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A Class of New Channel Estimation Approach Based on RBF Neural Network Technique

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Abstract. A new channel estimation method of neural network based on complex radial basis function (CRBF) is proposed to enhance the anti-interference ability of traditional pilot frequency estimation algorithm in power line communication (PLC). This method builds up a new channel model of complex field signals in PLC. The complete response model was established by using transmitting terminal's pilot signal as input sample data, pilot signal's frequency response as output sample data, and pre-setting mean square error (MSE) and diffusion constant.

Keywords: power line communication, orthogonal frequency division multiplexing, channel estimation, complex radical basis function algorithm.

1 Introduction

Power line communication is a new developing science and technology in recent years; It uses the existing power line as a communication medium for data transmission. It makes full use of the electric facilities, takes full advantages of power resources, and makes electric power communication industry develop a lot. PLC has quick construction speed and less investment characteristics. While the distribution network is not designed specifically for communication, it is not an ideal transmission medium. Besides the transmission channel attenuation, and due to the presence of multipath reflection signals would be selective attenuation and intersymbol interference, channel characteristic performance as a time-varying frequency selective attenuation channel[1-2]. Orthogonal frequency division multiplexing (OFDM) technology can be a strong resistance to multipath, achieving to a high transmission data speed and effectively dealing with the poor channel environment in the low-voltage power[3-5]. However the data still under the influence of channel fading, reasonable compensation should be made at the receiving end[6-7]. At the receiving end to makes the signal equilibrium it needs to be aware of the frequency domain of the channel frequency transmission characteristics. Accurate estimate of the channel model becomes the key technology of the whole system performance.

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As now, the estimation based on pilot channel used rather widely as mentioned in the literature. Firstly, calculating the frequency response in the pilot position power line channel and through interpolation and smoothing algorithms determines all the channel response. However, this method calculated through interpolation has a high bit error rate problem.

Radial basis function (RBF) neural network is a new kind of three-layer feedforward neural network, it can realize the non-linear relationship mapping, in theory it can approximate arbitrary function. As now, The applications of RFB network in real number domain is a lot, but literatures about applying RBF network in complex domain is still very limited.

In this paper a neural network algorithm based on the complex radial basis function (CRBF) is proposed to solve the problem of power line communication channel estimation.

CRBF neural network algorithm was conducted on the basis of the RBF neural network algorithm dimension transformation. The input and output of neural network turn into plural form. The benefits of such changes mathematical expression is output data contained in a group with plural weighted linear combination of the data. And ordinary real radial basis function (RBF) neural network algorithm's input and output data could be seen as special cases of complex radial basis function neural network algorithm, namely for the weight of the input and output values are real numbers. Because a hidden node response can be seen as a form of the generalized potential function, it will show in the application channel balance a hidden node actually realized the conditional probability density function for a given channel status. As a result, the RBF evolved into CRBF neural network algorithm gives better solution to the hidden nodes of neural network response, handling of the channel estimation is more accurate.

2 OFDM system model

With the development of science and technology, the orthogonal frequency division multiplexing technology is put forward to meet people's raising requirement for the quality of mobile communication. In the 1970s, the basic theory of OFDM technology was consolidated by S.B.W Einstein who proposed a new multicarrier modulation method using Fourier transform technique. And then L.J.Cimini solved the problem of the orthogonal frequency division multiplexing(OFDM) technology applied in wireless communication, which made OFDM get rapid development in the field of information and communication. This technique mainly uses the multi-carrier modulation technology, first, the data bits to be transmitted is decomposed into several low rate of child data bits, then, these decomposed data bits are transmitted in parallel on orthogonal subcarrier channel. The technology has been widely used in ADSL, WLAN, and other wireless communication system; it not only has reduced the mutual interference between the carrier channels, but also has greatly improved the spectrum efficiency. In addition, OFDM is easy to be combined with technologies of space-time coding, spatial diversity, suppress interference and smart antenna to improve the reliability of information transmission.

Based on the OFDM pilot frequency the channel estimation process is shown as Figure 1, after mapping and desterilizing bit stream to k parallel bit streams, we can get x(n) through IFFT by inserting pilot frequency signal. The process of using the IFFT implementation of OFDM can be described as follow,

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) exp(j2\pi nk/N) \quad . \tag{1}$$

Where X(k) is the modulated plural data; k=0,1,…,N-1, k is the subcarrier serial number, N is the subcarrier number; n=0,1,…,N-1.

At the receiving end, the kth subcarrier's output is

$$Y(k) = X(k)H(k) + W(k) \quad . \tag{2}$$

Where X(k) represents sending end and W(k) represents receiving end of the *k*th subcarrier modulating signal. It is the *k*th subcarrier's channel transfer function in form of Gaussian white noise's frequency domain.

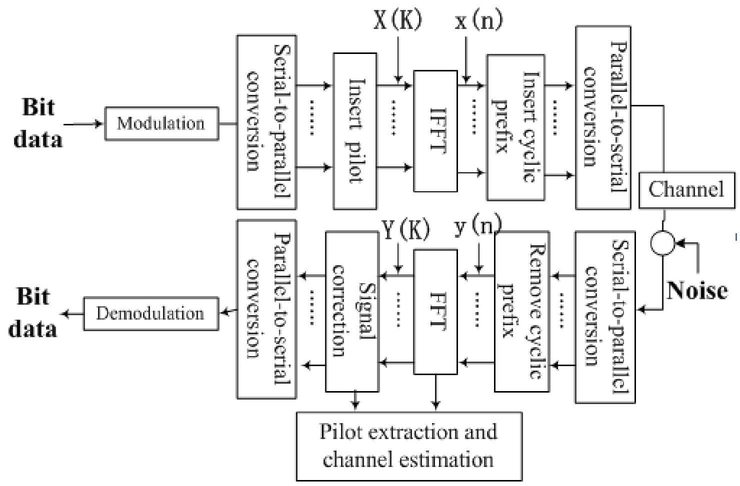

Fig. 1. Transmission diagram of Pilot method of OFDM system

QPSK modulation is photograph Shift Keying (Quadrature Phase Shift Keying), it is one of the four Phase Keying. QPSK uses the four different phase of the carrier to represent the digital information. Because each kind of carrier phase represents two bits of information, so each quaternary element is also known as dual bit symbol. Expressed a and b as the two bit of information, the relationship between them and phase θ_k usually arranged according to gray code, their relations are shown in table 1, the vector diagram as shown in figure 4. For data I_k、Q_k after processing by the way A, the output form of waveform amplitude has three values:-1,+1,0. For data I_k、Q_k

after processing by the way B, the output form of waveform amplitude has two values:-0.707,+0.707.

Table 1. QPSK modulation way of working

dual bit symbol		θ_k	
a	b	WAY A	WAY B
0	0	0°	225°
1	0	90°	315°
1	1	180°	45°
0	1	270°	135°

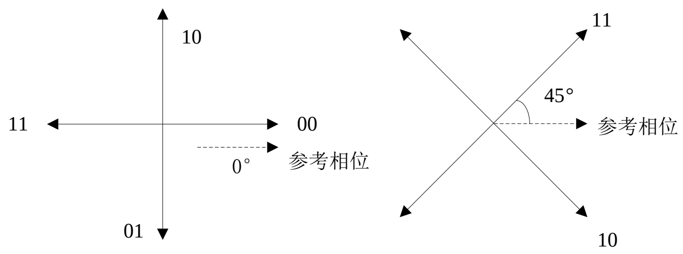

Fig. 2. QPSK modulation vector diagram.

3 Traditional pilot frequency estimation algorithm

As to traditional pilot frequency estimation algorithm, it needs the estimated value of pilot channel points, the receiving symbols is:

$$Y_n = X_n H_n + W_n \quad (3)$$

Where X_n is $n \times n$ order diagonal matrix of sending pilot signal, Yn is the receiver signal, Hn is the channel response needs to be estimated, W_n is $n \times 1$ vector quantity as a gaussian white noise, n is the number of pilot. Set channel estimation at pilot frequency point as $\hat{H}_{LS}$. Then under the least square principle the objective function is

$$J = (Y_n - X_n \hat{H}_{LS})^H (Y_n - X_n \hat{H}_{LS}) \quad (4)$$

Equation to J's minimum

$$\frac{\partial J}{\partial \hat{H}_{LS}} = 0 \quad (5)$$

Then solve the channel estimation $\hat{H}_{LS}$ of the pilot frequency point. After using the least squares method to obtain the channel estimation at the beginning of the pilot symbols, using linear interpolation algorithm to get the whole channel response, in the *k*th subcarrier it is:

$$\hat{H}(k) = \hat{H}(mL+1) = \hat{H}_{LS}(mL) + \frac{1}{L}\{\hat{H}_{LS}(m+1)L - \hat{H}_{LS}(mL)\} \quad . \tag{6}$$

Where mL<k<(m+1)L, 0<l<L, L is pilot symbol's interval, m is the relative location of the pilot frequency.

4 Conclusion

In this paper, a complex radial basis function neural network algorithm has been proposed to solve the problem of channel estimation in power line communication.

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