Research on Communication Signal Processing and Parallel Decoding Algorithm Based on Neural Network

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Abstract
As a key multi-antenna access technology in the future mobile communication network, the distributed wireless mobile communication system is widely recognized for its wide coverage, high system capacity and high system power efficiency. Under this era condition, this paper proposes the novel communication signal processing and parallel decoding algorithm based on neural network. We pointed out that when training solution classification and approximation of function question forward feed neural network but uses the precision which the PSO algorithm training network achieved and exudes ability to have to surpass based on the gradient study algorithm and the genetic algorithm from the core experimental result looked the algorithm training the network also exists excessively fits the question is on the test collection mean error is bigger than on the training regulations mean error. And also, PDS correspondence system uses the latency in the receiving end to estimate carries on the decoding, however when actual correspondence, the receiving and dispatching node movement and the channel stochastic time-variable and change spatially as will cause the signal to compress or the expansion, serious when will be able to cause the pattern element to have the dislocation. The proposed model’s robustness and general performance are verified through the experimental simulation.

Key words: Neural Network, Communication Signal, Parallel Decoding, Algorithm Design

1. INTRODUCTION

Along with the modern communication technology development, the software correspondence thought tends to maturely (Moeskops, 2016). With the DSP chip or the general CPU chip the hardware platform which corresponds as unit coding but as far as possible many realizes the correspondence function with the basic software that is the Communications Today domain widespread use method(Wang, 2014; Akansu, 2016). Along with the DSP chip performance-to-price ratio enhancement, it in the correspondence, the automatic control, the instrument measuring appliance and so on many domain applications more and more is also widespread. However, the general broadband signal has the characteristics of reverberation background correlation and the large amount of information carried by the target echo. These features are more favorable for the parameter estimation, the target feature extraction and the target detection (Anghel, 2016; Chandrasekhar, 2016). Therefore, in the broadband signal processing theory, the research of array high resolution algorithm is deepened, and the processing of wideband array signal is much more complicated in theory and model than the processing of narrowband signal (Proklov, 2016; Sheng, 2016; Thomas, 2016). Therefore, how can the broadband array signal carry information is more reasonable, fully utilized, and can reduce the amount of the computing in the process and other issues will be broadband signal processing to study the very important issues.

Figure 1 The Modern Communication Systems
As shown in the figure one, the modern communication systems are demonstrated, although the UWB technology applies generally in the short distance correspondence, the certain applications to the correspondence speed very high request and actually have not requested to have the farther signal distance (Hsieh, 2016; Ibrahim, 2016). The extremely low power spectral density enables the UWB system to be possible in to satisfy certain protection distance under the condition and uses the same frequency band other wireless communications system coexistence, also causes the examination, the intercept communications and disturbs the UWB signal the order of complexity to be high, and these characteristics cause the UWB technology at aspects and so on security and the reliability have the special superiority (Dil, 2016; Heath, 2016). This paper first analyzes the limitations of one-dimensional communication signal processing, and then gives the concept of space-time signal processing features and the main technical content (Kenow, 2016; Le, 2016; Scholl, 2016)). On this basis, the space-time transmission pre-processing technology is discussed focusing on space-time pre-space transmission. Pre-coding and the pre-equalization and some other key technologies and their applications were systematically summarized and elaborated. As the essential part of the proposed paradigm, the neural network is analysed with the novel training methodology and countermeasure.

2. THEORORETICAL DESIGN AND ANALYSIS

2.1 The BP Neural Network

From the development trend of BP network, the hotspot of its research lies in the problems of BP itself, such as the problem of determining the number of hidden nodes and the slow convergence rate, and put forward many improved methods, such as genetic algorithm, simulated annealing algorithm and so on. In decided when uses the BP network solution actual problem, first considers is the neural network modelling question, like the input level node has several, the output level node has several and so on, once after these questions determined, the corresponding network knot pulled out fixedly has also gotten down, namely this time network was a static state, only could apply in one kind of specific application, if had to make other applications needed to consider carried on the modelling to the network structure, operated extremely complex, moreover the network parameter hypothesis extremely was also difficult. Dynamically create a network model, is to dynamically generate the network layer and the layers of the neuron nodes, that is, the input layer of neurons can be selected at the time of the creation, the output layer nodes can also be given at the time of creation, input layer and after determining the number of nodes in the output layer as the number of hidden layer nodes can be determined according to the relevant algorithm. After the three layers of neurons are determined, the whole network can be generated. In the following formulas, we define the essential objectives in the BP neural network.

\[
(x) = \text{arg max}_y \Pr(x \mid y = k)
\]

\[
\sum_i w_i = 1, \quad 0 \leq w_i \leq 1
\]

Where the \(\text{arg max}_y \Pr(x \mid y = k)\) can be treated as the optimization function and the \(0 \leq w_i \leq 1\) represents the range to be considered. A neural network each input node correspondence sample characteristic, but outputs the level nodal point number to be equal to the category number, an output node corresponds one kind. In training stage, if the input training sample category marking is i then trains the time the i-th node expected the output supposes is 1, but other output node is 0. in the recognition stage, when an unknown category sample affects to the input end, inspects each output node the output, and determines this sample category as and the value of exports biggest that node correspondence category and this is carries on the pattern recognition with the neural network the most essential way shown as the figure two.

![Image](image.png)

Figure 2 The Systematic Organization of the Neural Network Model
It is based on error back propagation of BP neural network and the connection weight of learning multilayer forward neural network, as it has a strong ability of nonlinear generalization and map. Normally, the BP neural network by some more than one input layer, hidden layer and one output layer each layer by passing information connection between the power connections and from the systematic level, we then define the model from the following perspectives and aspects.

- The established network for two layers BP neural network, BP neural network of transfer function as nonlinear function that is suitable for nonlinear classification problem. Transfer function model output layer adopts S Logistics, output value of the individual neurons is limited to 0 and 1 can be convenient to use binary code to distinguish the various modal 0.
- The network learning algorithm for the steepest decline in BP algorithm. K is the number of iterations, alpha as the learning speed calculation of actual when the default value of 0.01, weights of each layer and the correction of value between each type 3.
- In order to make the training samples sufficiently sufficient and to ensure that the target modality is within the output range of the ANSYS software, the training sample set selects the 24 resonant modal parameters starting at 80 kHz as the training samples and also the displacement distribution with a core basic 1800 phase difference The situation should also be taken into account.

Under this basis, the formulation procedure is shown as the follows. Where the demonstrated SSE is the basis information and the $\lambda w_i G(x - x_i, 2\sigma^2)$ is the objective function.

$$J = SSE + \lambda \sum_i |w_i|$$

$$g(x) = \text{sgn}\left( \sum_{i \in \text{SupportVectors}} \lambda w_i G(x - x_i, 2\sigma^2) - b \right)$$

Established by the neural network structure as shown in figure 3, the algorithms based on the error back propagation neural network for the two layers of multilayer forward neural network, it is composed of input layer, hidden layer and output layer, and cut off the connection between the power, input layer neurons has 25, the middle layer neurons with 66, there are four output layer neurons. Goal setting training error is 0.008, the maximum number of training for 2000 times.

**Figure 3** The Established Node for Transmission

### 2.2 The Novel Neural Network Training Standard

At present the main question which exists in the neural network application and the core research is how enhances the network to exude ability and the training speed question effectively for enable the network to have enough exudes ability request network outlet error in during the neighboring sample point change enough to be small therefore the network training basic request is the network outlet error undulating quantity enough is small as the follows.

$$d = \min \left( \sum_{i=1}^{n} (x_i - \theta_i)^2 \right)$$

**Figure 4**

BP algorithm is the most common neural network training algorithm. However, it is proved that the BP algorithm based on gradient descent depends on the selection of initial weights, and the convergence rate is slow and easy to fall into local optimum. The above-mentioned defects of BP are especially local optimization, the output of the trained neural network is inconsistent and unpredictable, resulting in reduced reliability of pattern classification and the issue can be reflected from the figure 4.
Compared with BP algorithm, genetic algorithm training the neural network to improve the classification accuracy at the same time can accelerate the convergence speed of the training. However, genetic algorithm complex genetic operations such as selection, reproduction, crossover and mutation make the training time of the neural network on the scale of the problem and complexity exponentially. Moreover, due to lack of effective mechanism of local search, convergence when close to the optimal solution slow and even appear convergence stagnation phenomenon. For this, we should consider using the formula 6–7.

\[
\begin{align*}
    f_{ij}(\mu_i, \sigma_j) &= e^{-\frac{||x_i - \mu_i||^2}{2\sigma_i^2}} \\
    f(\mu, \sigma) &= e^{-\frac{1}{2\sigma^2}}
\end{align*}
\]

Because the BP network modeling theory and practical application more inconsistent problems between modeling, in order to ensure the effectiveness of the model, the reliability and the rationality, we must follow certain principles as the follows.

- With the increase of hidden layer nodes, the training sample error is always decreasing. While the test sample error in the reduced to a certain extent, and there will be an increasing trend, that is, "over the fitting" phenomenon.
- The number of training sample is the network connection weights more than 5~10 times and cannot test sample, the model usually have good generalization ability.
- Hidden layer and input layer node number must be at least less than the training sample and generally requires less than network connection weights for training sample.

When training solution classification and approximation of function question forward feed neural network but uses the precision which the PSO algorithm training network achieved and exudes ability to have to surpass based on the gradient study algorithm and the genetic algorithm from the core experimental result looked the algorithm training the network also exists excessively fits the question is on the test collection mean error is bigger than on the training regulations mean error. The general training algorithm only trained the connection weights under the fully connected network structure, but the redundant connection of the neural network will reduce the efficiency of the information processing of the basic neurons, and the large number of redundant connections will even affect the correctness of the pattern classification. Neural network weights simultaneously train its connection structure delete the redundant connection, so that the neural network to obtain a matching problem with the information processing capabilities reflected from the formula 8.

\[
\eta(t) = \eta(0) e^{-\frac{t}{2}}
\]

We must point out that, the narrow sense neural network training only trains under the entire connection structure the connection weight but the neural network needs basic information-handling capacity determined according to the pattern classification question scale and the order of complexity that, the information-handling capacity insufficiency or surplus can affect its classified performance. The generalized neural network training should include to connecting the structure the optimization namely optimizes its connection structure during training weight deletes the redundancy connection based on the listed procedures.

- Collect as much as possible and typicality good sample data, and the collected data were randomly divided into the training sample, test sample (10%) and the test sample (20%) three parts. The training
sample is used to adjust the network connection weights according to the algorithm, test samples used to real-time monitor the training process, the test samples used for evaluation model of generalization.

- The network initial weight had decided directly training algorithm is restraints to the overall situation minimum point partial minimum point. Therefore, when training must be very many to the identical network architecture the stochastic change network initial connection weight.
- Determine the number of hidden layer nodes and its basic principle is: under the premise of meeting the accuracy requirement as compact structure, namely take as little as possible of the hidden layer and hidden layer nodes. So far, determine the number of hidden layer and hidden layer node number is not general calculation formula, but in establishing BP model, determine the number of hidden layer nodes and its principle is less efficient.
- Most of the above formula only considers the number of input and output nodes, without considering the number and quality of training samples, the complexity of the actual modeling problem, the type of conversion function, etc., so in most cases are invalid only as trial and error method rough initial value.

![Figure 5 The Enhanced Neural Network Training Flowchart](image)

### 2.3 Parallel Communication Systems

The parallel combination wide frequency correspondence is one kind has the high correspondence efficiency wide frequency mailing address, may satisfy the communications system to transmit the valid request well, in the solution communications system the correspondence time short with the transmission information content tenth of between mutually contradictory, and inherited the traditional wide frequency communications system anti-jamming, anti-has solved and so on the merits.
Ultra-wideband modulation technology is not the carrier wave, but with a very low duty cycle pulse as an information carrier radio technology. PPM modulation has the advantage of the orthogonality of the signal is easy to be guaranteed, and it is suitable for general multiple modulation. The technique is used to modulate the communication system. MBOK modulation technology is the use of pulse polarity modulation technology, the use of multiple pulses composed of orthogonal pulse to transmit information and it is a quadrature modulation, similar to the traditional time-frequency modulation can reach the limit modulation technology as follows.

\[ x = IFFT \left( \sum_{i=1}^{M} b_{i} X_{i} \right) = \sum_{i=1}^{M} b_{i} IFFT \{ X_{i} \} \]  

(9)

Based on parallel combination element mapping sequence characteristics analysis of some spread spectrum communication system, more suitable for multi-band modulation is adopted in the system of MPPM and MBOK modulation technology. Here mainly introduce MPPM modulation technology based on the parallel combination effect the performance of spread spectrum ultra-wideband communications system as follows.

Because the ultra-wide band characteristic may carry on the transmission directly to the pulse signal, while through the white Gaussian noise channel, in the receiving end supposition synchronous foundation and in the receiving end application correlation demodulation, the signal which docking receives carries on the maximum value distinction to determine the different information achieves the return to original state information the goal.

The steps can be summarized as the follows.

- Serial interface is designed for the customized communication control chip interface, it can support different frame format of the data and voice commands, and can also support the TDM bus is widely used in communications equipment.
- Provides the three lines, the interface can be connected to an optional serial, chip, and can be read from the subsystem when the subsystem is then identified as manufacturer ID and the expansion card type configuration information.
- Analysis of the parts can be seen that is a cheap, already can satisfy the need and function, bus interface chip using its eight parallel interface can realize low cost and high speed parallel bus as the basic communication function.
2.4 The Novel Parallel Decoding Algorithm

Usually in the transmission of each frame of data, we must first send a synchronization code to determine the decoding window of the time base, and then between the synchronization code and information code to have a time slot, usually greater than the multi-way expansion time. Set the synchronization code and the width of the slot is a fixed value. Once the receiver detects the synchronization code correlation peak, it can be decoded by measuring the delay difference between each pattern correlation peak and the synchronization code correlation peak. Due to different design criteria can be derived from different precoding matrix. Based on the analysis of the advantages and disadvantages of the above methods, the paper presents two schemes for the joint precoding based on distributed network and CoMP and the basic idea of the scheme is to choose collaboration set form collaborative RAU distributed antenna system, a central base station according to the general uplink feedback information to estimate the downlink transmission can be used for a variety of state and dynamically choose their own RAU, namely: according to the pilot information to estimate the channel parameters, according to the signal strength threshold selection for RAU transmission to be together. Each of the RAU is transmitted by their respective pre encoded data, the receiving end of the received signals to deal with the merger, in order to achieve the maximum gain, as far as possible to reduce the error, improve the quality of the reception.

The introduction grid coded modulation thought, will modulate and the code unifies is designing together, will increase between the coded identification the youngest Euclidean space will be away from. Like this uses a relatively simple code to be possible to obtain the big code gain, makes up loss which the signal collection expansion creates. In the figure 10, we show the signal before the coding.
Figure 10 The Signal before Coding Operation

When it like, uses 3 bit the quantification the pattern latency difference coded modulation, in does not expand the band width under the premise, reduces each bit signal-to-noise ratio using the code. If selects a code rate the code causes the signal collection points from 8 to increase 16 inevitably.

\[ N_{DB} = \sum_{k=0}^{K_{FB}-1} N_{FB,k} \]  
(10)

\[ N_{PL} = N_{DB} - N_{DB,CRC} - I_{MFB} \cdot K_{FB} \cdot N_{FB,CRC} \]  
(11)

\[ N_{CTC,k} = N_{RE,k} \cdot N_{SM} \cdot N_{mod} \]  
(12)

\[ N_{shift,i} = i \cdot N_{mod}; \]

\[ index_{k,j,i} = (N_{CTC,k} - N_{shift,i} + j) \mod N_{CTC,k}; \]

\[ u_{k,j,i} = (P_{k,j} + index_{k,j,i}) \mod N_{FB,Buffer,k}; \]

Shown as the formula 10~13, we demonstrate the coding procedures. The PDS correspondence system uses the latency in the receiving end to estimate carries on the decoding, however when actual correspondence, the receiving and dispatching node movement and the channel stochastic time-variable, change spatially as will cause the signal to compress or the expansion, serious when will be able to cause the pattern element to have the dislocation, it will open when the window according to the conventional copy correlation decoding method will look does not permit corresponding element will cause when the following decoding error code sharp growth.

- Conventional decoding, synchronous code given decoding the time base of the window and determine the best way to moment, use copy correlator receiver, in turn, work out later, the signal correlation peak time, so as to complete the decoding computation delay difference.

- Decoding at each frame received signal synchronization code is used to determine the base at the time of the window, thus correcting code segmented, but in communication due to the channel change and the origins of relative movement will cause the receiving synchronization code signal produce certain compression or extension. This compression or extension dislocation in the original position signal, when using the dislocation of receiving synchronous code base to estimate, it will cause the time base location biased estimate, when correcting code extraction, will not be able to get the complete right of correcting code signal, reset in coherent decoding useful information on the energy will be lost while resulting in a decline in the main related peak increases and vice.

- Since the transmitted correction code is known and does not carry the encoded information, in order to improve the accuracy of the basic time base estimation, when the signal misalignment does not exceed the deviation range that the system can withstand with range.
3. EXPERIMENT AND VERIFICATION

Application of simulation software for various precoding method mentioned above and joint transmission precoding scheme on the simulation analysis of performance parameters of the SNR and ber curve is used to describe. As reflected from the experimental result, dynamic adaptive decoding compared with the conventional copy-related decoding, and it is possible to dynamically correct the symbol offset in real time and dynamically search each pattern symbol carrying information to maximize the useful information to the copy correlator the influence of the fluctuation of the channel and the distance of the transmitting and receiving node on the signal. In the following figures we show the detailed experimental results.
4. CONCLUSIONS

In this manuscript, we propose the novel communication signal processing and parallel decoding algorithm based on neural network. The multi-point cooperative transmission technology is modeled on the distributed wireless communication system, and the advantages and disadvantages of various precoding are analyzed. The performance evaluation of the bit error rate performance of the edge users is analyzed as pre-coding, each RAU cooperative transmission and the receiving end of the merger strategy. Reflected from the experimental result, the proposed method obtains the satisfactory performance.

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