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Channel Estimation and Equalization Using DF Relay

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Abstract: ***The multiple input multiple output (MIMO) is a technique for sending and receiving more than one data signal on the same radio channel at the same time via multipath propagation. Multipath propagation thus multiplying the capacity of the radio link. Hence MIMO has several advantages over the conventional single-antenna systems such as high data capacity and better diversity against channel fading. One of the important parameter to be obtained in the case of MIMO system is the channel state information. In this work we are implementing an algorithm called least mean square algorithm for the estimation of channel state information (CSI) in MIMO systems and is compared with the existing forward link quadratic estimation algorithm. Along with estimation, an equalization is also done in order to eliminate the effects of inter symbol interference (ISI) and noise while transmitting through the channel.***

Keywords: MIMO, Channel state information, DF relay, Zero forcing equalizer, LMS algorithm

1. Introduction

The multiple input and multiple output (MIMO) is a method for multiplying the capacity of a radio link using multiple transmit and receive antennas to exploit multipath propagation. MIMO has become an unavoidable element of wireless communication. In the proposed work we are considering the estimation of channel state information (CSI) in MIMO systems. Channel state information refers to the known properties of a communication link that is; it deals with the information of how a signal propagate from transmitter to receiver. A relay called decode and forward (DF) relay is used in between the source and destination nodes. DF relay will sample, demodulate and decode the received signal. Decoded and regenerated signal is then transmitted to the destination. Adaptive DF relay offer path loss savings over conventional relaying and diversity gains. Several algorithm exists for channel state information estimation. Here we consider the least mean square algorithm for the purpose of estimation and then compares its ability with one of the existing channel estimation algorithm called forward link channel estimation. The LMS algorithm considered here uses the estimates of the gradient vector from the available data. It has several advantages over other CSI estimation algorithms.

Along with channel state estimation, an equalization process is also considered here. To remove the effects of channel from the received signal, in particular the inter symbol interference we use the equalizer arrangement. Circuit used to achieve equalization is termed as an equalizer. Zero forcing equalizer is considered here for this purpose. It refers to a form of linear equalization algorithm used in communication systems which applies the inverse of the frequency response of the channel. The name zero forcing corresponds to bringing down the ISI to zero in a noise-free case. The equalizer applies the inverse of the channel frequency response to the received signal to restore the signal after the channel. This will automatically reduce the ISI to zero.

2. System Model

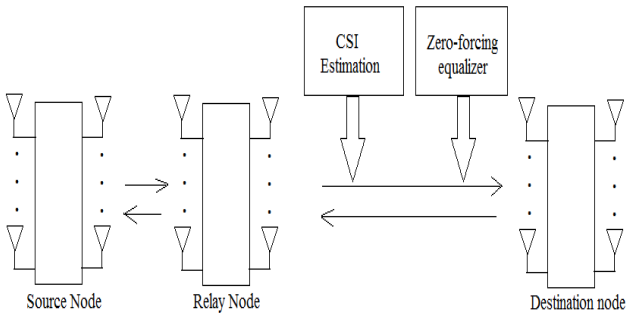

Figure 1: Proposed system model

Here we considered a MIMO system consisting of a source node, relay and a destination node. The relay is placed in-between the source and the destination nodes in order to transmit signals from source to destination. Here a decode and forward (DF) relay is considered. DF relay decodes and demodulates the received signals and then it is transmitted to receiver after re-encoding. Also, the problem of noise amplification in relays can be avoided by using a DF relay. Our aim is to obtain the channel state information (CSI). There are several methods exists for the purpose of CSI estimation and here we consider the estimation using an algorithm termed as the least mean square (LMS) algorithm. The LMS algorithm, introduced by Widrow and Hoff is an adaptive algorithm that uses a gradient-based method of steepest decent. The LMS algorithm uses the estimates of the gradient vector from the available data.LMS incorporates an iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error. Compared to other algorithms, LMS algorithm is relatively simple; it doesn't require correlation function calculation nor does it require matrix inversions. Hence we

are considering LMS algorithm for channel state information estimation.

Basic weight update equation for LMS algorithm is represented as :-

$w(n+1) = w(n) + \mu x(n)e(n)$ (1)

where;

- w(n+1) – weight update
- w(n) – old value of weight
- μ - step size parameter
- e(n) – mean square error

After CSI estimation we consider an equalizer arrangement. Her in our work we take a zero-forcing equalizer arrangement for the purpose. The circuit used to achieve equalization is called an equalizer and the process of adjusting the balance between frequency components within an electronic signal is termed as equalization. Zero forcing equalizer refer to a form of linear equalization algorithm used in communication systems which applies the inverse of the frequency response of the channel to the received signal to restore the signal after the channel. The name zero forcing corresponds to bringing down the ISI to zero in a noise-free case. Zero forcing algorithm is also termed as interference nulling algorithm. After equalization process, signal is transmitted to the destination node.

3. Comparative Study

There are several schemes exists for the purpose of channel state information estimation. Here we consider the forward link quadratic estimation method along with our proposed scheme for a comparative study. The main strategy behind the forward link algorithm relies on the fact that source can over-hear the transmitted signal when relay forwards its received data to destination. In forward link estimation we consider amplify and forward relay for the purpose of transmission. But the relay has the drawback of noise amplification. Along with this, the algorithm exhibits several disadvantages. The algorithm is computationally very complex. Also the algorithm works properly only if the source node has no fewer antennas than does the relay. Hence in order to avoid these disadvantages, we take LMS algorithm for the estimation of channel state information. It has less complexity. A comparative study of these two estimation methods are obtained using matlab software.

4. Simulation Results

MATLAB (MATrix LABoratory) is used for obtaining simulation results. MATLAB is a tool for numerical computation and visualization. It is a high performance language for technical computing and provide easy access to matrix software. Applications include system simulations, algorithm development, data acquisition, visualization, computing and prototyping.

In figure 2, SNR versus NMSE is plotted. The proposed estimation scheme is compared with one of the existing scheme called forward link quadratic estimation algorithm. The normalized mean square error is an estimator of the overall deviations between predicted and measured values. From simulation results we can see that the normalized mean square error, that is, the deviation is less for the proposed scheme when compared with the existing scheme. NMSE at different values of SNR are evaluated here. SNR is a measure that compares the level of a desired signal to the level of background noise. Here, with increasing the value of SNR the value of NMSE reaches a constant level.

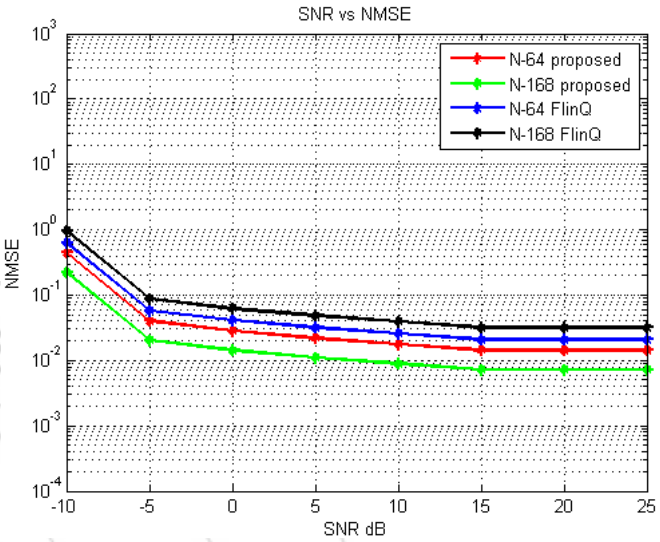

Figure 2: SNR vs NMSE

In figure 3, bit error rate is compared for existing and proposed schemes. Bit error rate (BER) simply refers to the number of bit errors per unit time. Hence we have to reduce the BER rate while transmitting. BER performance is evaluated with different values of SNR. With increase in SNR value, we can see a sudden decrease in bit error rate. As SNR attains a high positive value, BER reaches to a very low value. A better BER performance can be seen for the proposed scheme.

Channel capacity is evaluated along with SNR in figure 4. Here we can see that the proposed method shows a better channel capacity than the existing forward link channel estimation method.

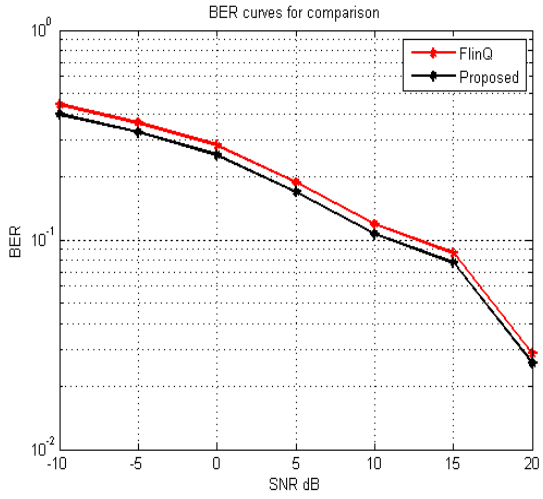

Figure 3: BER comparison curve

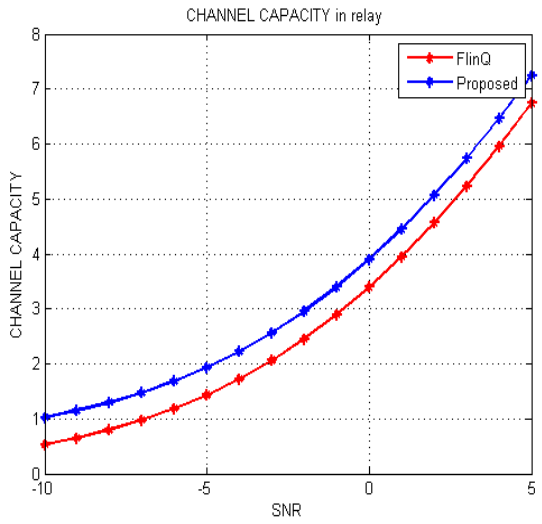

Figure 4: Channel capacity comparison

5. Conclusion

In our proposed work we are considering a MIMO system that uses a DF relay to obtain a noise free signal transmission. Our main aim is to estimate the channel state information by using the least mean square algorithm. The algorithm is simple to implement compaired to other existing algorithms. After CSI estimation an equalization is with the help of a zero forcing equalizer arrangement. Equalization bring down the inter symbol interference to zero in a noise free case by adjusting the balance between frequency components within the signal.

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Author Profile

Silpa S Kishore received the Btech degree in Electronics and Communication Engineering from Mount Zion College of Engineering in 2013. Now she is doing her Mtech degree in Communication Engineering from the same institution.