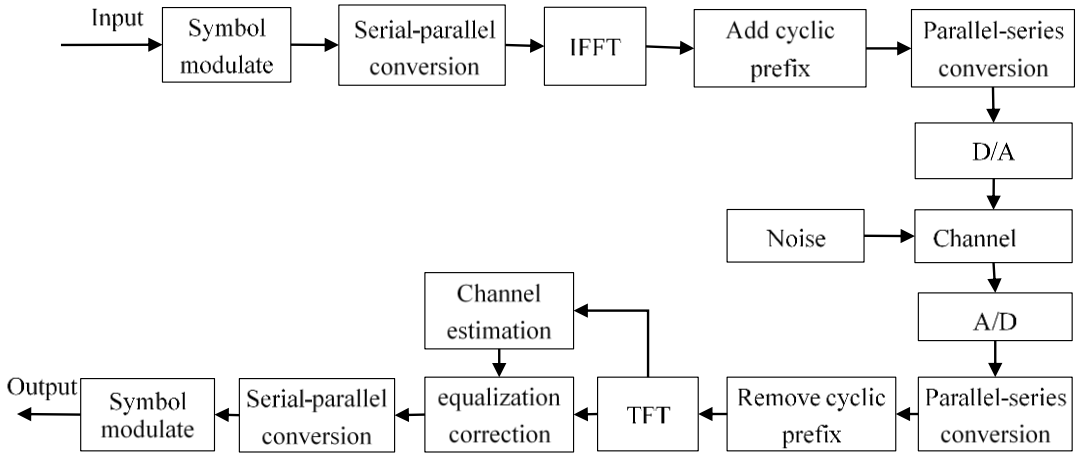

Figure 1. The block diagram of the OFDM system

2. Research on Channel Estimation Algorithms

There are three key technologies in OFDM system: equalization ratio technology, synchronization technology and channel estimation. Channel estimation algorithm is one of the three key technologies in OFDM system. There are three main types of channel estimation algorithms: pilot sequence estimation algorithm, training sequence-based estimation algorithm and blind estimation algorithm. Among the three kinds of channel estimation algorithms, pilot-based channel estimation algorithm is the simplest one in terms of complexity, and it is also the research basis of other algorithms [5]. The theoretical principle of channel estimation algorithm based on pilot is to insert pilot signal into the transmitted signal according to certain rules, and transmit pilot signal and original data signal in the channel at the same time. Pilot signal is extracted by correlation demodulation technology at the receiver. There are many orthogonal sub-carrier signals in OFDM system, and many sub-channel signals are superimposed to output. Therefore, it is necessary to compare the original pilot signal with the extracted pilot signal, and then get all the channel information again through the corresponding interpolation method, so as to realize the channel estimation.

The principle of blind channel estimation is to estimate the channel by using the characteristic that a part of the modulated signal is determined. Semi-blind channel estimation combines some characteristics of blind channel estimation method and pilot channel estimation method, and inserts fewer pilots [7]. Compared with the low bandwidth utilization of pilot channel estimation algorithm, blind channel estimation algorithm and semi-blind channel estimation algorithm have relatively high bandwidth utilization, but they also have their own shortcomings. They need to observe data for a long time, and there will be phase ambiguity, slow convergence speed, and error problems in the propagation process. At present, the most popular channel estimation method is the hidden training sequence channel estimation algorithm, which superimposes the training sequence symbols in the original data part symbols and transmits them through the channel together. Because the received signal symbols are not correlated with the training sequence signal symbols, the information of the transmission channel can be obtained by special algorithm. However, the correlation between the training sequence and the original transmission data has a great impact on the results, so the smaller the correlation between the training sequence and the original transmission data, the better the channel estimation effect.

3. Pilot Channel Estimation Method

Pilot channel estimation method inserts known pilot signals into the transmitted signals. Generally, the insertion methods are comb, block and plum blossom. The insertion domain can be divided into time-domain insertion, frequency-domain insertion and time-domain frequency-domain

insertion simultaneously. We transmit pilot signal and transmit signal simultaneously in the channel. At the receiving end, we can calculate a functional relationship by linking the received pilot data with the original known pilot data through a certain algorithm. This function is the reflection of the channel. The original channel data can be restored by some interpolation method, and the interpolation method should be selected according to the specific situation. But the interpolation method should satisfy the Nyquist sampling theorem, that is, the frequency of the sampled signal should be more than twice the maximum frequency of the transmitted signal, that is, the frequency of the inserted pilot signal should be at least twice the frequency of the transmitted signal. Only by satisfying the Nyquist sampling theorem can we restore the original transmission information without distortion at the receiving end. In time domain, the interval between the inserted pilot signals should be less than or equal to 1/2 FM, in which FM is the frequency of the transmitted signal. In terms of better tracking signals, the smaller the interval between the inserted pilot signals is, of course, the better. But the inserted pilot signals themselves waste the bandwidth of the channel bandwidth, which is equivalent to sacrificing a part of the bandwidth of the channel to achieve the purpose of channel estimation. . Too small spacing will result in more bandwidth waste, which is not worth the loss. Therefore, in order to reflect the channel information more comprehensively, the insertion positions of pilot signals can be divided into three categories: block, comb and plum blossom. Block position insertion is to insert pilot signals from the time domain, that is to say, periodically into the subcarriers of OFDM symbols. This channel estimation method covers a wide range of pilot frequencies, which is beneficial to sTable channel conditions. It has better frequency selectivity and no need for frequency domain interpolation. However, the disadvantage is that the sampling signal is discrete and the information loss between the two pilots occurs to a certain extent. This interpolation method is suiTable for the channel with slow attenuation and small change. Comb position insertion is to insert inverted signals on some fixed subcarriers and transmit data on other carriers. Contrary to block insertion, comb position insertion is continuous in time domain and has intervals in frequency domain. This interpolation method has a great influence on frequency, but it has an advantage over block interpolation in tracking channel changes. In order to make up for the shortcomings of the first two interpolation methods, the two methods are mixed, that is, the so-called plum-blossom position interpolation method, also known as mesh position interpolation. This method has better effect, but its calculation is complex and time-consuming. This method can be used when the real-time requirement is not too high.

4. Conclusion

With the development and maturity of OFDM technology, this technology has been widely used in signal transmission. Channel estimation is one of the key technologies in OFDM system. There are mainly blind channel estimation algorithm and pilot channel estimation algorithm. Pilot channel estimation algorithm is the easiest channel estimation algorithm. It plays a fundamental role in our research on other channel estimation algorithms. But it is not the best method in channel bandwidth utilization. Its channel bandwidth is slightly wasted and is not the optimal channel estimation method. With the in-depth study of channel estimation algorithm, in the future communication field, channel information transmission will become faster and more reliable.

References

[1] Li Lianghua. Research on high-speed satellite-to-ground data transmission system based on variable coding multi-carrier modulation technology [D]. Beijing: University of Chinese Academy of Sciences (National Center for Space Science, Chinese Academy of Sciences), 2018

[2] Zhang Jidong, Zheng Baoyu. Pilot-based channel estimation and its research progress [J], Journal of Communications, 2003, 24 (11).

[3] Cao Peng. Identification and parameter estimation of HF multi-carrier signal [D]. Zhengzhou: PLA Information Engineering University, 2010.

[4] Wang Jing. Research on Joint Time-Frequency Offset Synchronization Estimation Algorithms for OFDM Systems [D]. Jilin University, 2007

[5] Guo Jianying. Key Technologies and Applications of OFDM [J]. Shaanxi Electronic Technology, 2011, 4:15

[6] Zhang Weiwen, Li Hongliang, Zhao Ming, etc. OFDM synchronization method for multipath fading channels [J]. Communication and network 2017, 11 (9):55-59

[7] Research on Channel Estimation Algorithms and Polarization Multiplexing Technology for Wang Handong. DDO-OFDM System [D]. Shenyang: Northeast University, 2015

[8] Wang Wei. Instrumentation design and implementation of polarized light time domain reflectometer [D]. Nanjing University, 2018.

[9] Pilot-based channel estimation for Liu Junlei, Ye Fang, Zhu Qi. OFDM systems [J]. Journal of Chongqing University of Posts and Telecommunications, 2004, 16 (4): 17-20

[10] Shifeng, Hu Dengpeng, Wang Chen, et al. An adaptive OFDM symbol synchronization algorithm based on PN sequence weighted preamble [J]. Journal of Electronics and Information, 2011, 33 (5): 1166-1171

[11] Performance Analysis of Pilot-based Channel Estimation Algorithms in Ma Yufeng-OFDM System [J]. Sci-tech Perspective, 2012, (14): 171-173.

[12] Xiaodai Dong, Wu-Sheng Lu, Anthony C.K. Soong Senior Member. Linear Interpolation in Pilot Symbol Assisted Channel Estimation for OFDM [J].

[13] Liu Qiaoping, Li Yanping. Orthogonal Frequency Division Multiplexing Technology and Its Application in 4G Mobile Communications [J]. Computer Technology and Development, 2014, 9:110

[14] Zhao Li. Research on Dynamic Resource Allocation Algorithms for OFDM System [D]. Jinan: Shandong University, 2012