An Extensive Review on Pilot Assisted Channel Estimation in MIMO-STBC Systems over Time-Varying Fading Channels

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Abstract: In communication systems transmitting data through unknown fading channels, traditional detection techniques are based on channel estimation (e.g., by using pilot signals), and then treating the estimates as perfect in a minimum distance detector. In this research study, we analysis and investigate an optimal detector that does not estimate the channel explicitly but jointly processes the received pilot and data symbols to recover the data. This optimal detector outperforms the traditional detectors (mismatched detectors). In order to approximate correlated fading channels, such as fast fading channels and frequency-selective fading channels, basis expansion models (BEMs) are used due to high accuracy and low complexity.

Keywords: - pilot symbol assisted modulation; MIMO system; STBC codes.

I. INTRODUCTION

Many wireless communication techniques and components require knowledge of the channel state to achieve their optimal performance. In practice, this knowledge is often acquired by estimation. The estimation can be performed blindly by using only unknown data symbols, but more frequently, it is performed with the aid of pilot symbols which are known at the receiver side. Although occupying transmission bandwidth and energy, pilot-based channel estimation and detection offers reliable performance with a relatively low complexity, especially for time-variant or frequency-selective fading channels. Therefore, pilot symbol assisted modulation (PSAM) is widely analyzed to detect data symbols in fading channels by inserting known pilot symbols into data blocks.

In communication systems transmitting data through unknown channels, traditional detection techniques are based on channel estimation (e.g., by using pilot signals), and then treating the estimates as perfect in a minimum distance detector; we call such detectors mismatched. A better detection performance can be obtained in an optimal detector that does not estimate the channel explicitly but jointly processes the received pilot and data symbols to recover the data. The optimal detector in was obtained for communication scenarios with space-time coding in a channel with uncorrelated fading and additive white noise. This consider a more general scenario that is applicable to channels with correlated fading. The generic optimal detector and specify it for frequency-flat fading channels. Compare its detection performance with that of mismatched detectors using different channel estimation techniques for both cases of time-invariant and time-variant fading.

Diversity Techniques for Fading Channels

The characteristics of wireless channel impose fundamental limitations on the performance of wireless communication systems. The wireless channel can be investigated by composing it into two parts, i.e., large-scale (long-term) impairments including path loss, shadowing and small-scale (short-term) impairment which is commonly referred as fading. The former component is used to predict the average signal power at the receiver side and the transmission coverage area. The latter is due to the multipath propagation which causes random fluctuations in the received signal level and affects the instantaneous signal-to-noise ratio (SNR).

For a typical mobile wireless channel in urban areas where there is no line of sight propagation and the number of scatters is considerably large, the application of central limit theory indicates that the complex fading channel coefficient has two quadrature components which are zero-mean Gaussian random processes. As a result, the amplitude of the fading envelope follows a Rayleigh distribution. In terms of error rate performance, Rayleigh fading converts the exponential dependency of the bit-error probability on the SNR for the classical additive

Time Diversity

In this form of diversity, the same signal is transmitted in different time slots separated by an interval longer than the coherence time of the channel. Channel coding in conjunction with interleaving is an efficient technique to provide time diversity. In fast fading environments where the mobility is high, time diversity becomes very efficient. Though, for slow fading channel (e.g., low mobility environments, fixed-wireless applications), it offers little protection unless significant interleaving delays can be tolerated.

Frequency Diversity

In this form of diversity, the same signal is sent over different frequency carriers, whose separation must be larger than the coherence bandwidth of the channel to ensure independence among diversity channels. Since multiple frequencies are needed, this is generally not a bandwidth-efficient solution. A natural way of frequency diversity, which is sometimes referred to as path diversity, arises for frequency-selective channels. When the multipath delay spread is a significant fraction of the symbol period, the received signal can be interpreted a linear combination of the transmitted signal weighted by independent fading coefficients.

Channel Estimation Methods

Many detection techniques require the knowledge of the channel impulse response, which can be provided by a separate channel estimator. For wireless systems, channel estimation can be di-cult and computationally intensive, in particular for those using multiple sub-bands and multiple antennas. In fact, its function is to estimate the amplitude and phase shift caused by the multipath propagation for every sub-band and for every transmit/receive antenna pair. The channel estimation techniques can be classified in pilot-assisted, decision-directed and blind, according to the available information about the transmitted signal.

An extensive overview of channel estimation techniques employed in OFDM systems, both for SISO and MIMO scenario. In the following subsections, given that estimation of the wireless channel is a very broad topic, a particular emphasis will be placed on the methods developed for multi-carrier and multiple antenna systems. Furthermore, considering that two MMSE channel estimation techniques based on GA and PSO will be presented in this study, the application of evolutionary strategies to channel estimation issues will be also considered.

Pilot-Assisted

Pilot-assisted methods use a subset of the available sub carriers to transmit training sequences known to the receiver. The desired frequency domain channel transfer function is directly estimated over the pilots and an interpolation method is then used to obtain the remaining values. The most important issues are the optimum choice of training sequences, their placement, their dimension and the used interpolation method.

The importance of the pilot pattern choice has been evidenced, by comparing in terms of BER several positioning of the pilot symbols, both in time and frequency. The number and placement of pilots in the time-frequency grid has been extensively studied, and their references. It represents an important topic, affecting not only the quality of CIR evaluation but the transmission rate as well.

Decision-Directed

The Decision-Directed (DD) approaches consider all the sub carriers as pilots. The channel estimation of a previous OFDM symbol is used for the data detection of the current estimation, and there after the newly detected data is used for the estimation of the current channel. The resulting channel transfer function cans be accurate in the absence of symbol old errors and in particular for slowly varying fading channels, without signaling overhead.

Space-Time Coding

Space-time trellis codes (STTCs) combine the channel code design with symbol mapping onto multiple transmit antennas. The data symbols are cleverly coded across space and time to extract diversity advantages [8]. Figure 1.1 illustrates a space-time coded system.

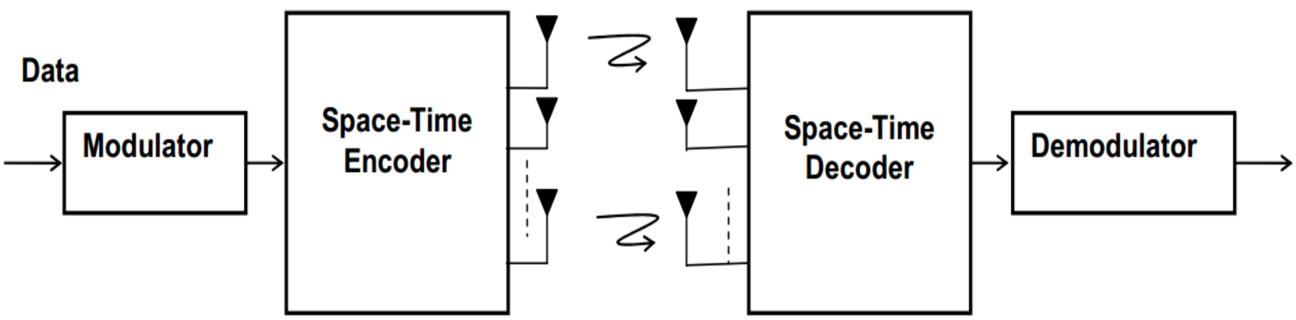

Figure 1.1: Block diagram of a space-time coded system.

II. LITERATURE SURVEY

Sr. No.	TITLE	AUTHORS	YEAR	METHODOLOGY
1	Pilot assisted channel estimation in MIMO-STBC systems over time-varying fading channels	E. Ben Slimane, S. Jarboui, Z. Ben Mabrouk and A. Bouallègue	2014	Propose a straightforward MIMO channel estimation method before being used by STBC decoder.
2	A simple transmit diversity technique for wireless communications	S. M. Alamouti	Oct 1998	Presents a simple two-branch transmit diversity scheme.
3	Space-time block codes from orthogonal designs	V. Tarokh, H. Jafarkhani,and A. R. Calderbank	Jul. 1999	Introduce space–time block coding, a new paradigm for communication over Rayleigh fading channels using multiple transmit antennas.
4	Training-based MIMO channel estimation: a study of estimator trade-offs and optimal training signals	M. Biguesh and A. B. Gershman	March 2006	Consider the popular linear least squares (LS) and minimum mean-square-error (MMSE) approaches and propose new scaled LS (SLS) and relaxed MMSE techniques.
5	An analysis of pilot symbol assisted modulation for Rayleigh fading channels [mobile radio]	J. K. Cavers	Nov 1991	Author presents pilot-symbol-assisted modulation (PSAM) on a solid analytical basis.

E. Ben Slimane, S. Jarboui, Z. Ben Mabrouk and A. Bouallègue, [1] in this research, challenges regarding the provision of channel state information (CSI) in multiple-input multiple-output (MIMO) systems based on space time block codes (STBC) over slow time-varying Rayleigh fading channels are addressed. Authors develop a novel MIMO channel estimation algorithm that adopts a pilot symbol assisted modulation (PSAM) which has been proven to be effective for fading channels. In this approach, pilot symbols are periodically inserted into the data stream that is sent through the orthogonal STBC encoder. At the receiver, author propose a straightforward MIMO channel estimation method before being used by STBC decoder. Simulation results indicate that the proposed pilot-assisted MIMO concept provides accurate channel estimates. The impact of Doppler frequency on performance scheme is also investigated by simulation.

S. M. Alamouti, [2] this paper presents a simple two-branch transmit diversity scheme. Using two transmit antennas and one receive antenna the scheme provides the same diversity order as maximal-ratio receiver combining (MRRC) with one transmit antenna, and two receive antennas. It is also shown that the scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M. The new scheme does not require any bandwidth expansion or any feedback from the receiver to the transmitter and its computation complexity is similar to MRRC.

V. Tarokh, H. Jafarkhani,and A. R. Calderbank, [3] introduced space–time block coding, a new paradigm for communication over Rayleigh fading channels using multiple transmit antennas. Data is encoded using a space–time block code and the encoded data is split into n streams which are simultaneously transmitted using n transmit antennas. The received signal at each receive antenna is a linear superposition of the n transmitted signals perturbed by noise. Maximum likelihood decoding is achieved in a simple way through decoupling of the signals transmitted from different antennas rather than joint detection. This uses the orthogonal structure of the space–time block code and gives a maximum-likelihood decoding algorithm which is based only on linear processing at the receiver. Space–time block codes are designed to achieve the maximum diversity order for a given number of transmit and receive antennas subject to the constraint of having a simple decoding algorithm.

The classical mathematical framework of orthogonal designs is applied to construct space–time block codes. It is shown that space–time block codes constructed in this way only exist for few sporadic values of n. Subsequently, a generalization of orthogonal designs is shown to provide space–time block codes for both real and complex constellations for any number of transmit antennas. These codes achieve the maximum possible transmission rate for any number of transmit antennas using any arbitrary real constellation such as PAM. For an arbitrary complex constellation such as PSK and QAM, space–time block codes are designed that achieve 1/2 of the maximum possible transmission rate for any number of transmit antennas. For the specific cases of two, three, and four transmit antennas, space–time block codes are designed that achieve, respectively, all, 3/4, and 3/4 of maximum possible transmission rate using arbitrary complex constellations. The best tradeoff between the decoding delay and the number of transmit antennas is also computed and it is shown that many of the codes presented here are optimal in this sense as well.

M. Biguesh and A. B. Gershman, [4] studied the performance of multiple-input multiple-output channel estimation methods using training sequences. Consider the popular linear least squares (LS) and minimum mean-square-error (MMSE) approaches and propose new scaled LS (SLS) and relaxed MMSE techniques which require less knowledge of the channel second-order statistics and/or have better performance than the conventional LS and MMSE channel estimators. The optimal choice of training signals is investigated for the aforementioned techniques. In the case of multiple LS channel estimates, the best linear unbiased estimation (BLUE) scheme for their linear combining is developed and studied.

J. K. Cavers, [5] the author presents pilot-symbol-assisted modulation (PSAM) on a solid analytical basis, a feature missing from previous work. Closed-form expressions are presented for the bit error rate (BER) in binary-phase-shift-keying (BPSK) and in quadrature-phase-shift-keying (QPSK), for a tight upper bound on the symbol error rate in 16 quadrature-amplitude-modulations (16-QAM), and for the optimized receiver coefficients. The error rates obtained are lower than for differential detection for any combination of signal-to-noise ratio (SNR) and Doppler spread, and the performance is within 1 dB of a perfect reference system under slow-fading conditions and within 3 dB when the Doppler spread is 5% of the symbol rate

III. PROBLEM IDENTIFICATION

In the previous research work PSAM estimation method had been proposed for MIMO based on orthogonal STBC codes. The transmitter just inserts known equally and optimally spaced pilot symbols in data information block. The combined signal is coded using orthogonal STBC code. The transmitted signal is corrupted by slow fading and additive noise. The slow fading channel is modeled by Jakes model; also it is chosen to be constant over the STBC code word period. The receiver estimates and interpolates the channel measurements provided by the pilot symbols in order to obtain the amplitude and the phase reference for detection. Simulation results show that the channel estimation based on PSAM technique is accurate I term BER for the two MIMO schemes. It has been also shown that the estimation method is suitable for slow time-varying fading channel and it can be extended to fast time-varying fading channel.

IV. CONCLUSION

Wireless communication is one of the most active areas of research over the past and the current decades. A variety of services have been oared in such a context, starting from Voice, continuing to Data and now to Multimedia. Significant reductions in cost and time can also be achieved using wireless solutions, providing even several benefits to the users in terms of mobility and edibility in the placement of terminals. Wireless mobile systems have begun to permeate all areas of the daily life and are therefore required to provide high-speed, high-capacity and high-quality services with performances closer to those afforded by wire line systems. This evolution has been made possible by academic and industrial Research and Development (R&D) labs with the implementation of three generations of cellular systems.

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