Comparative Analysis of Channel Estimation for MIMO Relay Channels

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Abstract-In this comparative study we have presented the performance of dual-hop multiple-input multiple-output (MIMO) amplify-and-forward (AF) relay systems by considering the source-to-relay and relay-to-destination channels undergo Rayleigh and Rician fading, respectively. Several MIMO techniques and practical relaying scenarios have been studied the effect of such asymmetric fading on the MIMO AF relaying systems. The performance of the optimal single stream beam forming on non-coherent AF MIMO relaying. We study the tools of finite-dimensional random matrix theory to statistically characterize the instantaneous signal-to-noise ratio (SNR). The closed-form expressions of the cumulative distribution function, probability density function, and moments of SNR are derived and used to analyze the performance of the system with outage probability, bit error rate (BER), and ergodic capacity. We have analyzed the effect of co-channel interference (CCI) and feedback delay on the multi-antenna AF relaying over asymmetric fading channels. Here, transmit beam forming vector has been studied using outdated channel state information due to the feedback delay from relay-to-source, and the relay node experience CCI due to frequency reuse in the cellular network.

Keywords:- bit error rate, cumulative distribution function, multiple-input multiple-output, moments, Channel estimation, Robust, Rayleigh fading.

I. INTRODUCTION

Modern wireless communication systems push for high information rates, solid communications, scope upgrades, and less power prerequisites. Numerous info various yield (MIMO) transferring can be recognized as a possibility for meeting these difficulties. MIMO strategy gives higher ghostly proficiency and enhances the unwavering quality of the correspondence communication systems [1, 2]. Cooperative relay communication enhances the throughput and extends the coverage area [3, 4, 5, 6, 7]. This also reduces the need the need to utilize high transmitter power, which thusly brings about decreased obstruction to different hubs. Both methods can likewise be utilized to accomplish spatial differing qualities. Late studies have expanded enthusiasm on the MIMO handing-off that can ideally use key assets of remote blurring, and accomplish the advantages of both techniques [8]

A digital communication system is often divided into several functional units as shown in Fig.1. The assignment of the source encoder is to speak to the computerized or simple data by bits in a proficient way.

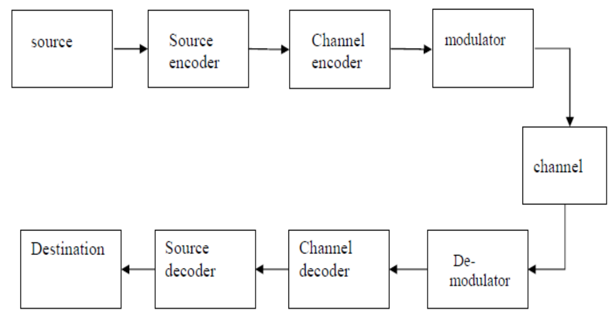

Fig.1. Functional Block in a Communication System

The bits are then encouraged into the channel encoder, which includes bits in an organized manner to empower recognition and redress of transmission mistakes. The bits from the encoder are gathered and changed to specific images, or waveforms by the modulator and waveforms are blended with a bearer to get a sign suitable to be transmitted through the channel. At the collector the opposite capacity happens. The got signs are demodulated and delicate or hard estimations of the comparing bits are gone to the decoder. The decoder breaks down the structure of got bit example and tries to recognize or right mistakes. At last, the rectified bits are nourished to the source decoder that is utilized to remake the simple discourse signal or advanced information data.

MIMO SYSTEM

Generally, multipath propagation would cause channel fading, which is regarded as a harmful factor to wireless communication [3]. This study demonstrates that in a MIMO system, multipath transmission can be positive to the remote correspondence. Different radio wires (or exhibit reception apparatuses) and numerous directs are utilized as a part of the transmitter and collector of MIMO system [3]. In the transmitter, the serial information image stream after the fundamental space-time handling is sent to the transmit radio wires, and afterward transmitted to the beneficiary. In the beneficiary, they got information images are recuperated through a mixed bag of space-time identification advancements. So as to ensure viable partition of the different sub-information image streams, the antennas must be separated with a sufficient distance (usually more than half a carrier wavelength) in order to prevent too much correlation between the received signals at the different antennas [3]. Fig. 2 illustrates a MIMO system.

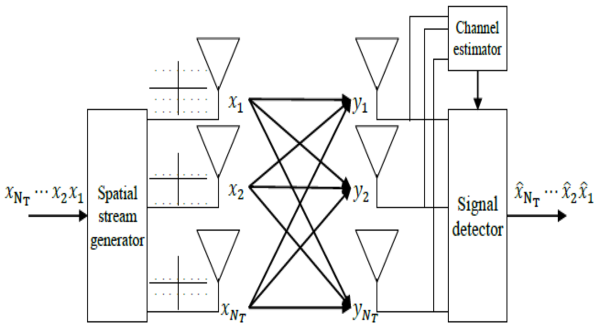

Fig. 2. MIMO system

As shown in Fig. 1.2, signals are transmitted by antennas, and after propagating over the wireless channel such as the urban channel, they are received at the receive antennas. Each receiving antenna receives a superposition sum of the signals from the transmitting antennas.

MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO)

During the past decades, MIMO technology [9] has attracted attention in wireless communications, since it offers both of spatial diversity and multiplexing gain without requiring additional bandwidth or transmits power [3].

Properties of MIMO transmissions

Spatial diversity can be negotiated in two different ways according to the number of transmitted data streams.

$$d = \lim_{SNR \to +\infty} \frac{log[P_b(SNR)]}{\log(SNR)}$$

Regardless of the fact that the BER is a generally utilized measure, this pointer has a noteworthy downside: it relies on upon the adjustment conspire that is utilized to transmit the information. To maintain a strategic distance from this reliance, another measure is frequently utilized as a part of this connection: the outage probability. The outage probability *pout* stands for the probability that the mutual information (*I*D) of the transmission is less than a given spectral efficiency (*R*),

$$P_{out} = P_r[ID < R]$$

Limitations of MIMO transmissions

MIMO transmissions induce an additional cost due to the installation of multiple antennas on the terminals. Moreover, an additional processing time is required to process several emitted and/or received signals.

$$\gamma = \frac{c}{f_c}$$

II. SYSTEM MODULE

Block-type channel estimation uses pilot tones inserted in all of the sub-bearers of an MIMO block. Since we discuss the single-transmit antenna case, by sending a training MIMO block consisting of pilot tones, we might get the initial estimate of the channel coefficients prior to data transmission. The single-transmit antenna MIMO system with channel estimator that we utilized in system model is indicate in Fig. 3. Though we utilized QPSK modulation, the estimation algorithms might be utilized with any different digital modulation scheme.

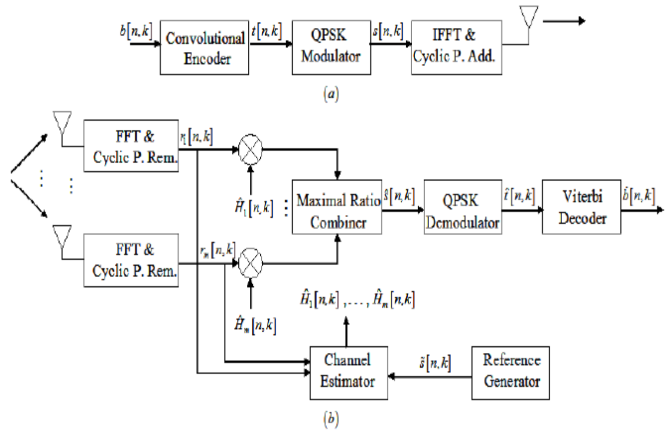

Fig. 3. MIMO system with block-type channel estimator

In Figure 9,$b[n, k]$ represents the binary data before encoding, t $[n, k]$is the binary data after encoding, $s[n, k]$is the QPSK modulated signal before the IFFT operation and $r_m[n,k]$ is the received signal after the FFT operation where *n* is the MIMO block index (time index), *k* is the MIMO sub-bearer (tone) index (frequency and sample index) and *m* is the receive antenna index. The correspondent received signal might be communicated as

$$r_m[n,k] = H_m[n,k]s[n,k] + w_m[n,k]$$

where $w_m[n,k]$represents additive white Gaussian noise as explained. The frequency reaction of the channel during the transmit antenna and the m^{th} receive antenna at the n^{th} MIMO block and k^{th} tone is denoted as $H_m[n,k]$. The channel is assumed independent for dissimilar *m*'s but with the same statistics as characterized. We perform channel estimation for each receive antenna independently.

Least-Square (LS) Channel Estimation

Channel estimation is based on standard LS techniques. We might write the transmitted and the received signals in vector form as

$$r[n] = [r[n,0], r[n,1], \dots, r[n,K-1]]$$

$$s[n] = [s[n,0], s[n,1], \dots, s[n,K-1]]$$

Where r $[n]$ and $s[n]$ are the vectors containing samples r $[n, k$]and $s[n, k]$ respectively for , and K is the total number of sub-bearers in an MIMO symbol. By simply dividing $k = 0, 1, \dots, K-1$ r $[n, k$]by $s[n, k]$we get the frequency reaction of the channel plus some noise. In this way, we might communicate the estimated channel frequency reaction by [5]

$$\hat{H}[n,k] = \frac{r[n,k]}{s[n,k]}, for\ k = 0,1,\dots,K-1$$

While the transmitted signal is QPSK with unit magnitude

$$\frac{1}{s[n,k]} = s^*[n,k]$$

and we might rewrite Equation (4.3) as

$$\hat{H}[n,k] = r[n,k]s^*[n,k], for\ k = 0,1,\dots,K-1$$

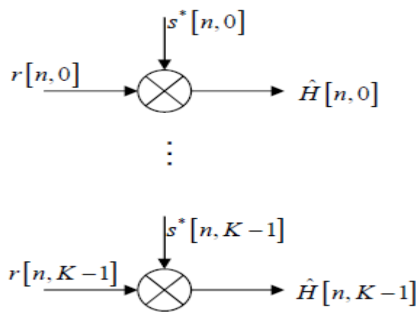

Fig.4. LS channel estimator

While implementing this estimation technique, the frequency reactions of the channels corresponding to dissimilar MIMO blocks and sub-bearers are assumed to be independent of each different. Thus, nothing of the correlation properties of the channel is utilized and the estimation is based on a Gaussian channel model [5]. The block diagram of the LS channel estimator is indicating in Figure 10.

As seen in Equation (4.3), we require information of the transmitted MIMO symbol in order to get the LS approximation of the channel frequency reaction. During the preliminary training period, we use symbols known at the receiver while during data transmission we utilize the recreated data symbols.

Modified LS Channel Estimation

LS estimation techniques have very low complexity, and they are easy to implement. The drawback of the LS estimator is a large mean-square-error (MSE). The modified LS estimator discussed here increases the performance of the LS estimator at the expense of higher complexity.

The LS estimation technique presented in the assumes independent segments of the frequency reaction and does not use the correlation properties of the channel, thus making it sensitive to noise. The discrete samples of the impulse reaction are correlated in time up to the maximum time delay spread T_m of the channel. By utilizing these time-domain statistics of the channel, improve the performance of the LS channel estimator for a wide range of SNRs [5].

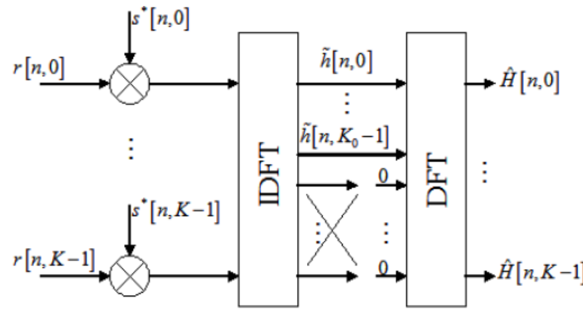

Fig. 5. Modified LS Channel Estimator

The modified LS channel estimator block diagram is indicating in Figure 11. A temporal estimation of H [n, k]is obtained as [3]

$$\tilde{H}[n,k] = r[n,k]s^*[n,k] = H[n,k] + w[n,k]s^*[n,k]$$

By attractive the IDFT of $\tilde{H}[n,k]$, the channel impulse reaction $\tilde{h}[n,k]$ in the time-domain. The maximum delay spread of the channel impulse reaction is assumed to be less than the guard time interval to avoid ISI. Since this is known a priori, the use this property to improve the performance of the channel estimator. By excluding low energy taps and utilizing only the first *K0* taps of $\tilde{h}[n,k]$, to eliminate some of the channel noise energy. The index *K0* depends on the channel delay profiles and might be taken as [3]

$$K_0 = \left\lceil \frac{KT_m}{T_s} \right\rceil$$

Where K is the total number of tones in an MIMO symbol, *Tm* is the maximum delay spread of the channel and *Ts* is the MIMO symbol time. The modified LS estimate of the channel frequency reaction by attractive the K-point discrete Fourier transform (DFT) of $\tilde{h}[n,l], for\ l = 0,1,\dots,K_0-1$. This is equivalent to padding the impulse reaction with $K - K_0$ zeros and then attractive its DFT. In cases where do not have any information about the delay profiles of the channel, Use the length of the guard interval as a substitute for K_0 .

By keeping the dominant segments of the channel impulse reaction, to make the estimate less sensitive to noise. This stems from the fact that the noise is stationary, but the energy of the channel taps decrease rapidly after *K0* taps.

Comb-Type Channel Estimation for Systems with a Single Transmit Antenna

In comb-type channel estimation, which is also known as pilot symbol aided channel estimation, then periodically insert pilot tones in the MIMO blocks and transmit them along with the data. Since the frequency reaction of the channel at the pilot inserted sub-bearers, to obtain the whole channel frequency reaction by utilizing an interpolation technique. The block diagram of the comb-type channel estimator that then it utilized for single-transmit antenna systems in study is indicated in Fig. 6.

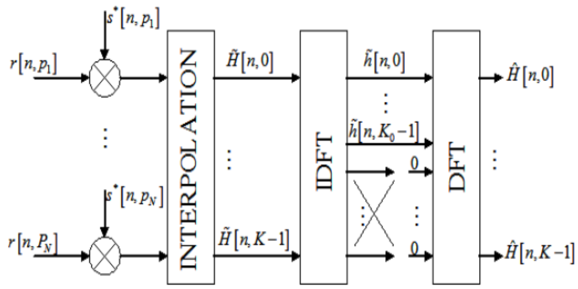

Fig. 6. Comb-type channel estimator for single-transmit antenna systems

III. LITERATURE REVIEW

In the year of 2012 Chiong, C.W.R.; Yue Rong; Yong Xiang,[1] Investigated on in conventional two-phase channel estimation algorithms for dual-hop multiple-input multiple-output (MIMO) relay systems, the relay-destination channel estimated in the first phase is used for the source-relay channel estimation in the second phase. For these algorithms, the mismatch between the estimated and they investigate the impact of such channel state information (CSI) mismatch on the performance of the two-phase channel estimation algorithm. By explicitly taking into account the CSI mismatch, they develop a robust algorithm to estimate the source-relay channel. Numerical examples demonstrate the improved performance of the proposed algorithm.

In the year of 2012 Rui, Y.; Hu, H.; Yi, H.; Chen, H.-H.,[2] presented a Employing user pairing schemes in uplink virtual multiple-input multiple-output (V-MIMO) systems can significantly improve system capacity owing to multi-user diversity. Most of the existing user pairing algorithms was developed under the assumption that a scheduler always possesses the perfect channel state information (CSI). taking into account the effects of channel estimation error (CEE), the authors propose a robust user pairing algorithm based on a closed-form average sum rate under CEE. In addition, the authors further propose an adaptive user selection scheme as an effort to maximize the sum rates owing to the rate constraint under CEE. The gain of the proposed method is shown in studies.

In the year of 2011 Chengwen Xing; Shaodan Ma; Zesong Fei; Yik-Chung Wu; Jingming Kuang,[3] proposed on joint transceiver design for dual-hop amplify-and-forward (AF) MIMO relay systems with Gaussian distributed channel estimation errors in both two hops is investigated. Due to the fact that various linear transceiver designs can be transformed to a weighted linear minimum mean-square-error (LMMSE) transceiver design with specific weighting matrices, weighted mean square error (MSE) is chosen as the performance metric. Precoders matrix at source, forwarding matrix at relay and equalizer matrix at destination are jointly designed with channel estimation errors taken care of by Bayesian philosophy. Several existing algorithms are found to be special cases of the proposed solution. The performance advantage of the proposed robust design is demonstrated by the studies.

In the year of 2011 Chengwen Xing; Zesong Fei; Yik-Chung Wu; Shaodan Ma; Jingming Kuang,[4] described the robust transceiver design for dual-hop amplify-and-forward (AF) MIMO relay systems with Gaussian distributed channel estimation errors. Aiming at maximizing the mutual information under imperfect channel state information (CSI), source precoder at source and forwarding matrix at the relay are jointly optimized. Using some elegant attributes of matrix-monotone functions, the structures of the optimal solutions are derived first. Then based on the derived structure an iterative water filling solution is proposed. Several existing algorithms are shown to be special cases of the proposed solution. Finally, the effectiveness of the proposed robust design is demonstrated by the studies.

In the year of 2010 Chengwen Xing; Shaodan Ma; Yik-Chung Wu; Tung-Sang Ng,[5] proposed on robust transceiver design based on minimum-mean-square-error (MMSE) criterion for dual-hop amplify-and-forward MIMO relay systems is investigated. The channel estimation errors are modeled as Gaussian random variables, and then the effect are incorporated into the robust transceiver based on the Bayesian system. An iterative algorithm is proposed to jointly design the precoder at the source, the forward matrix at the relay and the equalizer at the destination, and the joint design problem can be efficiently solved by quadratic matrix programming (QMP).

In the year of 2010 Chengwen Xing; Shaodan Ma; Yik-Chung Wu,[6] described a addresses the problem of robust linear relay precoder and destination equalizer design for a dual-hop amplify-and-forward (AF) multiple-input multiple-output (MIMO) relay system, with Gaussian random channel uncertainties in both hops. By taking the channel uncertainties into account, two robust design algorithms are proposed to minimize the mean-square error (MSE) of the output signal at the destination. One is an iterative algorithm with its convergence proved analytically. The other is an approximated closed-form solution with much lower complexity than the iterative algorithm. Although the closed-form solution involves a minor relaxation for the general case, when the column covariance matrix of the channel estimation error at the second hop is proportional to identity matrix, no relaxation is needed and the proposed closed-form solution is the optimal solution. Simulation shows that the proposed algorithms reduce the sensitivity of the AF MIMO relay systems to channel estimation errors, and perform better than the algorithm using estimated channels only. Furthermore, the closed-form solution provides a comparable performance to that of the iterative algorithm.

In the year of 2009 Filho, A.M.A.; Pinto, E.L.; Galdino, J.F.,[7] proposed on A new variable step-size least mean squares (VSS-LMS) algorithm for the estimation of frequency-selective communications channels is herein presented. In contrast to previous researches, in which the step-size adaptation is based on the instantaneous samples of the error signal, this algorithm is derived on the basis of analytical minimization of the ensemble-averaged mean-square weight error. A very simple rule for step-size adaptation is obtained, using a small number of communication system parameters. This is another significant difference from other proposals, in which a large number of control parameters should be tuned for proper use. The algorithm here proposed is shown to be applicable to both time-varying and time-invariant scenarios. While the lack of a termination rule for step-size adaptation is a common characteristic of other schemes, the algorithm here presented adopts a criterion for stopping the step-size adaptation that assures optimal steady-state performance and leads to large computational savings. A performance comparison with other VSS-LMS schemes is provided, including their application to maximum likelihood sequence estimation receivers using per survivor processing (MLSE/PSP). The studies show that the algorithm proposed in this research has good performance characteristics and a very low computational cost, especially in the application to MLSE/PSP receivers. Besides, this algorithm is shown to be robust to changes in the signal-to-noise ratio (SNR).

In the year of 2008 Feifei Gao; Yonghong Zeng; Nallanathan, A.; Tung-Sang Ng,[8] described a novel subspace (SS) based blind channel estimation method for multi-input, multi-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems is proposed in this research. With an appropriate re-modulation on the received signal blocks, the SS method can be effectively applied to the cyclic prefix (CP) based MIMO-OFDM system when the number of the receive antennas is no less than the number of transmit antennas. These features show great compatibility with the coming fourth generation (4G) wireless communication standards as well as most existing single-input single-output (SISO) OFDM standards, thus allow the proposed algorithm to be conveniently integrated into practical applications. Compared with the traditional SS method, the proposed algorithm exhibits many advantages such as robustness to channel order over-estimation, capability of guaranteeing the channel identifiability etc. Analytical expressions for the mean-square error (MSE) and the approximated Cramer-Rao bound (ACRB) of the proposed algorithm are derived in closed forms. Various numerical examples are conducted to corroborate the proposed studies

IV. PROBLEM FORMULATION

The first challenge concerns dual-hop MIMO correspondences system utilizes different receiving wires of both transmitting end and getting end, the information throughput and the range usage can become exponentially to meet the prerequisites of high transmission rate use of correlation based estimators, high transmission execution and high information throughput, MIMO enhances interchanges system execution by full utilization of space differences. Then, MIMO has been broadly considered in the educated community and industry. MIMO is a productive multi-bearer transmission innovation. It changes over rapid serial information streams to moderately low transmission rate of images on a gathering of sub channels by serial/parallel transformation. In MIMO, each subcarrier is orthogonal to one another. In recurrence space, the reactions of the sub channels cover. In this manner MIMO can give a higher range usage than typical recurrence division multiplexing system.

V. CONCLUSIONS

We analyzed the performance of different type of dual-hop MIMO dual hop system over asymmetric fading channels. In particular, optimal beam forming AF MIMO relaying, Relay Selection on dual hop AF MIMO with OSTBC, Effect of CCI and feedback delay on the multi-antenna AF re-laying. Asymmetric fading of the dual hop system is considered as the source-relay and the relay-destination channels undergo Rayleigh and Rician fading respectively. An accurate and efficient channel estimation procedure is necessary to coherently demodulate the received data. As opposed to former standards using MIMO modulation, the new standards rely on QAM modulation and thus require channel estimation. After comparing and it was found that in case of two antenna asymptotic are reasonable same and nearly equal to same as that of analytical mutual information but when compared to four and eight antenna at the terminal, analysis has been shown improvement in MI as high by increase number of antennas.

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