Simulation of Rayleigh channel and improve of channel estimation using Artificial Neural Network

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Abstract: A statistical characteristic of wireless channels is partially covered by the Rayleigh distribution. It best represents the condition where there are secondary reflections due to high rise structures are always threatening to degrade communication quality. An ANN can be used to provide an estimate of the channel to minimize some of the deficiencies of multi-user transmission under Rayleigh multipath fading. The ANN can be trained to tackle such fading and associated disturbance, channel estimation task is critical for coherent detection and demodulation, in this paper we will present simulation of Rayleigh channel fading by using Neural Network techniques as standard Back propagation (BP).
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1. Introduction

The radio channels in any Transmitter digital communication systems are usually multipath fading channels, which are causing inter symbol interference (ISI) in the received signal. To remove ISI from the signal, many kind of equalizers can be used. Detection algorithms based on trellis search offer a good receiver performance, but still often not too much computation. Therefore, these algorithms are currently quite popular. However, these detectors require knowledge on the channel impulse response (CIR), which can be provided by a separate channel estimator. Usually the channel estimation is based on the known sequence of bits, which is unique for a certain transmitter and which is repeated in every transmission burst. Thus, the channel estimator is able to estimate CIR for each burst separately by exploiting the known transmitted bits and the corresponding received samples.

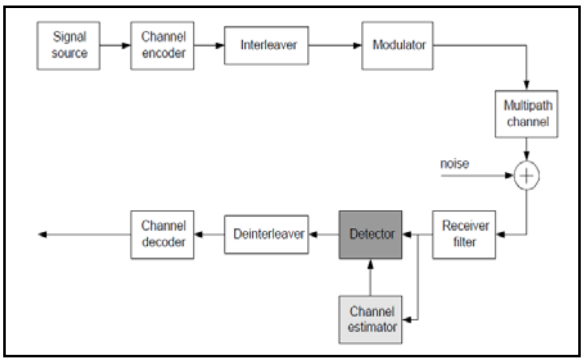

Figure [1]: layout block diagram for TDMA

Figure 1 shows a generic simulation layout for a TDMA based mobile system, which exploits channel estimation and signal detection operations in equalization [1]. The digital source is usually protected by channel coding and interleaved against fading phenomenon, after which the binary signal is modulated and transmitted over multipath fading channel. Additive noise is added and the sum signal is received. Due to the multipath channel there is some inters symbol interference (ISI) in the received signal. Therefore a signal detector needs to know channel impulse response (CIR) characteristics to ensure successful equalization (removal of ISI). Note that equalization without separate channel estimation. After detection the signal is deinterleaved and channel decoded to extract the original message.

Signal fading refers to the rapid change in received signal strength over a small travel distance or time interval. This occurs because in a multipath propagation environment, the signal received by the mobile at any point in space may consist of a large number of plane waves having randomly distributed amplitudes, phases, delays and angles of arrival. These multipath components combine vectorily at the receiver antenna. They may combine constructively or destructively at different points in space, causing the signal strength to vary with location. If the objects in a radio channel are stationary, and channel variations are considered to be only due to the motion of the mobile, then signal fading is a purely spatial phenomenon. A receiver moving at high speed may traverse through several fades in a short period of time. If the mobile moves at low speed, or is stationary, then the receiver may experience a deep fade for an extended period of time. Reliable communication can then be very difficult because of the very low signal-to-noise ratio (SNR) at points of deep fades.

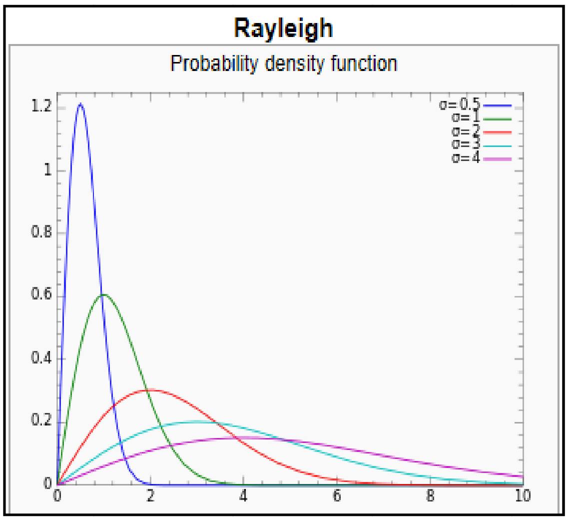

Fig [2]: Rayleigh probability density function (pdf)

The Rayleigh distribution Figure 2 provides a good fit to the signal amplitude measurement in environments where no line-of-sight or dominant path exists. The probability density function of the Rayleigh distribution is given by

$$p(r) = \begin{cases} \frac{r}{\sigma^2} exp\frac{r^2}{2\sigma^2} & r \geq 0 \\ 0 & otherwise \end{cases} \qquad (1)$$

Where σ^2 is the parameter of the distribution.A plot of the Rayleigh probability density function is shown in below Figure The Rayleigh distribution is related to the zero-mean Gaussian distribution in the following manner. Let $X1$ and XQ be two independent, identically distributed, zero-mean Gaussian random variables with variance σ^2.The marginal probability density functions of $X1$ and XQ are given by

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(\frac{-x^2}{2\sigma^2}\right), -\infty < x < \infty \qquad (2)$$

Then the random variable$R$, define as :

$$R = \sqrt{X1^{\,2} + XQ^{\,2}} \qquad (3)$$

It is distributed according to the Rayleigh probability density function [1] given in Equation (1). The fact that the Rayleigh distribution provides a good fit to the measured signal amplitudes in a non-line-of-sight environment can be explained as follows. When a signal is transmitted through a multipath propagation channel, the in-phase and quadrature-phase components of the received signal are sums of many random variables. Because there is no line-of-sight or dominant path, these random variables are approximately zero-mean. Therefore, by the central limit theorem, the in-phase and quadrature-phases components can be modeled approximately as zero mean Gaussian random processes. The amplitude, then, is approximately Rayleigh distributed.

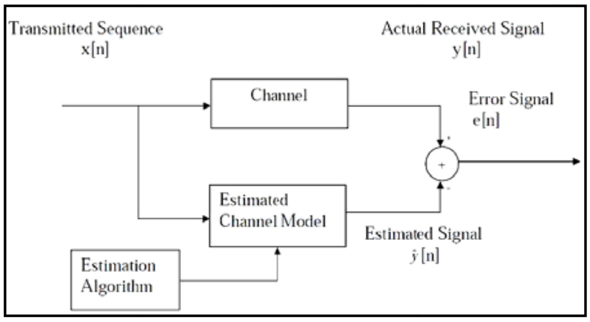

Figure [2]: block diagram for channel estimation [2]

If the channel is assumed to be linear, the channel estimate is simply the estimate of the impulse response of the system. It must be stressed once more that channel estimation is only a mathematical representation of what is truly happening. A "good" channel estimate is one where some sort of error minimization criteria is satisfied. In the figure.2 e*(n)* is the estimation error. The aim of most channel estimation algorithms is to minimize the mean squared error, E [$e2$ (n)] while utilizing as little computational resources as possible in the estimation process [2].

2. Using Artificial Neural Network for improving Channel Estimation

Artificial neural networks could surpass the capabilities of conventional computer-based pattern recognition systems. An artificial neural network seeks to emulate the function of the biological neural network that makes up the brains found in nearly all higher life forms found on Earth. Neural networks are made up of neurons.

2.1 Neurons

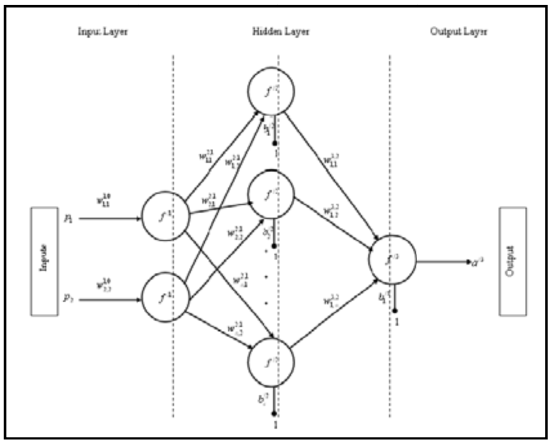

Figure [3]: Architecture of ANN Back propagation [3]

Neurons are the most important units in the nervous system. There are approximately 100 billion neurons in the brain, each of which is amazingly complex in itself. From a simplistic viewpoint, a neuron is a basic processing unit. A neuron receives input from other neurons, processes and integrates it, then bases its output (or lack thereof) on this integration [4].

Training using BPNN is suggested to be performed each 100 DVB-H super-frames and training is performed by sending training data over pilots of higher power and then the receiver performs the training process of the BPNN which identify the channel model. The receiver uses the pilots of 1 super-frame for the next 99 super-frames and training is repeated again each 100 super-frames by using the resulting weights, as best estimate weights, for the estimation of the next 100 frames. The receiver multiplies the data by the inverse channel model to perform the equalization.

2.2 Back Propagation Network

It is a systematic method for training MNN. It has a Mathematical foundation. It is multi-layer forward N/W using Delta Learning Rule. I.e. also Known as back-propagation rule. The aim of this N/W is to train the net to achieve a balance b/n the ability to respond correctly to the input Patterns that are used for training and the ability to provide good response to the input that are similar figure 3.

The number of layers and the number of processing element per layer are important decisions. These parameters to a feed forward, back-propagation topology are also the most ethereal. They are the art of the network designer. There is no quantifiable, best answer to the layout of the network for any particular application. There are only general rules picked up over time and followed by most researchers and engineers applying this architecture of their problems.

3. Implementation

By applying ANN for Rayleigh fading channel estimation, there are a lot of techniques can be used in Neural Network, one of them is Back propagation, as Figure 4 below shown that after adding adaptive white Gaussian Noise to the Ray channel, there is an error which is take the difference between the NN output and the desired output, and this error will feed the NN as Back propagation feedback to make correction until reach to the best desired output

As mention above, there are a lot techniques and algorithms can be used in NN, we used here the standard technique for Back propagation (with single hidden layer), as figure 5 shows that, the estimate channel using simulation by matlab code.

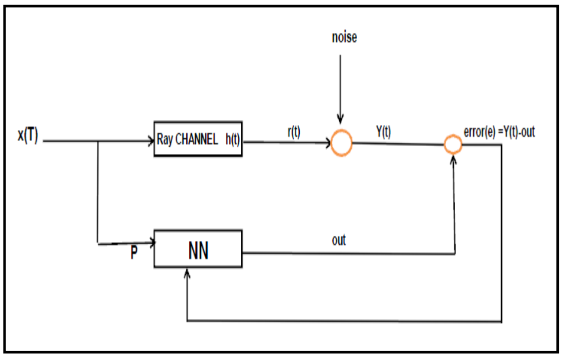

Figure [4]: block diagram for channel estimation using NN

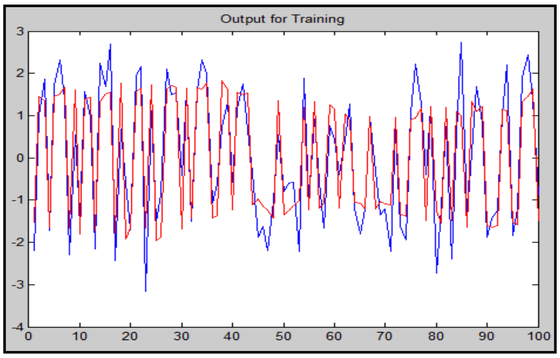

Figure [5]: simulation the estimate channel by BP NN

Conclusion

In this paper shows that ANN is one of the best technique to estimate the channel, it can correct and update itself be back propagation feeding the error, and there are a lot of NN algorithm technique, here used the standard back propagation, by this supervised algorithm, can be controlled by learning rate and number of iterations until reach to the desired output.

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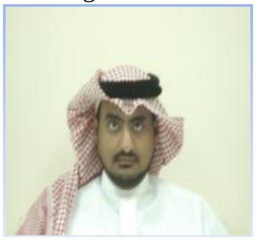

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