MMSE Channel Estimation for MIMO-OFDM Using Spatial and Temporal Correlations

[1]Eragadindla Narayanamma, [2]Allanki Sanyasi Rao

PG Scholar Balaji institute of Technology & Science

Associate Professor Balaji institute of Technology & Science

Abstract:- Channel has been introduced to achieve high data speed and better bit rate. The system becomes more efficient when OFDM (Orthogonal Frequency Division Multiplexing) is combined with MIMO to obtain high transmission rates, good quality of service and minimize the probability of error. Channel estimation is of great importance in MIMOOFDM system. To improve accuracy of the channel, this paper proposes a parametric sparse multiple input multiple output (MIMO)-OFDM channel estimation scheme based on the finite rate of innovation (FRI) theory, whereby super-resolution estimates of path delays with arbitrary values can be achieved. For outdoor communication scenarios, where wireless channels are sparse in nature, path delays of different transmit-receive antenna pairs share a common sparse pattern due to the spatial correlation of MIMO channels. Meanwhile, the channel sparse pattern is nearly unchanged during several adjacent OFDM symbols due to the temporal correlation of MIMO channels. The proposed scheme performs better than existing schemes.Meanwhile, both the spatial and temporal correlations of wireless MIMO channels are exploited to improve the accuracy of the channel estimation.

Keywords: MIMO-OFDM, Super-resolution, sparse channel estimation, finite rate of innovation (FRI), spatial and temporal correlations

INTRODUCTION:- In broadband wireless communications, MIMO (Multiple Input Multiple Output) OFDM becomes more efficient to achieve high data rate and better performance. Accurate and efficient channel estimation plays a key role in MIMO-OFDM wireless communications. Channel capacity of MIMO-OFDM system is increased by channel estimation. The increase in the demand for bandwidth and different high performance services opened the door for using multiple antennas at transmitter and receiver. The wireless channel properties are dynamic in nature as it is frequency selective and time-dependent. Multiple Input Multiple Output (MIMO)-OFDM is widely recognized as a key technology for future wireless communications due to its high spectral efficiency and superior robustness to multipath fading channels [1]. In general, there are two groups of channel estimation schemes for MIMO-OFDM system. The first one is nonparametric channel estimation scheme, which adopts orthogonal frequency-domain pilots or orthogonal time-domain training sequences to convert the channel estimation in MIMO systems to that in single antenna systems [2]. However, such scheme suffers from high pilot overhead when

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

the number of transmit antennas increases. The second category is parametric channel estimation scheme, The parametric scheme is more favorable for future wireless systems as it can achieve higher spectral efficiency. However, path delays of sparse channels are assumed to be located at the integer times of the sampling period [3], which is usually unrealistic in practice. In this work, a more practical sparse MIMOOFDM channel estimation scheme based on spatial and temporal correlations of sparse wireless MIMO channels is proposed to deal with arbitrary path delays [9]. Third, we reduce the pilot overhead by using the finite rate of innovation (FRI) theory [8], which can recover the analog sparse signal with very low sampling rate, as a result, the average pilot overhead per antenna only depends on the channel sparsity level instead of the channel length. 2. SPARSE MIMO CHANNEL MODEL The MIMO channel is shown in Fig. 1, and its following characteristics will be considered in this letter. (A) Channel Sparsity In typical outdoor communication scenarios, the CIR is intrinsically sparse due to several significant scatterers [3], [5]. For an □ □× □ □ MIMO system, the CIR (□,□)□(between the ith transmit antenna and the jth receive antenna can be modeled as

$$h^{(i,j)}(t) = \sum_{p=1}^{P} \alpha_p^{(i,j)} \delta\left(t - \tau_p^{(i,j)}\right),\ 1 \le i \le N_t, 1 \le j \le N_r \quad (1)$$

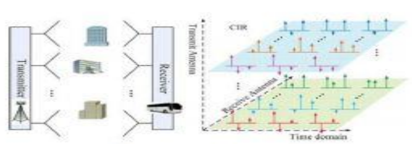

Figure 1: Spatial and temporal correlations of wireless MIMO channels.

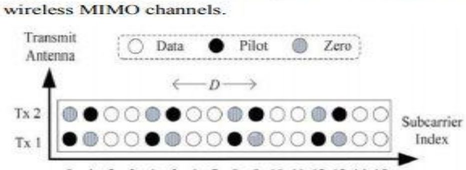

Figure 2: Pilot pattern. Note that the specific $N_t = 2$,

D= 4, □ □=4, and □ □ _□ □ □ □ □ = 8 are for use illustration purpose, where □ (.) is the Dirac function, P is the total number of resolvable propagation paths, and □ □(□,□)□ and (□,□) denote the path delay and path gain of the pth path, respectively. (B) Spatial Correlation Because the scale of the transmit or receive antenna array is very small compared to the long signal transmission distance, channels of different transmitreceive antenna pairs share very similar scatterers. Meanwhile, for most communication systems, the path delay difference from the similar scatterer is far less than the system sampling period. Therefore, CIRs of different transmit-receive antenna pairs share a common sparse pattern, although the corresponding path gains may be quite different. (C) Temporal Correlation For wireless channels, the path delays vary much slowly than the path gains, and the path gains vary continuously [6]. Thus, the channel sparse pattern is nearly unchanged during several adjacent OFDM symbols, and the path gains are also correlated. 3. PROPOSED METHOD (A) Sparse MIMO-OFDM Channel Estimation In this section, the widely used pilot pattern is briefly introduced at first, based on which a super-resolution sparse MIMO OFDM channel estimation method is then applied. Finally, the required number of pilots is discussed under the framework of the FRI theory. (B) Pilot Pattern The pilot pattern widely used in common MIMOOFDM systems is illustrated in Fig. 2. In the frequency domain □ pilots are uniformly spaced with the pilot interval D(e.g.,D= 4 in Fig. 2). Meanwhile, every pilot is allocated with apilot index lfor 0 ≤ l ≤ ἐᘅ −1, which is ascending with theincrease of the subcarrier index. Furthermore, to distinguishMIMO channels associated with

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

different transmit antennas,each transmit antenna uses a unique subcarrier index initialphase ◌ ̈ for ◌zero subcarriers toensure the orthogonality of pilots [4]. Therefore, for the ithtransmit antenna, the subcarrier index of the lth pilot is Consequently, the total pilot overhead per transmit is antenna , and thus, ◌can be also referred as the average pilot overhead per transmit antenna in this letter. (C) Super-Resolution Channel Estimation At the receiver, the equivalent baseband channel frequency response (CFR) H(f) can be expressed as Where superscripts iand jin (1) are omitted for convenience ⁄ is the system bandwidth, ◌ ◌and is the sampling period. Meanwhile, the Npoint discrete Fourier transform (DFT) of the timedomain equivalent baseband channel can be expressed as [5], i.eTherefore, for the (i, j)th transmit-receive antenna pair, according to (2)–(4), the estimated CFRs over pilots can be written as can be obtained by using the conventional minimum mean square error (MMSE) or least square (LS) method [2], and (◌,◌)◌[◌[is the additive white Gaussian noise (AWGN). Eq. (5) can be also written in a vector form as Because the wireless channel is inherently sparse and the small scale of multiple transmit or receive antennas is negligible compared to the long signal transmission distance, CIRs of different transmit-receive antenna pairs share common path delays, which is equivalently translated as a common sparse pattern of CIRs due to the spatial correlation of MIMO channels [5], i.eHence, by exploiting such spatially common sparse pattern shared among different receive antennas associated with the ith transmit antenna, we have Comparing the formulated problem (8) with the classical direction-of-arrival (DOA) problem [9], we find out that they are mathematically equivalent. Specifically, the traditional DOA problem is to typically estimate the DOAs of the P sources from a set of time-domain measurements, which are obtained from the ◌ sensors outputs at distinct time instants (time-domain samples). In contrast to our problem in (8), we try to estimate the path delays of Pmultipaths from a set of frequency-domain measurements, which are acquired from ◌ pilots of distinct antenna pairs (antenna-domain samples). It has been verified in [10] that the total least square estimating signal parameters via rotational invariance techniques (TLSESPRIT) algorithm in [9] can be applied to (8) to efficiently estimate path delays with arbitrary values. By using the TLS-ESPRIT algorithm, we can obtain superresolution estimates of path delays, i.e.,for $1 \le p \le P$, and thus, can be obtained accordingly. Then, path gains can be acquired by the LS method [7], i.e., is known at the receiver and has been estimated after applying the TLS-ESPRIT algorithm, we can easily obtain the estimation of the path. Finally ,the complete CFR estimation over all OFDM subcarriers can be obtained based on (3) and (4). Furthermore, we can also exploit the temporal correlation of wireless channels to improve the accuracy of the channel estimation. First, path delays of CIRs during several adjacent OFDM symbols are nearly unchanged [6], [7], which is equivalently referred as a common sparse pattern of CIRs due to the temporal correlation of MIMO channels. Thus, the Vandermonde matrix V in (8) remains unchanged across several adjacent OFDM symbols. Moreover path gains during adjacent OFDM symbols are also correlated

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

owing to the temporal continuity of the CIR, so As in (8) for several adjacent OFDM symbols are also correlated. Therefore, when estimating CIRs of the qth OFDM symbol, we can jointly exploit of several adjacent OFDM symbols based on (8Where the subscript ◌̀is used to denote the index of the OFDM symbol, and the common sparse pattern of CIRs is assumed in 2R + 1 adjacent OFDM symbols [7]. In this way, the effective noise can be reduced, so the improved channel estimation accuracy is expected. In contrast to the existing nonparametric scheme which estimates the channel by interpolating or predicting based on CFRs over pilots [1], [2], our proposed scheme exploits the sparsity as well as the spatial and temporal correlations of wireless MIMO channels to first acquire estimations of channel parameters, including path delays and gains, and then obtain the estimation of CFR according to (3) and (4). Discussion on Pilot Overhead Compared with the model of the multiple filters bank based on the FRI theory [10], it can be found out that of CIRs transmit-receive antenna pairs are equivalent to the semi period sparse subspaces, and the pilots are equivalent to multichannel filters. Therefore, by using the FRI theory, the smallest required number of pilots for each transmit antenna is 2Pin a noiseless scenario. For practical channels with the maximum delay spread although the normalized channel length is usually very large, the sparsity level Pis small, i.e., P ≪L [3]. Consequently, in contrast to the nonparametric channel estimation method where the required number of pilots heavily depends on L, our proposed parametric scheme only needs 2Ppilots in theory. Note that the number of pilots in practice is larger than 2Pto improve the accuracy of the channel estimation due to AWGN.

4. RESULTS

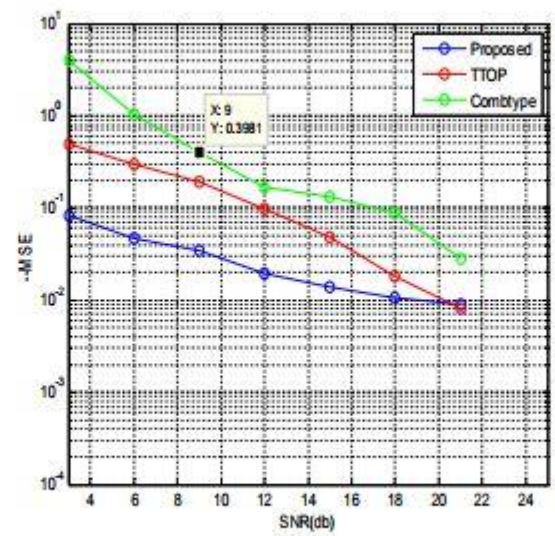

Figure 3: Performance assessment under static or AWGN channel

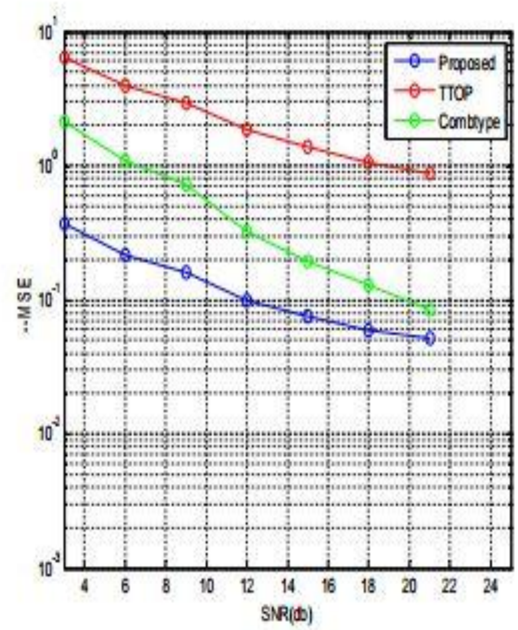

Figure 4: Performance assessment under ETU or vehicular channel

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

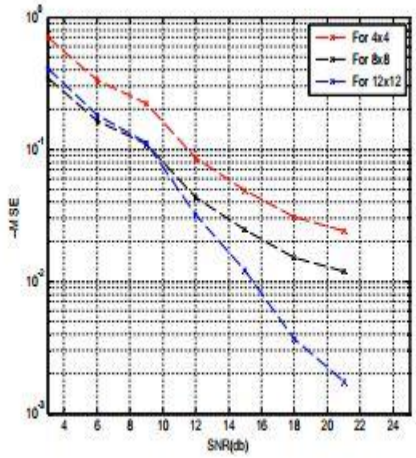

Figure 5: Performance assessment for different antenna systems

5. CONCLUSION Under the framework of the FRI theory, the required number of pilots in the proposed scheme is obviously less than that in nonparametric channel estimation schemes. Moreover, simulations demonstrate that the average pilot overhead per transmit antenna will be interestingly reduced with the increased number of antennas. The proposed super-resolution sparse MIMO channel estimation scheme exploits the sparsity as well as the spatial and temporal correlations of wireless MIMO channels. It can achieve super-resolution estimates of path delays with arbitrary values and has higher channel estimation accuracy than conventional schemes. Extension Channel estimation is a challenging task in the orthogonal frequency division multiplexing, in our proposed work we use estimated power delay profile algorithm for channel estimation using additive white Gaussian noise channel. Estimation of channel estimation is done by using the ETU channel for better performance and low run time complexity.

REFERENCES [1] G. Stuber et al., “Broadband MIMO-OFDM wireless communications,” Proc. IEEE, vol. 92, no. 2, pp. 271–294, Feb. 2004. [2] I. Barhumi, G. Leus, and M. Moonen, “Optimal training design for MIMO OFDM systems in mobile wireless channels,” IEEE Trans. SignalProcess., vol. 3, no. 6, pp. 958–974, Dec. 2009. [3] W. U. Bajwa, J. Haupt, A. M. Sayeed, and R. Nowak, “Compressed channel sensing: A new approach to estimating sparse multipath channels,” Proc. IEEE, vol. 98, no. 6, pp. 1058–1076, Jun. 2010. [4] L. Dai, Z. Wang, and Z. Yang, “Spectrally efficient time-frequency training OFDM for mobile large-scale MIMO systems,” IEEE J. Sel. AreasCommun., vol. 31, no. 2, pp. 251–263, Feb. 2013. [5] Y. Barbotin and M. Vetterli, “Estimation of sparse MIMO channels with common support,” IEEE Trans. Commun., vol. 60, no. 12, pp. 3705–3716, Dec. 2012. [6] I. Telatar and D. Tse, “Capacity and mutual information of wideband multipath fading channels,” IEEE Trans. Inf. Theory, vol. 46, no. 4, pp. 1384– 1400, Jul. 2000. [7] L. Dai, J. Wang, Z. Wang, P. Tsiaflakis, and M. Moonen, “Spectrumand energy-efficient OFDM based on simultaneous multi-channel reconstruction,” IEEE Trans. Signal Process., vol. 61, no. 23, pp. 6047–6059, Dec. 2013. [8] P. L. Dragotti, M. Vetterli, and T. Blu, “Sampling moments and reconstructing signals of finite rate of innovation: Shannon meets Strang-Fix,” IEEE Trans. Signal Process., vol. 55, no. 5, pp. 1741–1757, May 2007.