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A Novel Literature Review on Channel Estimation in OFDM System

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Abstract- In this innovative information age, high data rate and strong reliability features our wire-less communication systems and is becoming the dominant factor for a successful deployment of commercial networks. MIMO-OFDM a new wireless broadband technology, has gained great popularity for its capability of high rate transmission and its robustness against multipath fading and other channel impairments. A major challenge to MIMO-OFDM systems is how to obtain the channel state in-formation accurately and promptly for coherent detection of information symbols and channel synchronization. A complex equivalent baseband MIMO-OFDM signal model is presented by matrix representation. This review paper addresses the wireless location problem which is mainly based on the OFDM technology. It is assumed that the observation data is corrupted by a zero-mean additive white Gaussian noise with a very small variance. Under this assumption, the noise term in the quasi-liner form is proved to hold a normal distribution approximately. Hence the ML (maximum-likelihood) estimation and the LS-type solution are equivalent.

Key Terms— Channel Estimation, OFDM, Sparse, Channel estimation, Orthogonal Matching Pursuit.

I. INTRODUCTION

Wireless Systems are operating in an environment which has some specific properties compared to fixed wire line systems and these call for special design considerations. In a wired network, there are no fast movements of terminals or reflection points and the channel parameters are changing very slowly. The Mobile Communication Systems are often categorized as different generations depending on the services offered. The fist generation comprises the analog frequency division multiple access (FDMA) systems such as the NMT and AMPS (Advanced Mobile Phone Services) [1]. The second generation consists of the first digital mobile communication systems such as the time division multiple access (TDMA) based GSM (Global System for Mobile Communication), D-AMPS (Digital AMPS), PDC and code division multiple access (CDMA) based systems such as IS-95. These systems mainly offer speech communication, but also data communication limited to rather low transmission rates. The third generation started operations on 1st October 2002 in Japan.

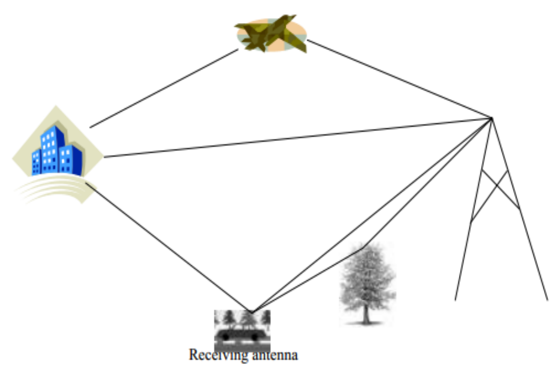

Fig. 1.2: Multipath Reception

During the past few years, there has been an explosion in wireless technology. This growth has opened a new dimension to future wireless communications whose ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with high data rates. To achieve such an objective, the next generation personal communication networks will need to be support a wide range of services which will include high quality voice, data, facsimile, still pictures and streaming video. These future services are likely to include applications which require high transmission rates of several Mega bits per seconds (Mbps). In the current and future mobile communications systems, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which leads to inter symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidates to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrow subchannels which are transmitted in parallel. Each subchannel is typically chosen narrow enough to eliminate the effect of delay spread. By combining OFDM with Turbo Coding 2and antenna diversity, the link budget and dispersive-fading limitations of the cellular mobile radio environment can be overcome and the effects of co-channel interference can be reduced.

II. WIRELESS SYSTEMS

A digital communication system is often divided into several functional units as shown in Figure 1.1. The task of the source encoder is to represent the digital or analog information by bits in an efficient way. The bits are then fed into the channel encoder, which adds bits in a structured way to enable detection and correction of transmission errors. The bits from the encoder are grouped and transformed to certain symbols, or waveforms by the modulator and waveforms are mixed with a carrier to get a signal suitable to be transmitted through the channel. At the receiver the reverse function takes place. The received signals are demodulated and soft or hard values of the corresponding bits are passed to the decoder. The decoder analyzes the structure of received bit pattern and tries to detect or correct errors. Finally, the corrected bits are fed to the source decoder that is used to reconstruct the analog speech signal or digital data input. In Figure 1.1: the modulator, the channel and the demodulator. The main question is how to design certain parts of the modulator and demodulator to achieve efficient and robust transmission through a mobile wireless channel.

The wireless channel has some properties that make the design especially challenging: it introduces time varying echoes and phase shifts as well as a time varying attenuation of the amplitude (fade). Orthogonal Frequency Division Multiplexing (OFDM) has proven to be a modulation technique well suited for high data rates on time dispersive channels [2]. There are some specific requirements when designing wireless OFDM systems, for example, how to choose the bandwidth of the sub-channels used for transmission and how to achieve reliable synchronization. The latter is especially important in packet-based systems since synchronization has to be achieved within a few symbols.

In order to achieve good performance the receiver has to know the impact of the channel. The problem is how to extract this information in an efficient way. Conventionally, known symbols are multiplexed into the data sequence in order to estimate the channel. From these symbols, all channel attenuations are estimated with an interpolation filter.

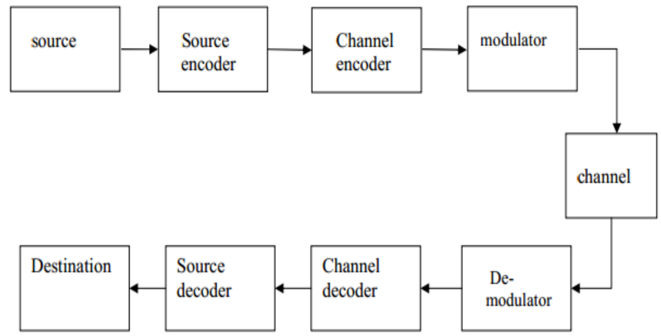

Fig1.1: Functional Block in a Communication System

For mobile or wireless applications, the channel is often described as a set of independent multipath components. The time varying impulse response can be described by [7]

$$h(t) = \sum_{i=0}^{M} a_i(t)\delta(\tau - \tau_i(t)) \qquad 1.1$$

Where $a_i(t)$ denotes the complex valued tap gain for path number i , $\tau_i(t)\tau$ is the delay of tap i , and δ is the Dirac delta function. Among the most important parameters when choosing the modulation scheme are the delay and the expected received power for different delays. Large delays for stronger paths mean that the interference between the different received signal parts can severe, especially when the symbol rate is high so that the delay exceeds several symbols.

III. LITERATURE REVIEW

In 2013, Researchers Zhanwei Hou, Yiqing Zhou and Jinglin Shi investigated OFDM based broadband wireless communications in high mobility with rapid time-varying Doppler shifts, where the received signal is significantly degraded by Doppler distortion. In a time-dispersive channel a modification is conducted to improve both estimators accuracy in a fading channel. In the simulation projected estimators are compared with existing single-carrier Doppler rate estimators to verify the effectiveness and efficiency of the proposed estimators in an OFDM system. Specifically results verify the low complexity of SOD estimator, the high accuracy of ML estimator, the insensitivity to initial Doppler shifts of both estimators and the accuracy improvement of modified estimators in a fading channel [6]. In 2013, Peng Cheng, Zhuo Chen and Yun Rui discovered

Channel estimation technique for an orthogonal frequency-division multiplexing broadband system over a doubly selective channel is very challenging. This is mainly due to the significant Doppler shift, which results in a time-frequency doubly-selective (DS) channel. Authors proposed a novel channel estimation system based on distributed compressive sensing (DCS) theory. The special decoupling form originating from a novel sparse pilot pattern is designed for such estimation, which results in an ICI-free structure and enables the DCS application to make joint estimation of these vectors accurately. Combined with a smoothing treatment process, the proposed scheme can achieve significantly higher estimation accuracy than the existing ones, although with a much smaller number of pilot subcarriers. Results confirm its performance merits.

In 2012, Elangovan, K. has done research in which to cancel the effect of fading, channel estimation and equalization procedure must be done at the receiver before data demodulation. In this work the comparisons of various algorithms, complexity and advantages, on the capacity enhancement for OFDM systems channel estimation techniques. Mainly three calculation algorithms are used in the equalizer to estimate the channel responses namely, Least Mean Square (LMS), Normalized Least Mean Square (NLMS) and Recursive Least Square (RLS) algorithms. These three algorithms are considered in this research work and performances are statically compared by using MATLAB Software [7].

In 2012, The-Hanh Pham and Ying-Chang Liang, presented an OFDM-based system under unknown narrow-band interference. Authors proposed an iterative receiver to jointly estimate the channel information, which consists of channel coefficients and noise-plus-interference variances of each sub-carrier, and detect the transmitted signals. The simulation outcomes show that the proposed receiver provides an extremely close bit-error-rate (BER) to that of the case where perfect channel information is available at the receiver. The mean-square-error (MSE) of the estimated parameters given by the proposed algorithm achieves improvement in performance [8].

In 2011, Niranjane, V.B.; Bhoyar and D.B. had given the research study in which multiple-input multiple communication system combined with the orthogonal frequency division multiplexing modulation technique can achieve reliable high data rate transmission over broadband wireless channels. The channel estimation based on comb type pilot arrangement through different algorithms for estimating channel at pilot frequencies. The estimation of channel at pilot frequencies is based on LS and MMSE channel estimation algorithm. The compared performances of channel estimation algorithm by measuring bit error rate vs. SNR with 16QAM modulation schemes. MMSE estimation has been shown to perform much better than LS but is more complex than LS for the MIMO [9].

In 2011, M.K. Gupta, S Shrivastava, and Raghuvanshi, presented the channel estimation is a process of characterizing the effect of the transmission channel on the input signal. In this research work authors compare the performance of Least Square (LS) and Linear Minimum Mean Square Error (LMMSE) channel estimation technique for Wavelet based OFDM system. The channel estimation based on block type pilot arrangement is performed by sending pilots at every sub-channel and using this estimation for a specific number of following symbols. In this paper we used wavelet transform instead of fast Fourier transform (FFT), which have more bandwidth efficiency, less prone to Doppler shift [10].

In the year 2010, Ming Liu, Crussiere, M. and Hélard, J. researched in time domain synchronous (TDS)-OFDM, the channel estimation is conventionally carried out based on the pseudo noise (PN) sequence. The PN sequence based channel estimation however suffers interference from adjacent OFDM data symbols. I this the data-aided channel estimation is carried out using the rebuilt OFDM data symbols as virtual training symbols. In contrast to the classical turbo channel estimation, interleaving and decoding functions are not used when rebuilding OFDM data symbols thereby reducing the complexity. 2-D estimate refinement and interpolation are proposed to improve the data-aided channel estimation. Results show that the performance of TDS-OFDM based DTMB system using the presented technique is very close to that with ideal channel estimation in terms of bit error rate [11].

In 2010, Wanlu Sun, Wei Yang and Lihua Li investigated the MIMO-OFDM systems, some subcarriers are often retained as virtual subcarriers for easier filter implementation and the performance of Discrete Fourier Transform (DFT)-based channel estimation will be degraded significantly due to dispersive distortion of actual channel impulse response (CIR). To overcome with this problem, researchers analyzed the effect of virtual subcarriers on channel estimation in theory and offer an effective channel estimation scheme. The projected method, which is based on Schur recursive algorithm, can expand channel frequency response (CFR) into all subcarriers with quite concise operations. Results show that the proposed scheme outperforms LS estimator and DFT-based channel estimator, in terms of both MSE and FER [12].

In 2009, Shih-Hao Fang, Ju-Ya Chen and Ming-Der Shieh presented A modified subspace-based blind channel estimation algorithm for OFDM systems. They showed that the OFDM symbols can be used to satisfy the necessary condition for achieving a full-row-rank signal matrix. Simulation outcomes show that the proposed algorithm outperforms conventional method in mean-squared error and bit error rate under static channel. Even with a smaller number of received OFDM symbols, the proposed method can perform well [13].

IV. LIMITATIONS IN EXISTING SYSTEM

1. Efficient channel estimation required the lower value of mean square error(MSE) and there is scope to do this, we will reduce this using our proposed approach.

Compressed Sensing is complex in terms of operation because it works on monitoring of channels continuously which is complex in operation.

V. PROPOSED METHODOLOGY

The proposed methodology to improve the estimation of channel based on OFDM wireless communication system we will work on below mentioned techniques either any one or combination of all three. Here we will try to reduce the mean square error (MSE).

1) We can use more advance modulation technique than in the base paper
   - 32-QAM or 64-QAM etc.
2) Filtering Technique at the receiver side to detect signal and reduce effect of noises
   - Median Filtering or,
   - Moving Average Filtering or,
   - FIR or IIR Filtering etc.
3) Space Diversity e.g. Antenna Diversity to enhance the reception/detection power

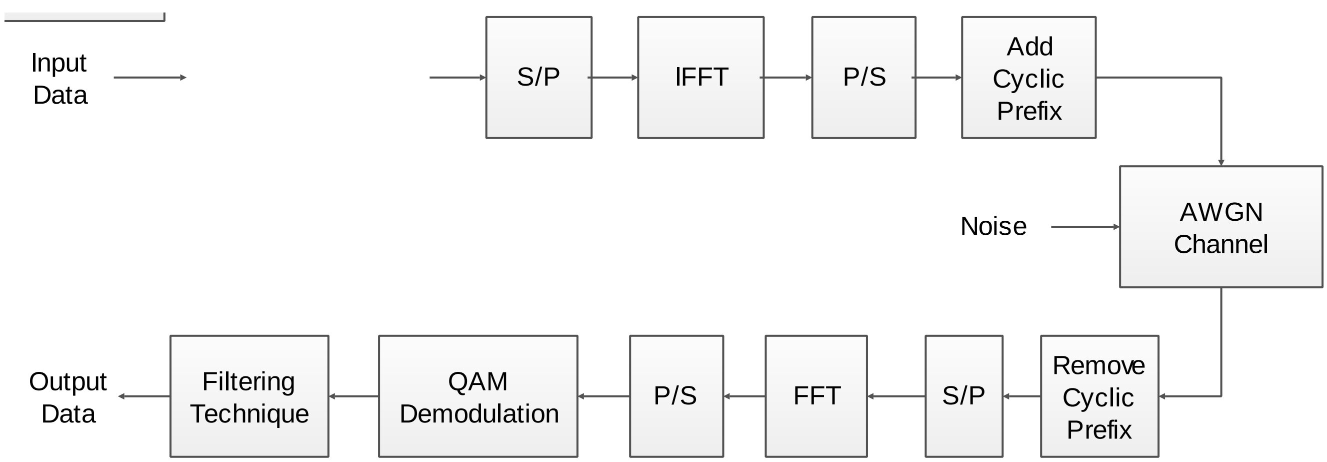

Fig. 4.1 Block Diagram of Proposed Approach

VI. CONCLUSIONS

In this review paper we address the problem of channel estimation of MIMO-OFDM systems. It starts from the matrix representation of the signal model of MIMO-OFDM systems, which clearly describes the relation of signals in frequency domain and time domain and expressing operations like adding CP and removing CP as matrix product. From the resulting MIMO-OFDM signal model, a pilot tone based channel estimation can be proposed with filtration technique to estimate the fast time-varying and frequency selective fading channel via the least-squares method. The least-squares is selected for the purpose of low complexity, though some other methods such as MMSE and ML may produce better estimation performance. To further reduce the computational complexity, the pilot tone matrix is designed as a unitary matrix to save the computation of the matrix inversion in the standard LS solution. Compared with some relative pilot tone designs in the literature, our channel estimation method differs in its ability to estimate fast time-varying wireless channel since pilot tones are inserted into each OFDM block lower complexity for MIMO-OFDM systems, we are looking at the following aspects in the future.

REFERENCES

[1] Rappaport, T., Wireless Communication: Principles and Practice. New Jersey: Prentice Hall, 1996.

[2] Chang, R., “Synthesis of band limited Orthogonal Signals for multichannel data transmission.” Bell System Technical Journal. vol. 46, (December 1996): pp. 1775-1796.

[3] Proakis, J., Digital Communications. New York: McGraw-Hill, 1998.

[4] Torrance, J., and Hanzo, L., “Comparative study of pilot symbol assisted modem systems.” Proceedings of IEEE conference on Radio Receivers and Associated Systems, Bath UK, (September 1995): pp. 36-41.

[5] Weinstein, S. and Ebert, P., “Data Transmission by Frequency Division Multiplexing using the Discrete Fourier Transform.” IEEE Transaction Communication Technology.vol. COM-19, (October 1971): pp. 628-634.

[6] Bello, P. A., “Selective Fading limitations of the KATHRYN modem and some system design considerations.” IEEE Transaction Communication Technology. vol.COM-13, (1965): pp. 320-333.

[7] Zimmerman, M. and Krisch, A., “The AN/GSC-10/KATHRYN/ variable rate data modem for HF radio.” IEEE Transaction Communication Technology. vol.CCM-15,(April 1967): pp.197-205.

[8] Hirosaki, B., “An analysis of automatic equalizers for orthogonally multiplexed QAM systems,” IEEE Transaction Communication Technology. vol. COM-28, (January 1980): pp. 73-83.

[9] Peled, A. and Ruiz, A., “Frequency Domain Data Transmission using Reduced Computational Complexity Algorithms.” Proceedings of International Conference on Acoustics. vol. 3, (April 1980): pp. 964-967.

[10] Ketel, I., “The Multitone Channel.” IEEE Transaction on Communication. vol. 37, (February 1989): pp. 119-124.

[11] Fazel, K. and Fettis, G., “Performance of an Efficient Parallel Data Transmission System.” IEEE Transaction Communication Technology. (December 1967): pp. 805-813. 46

[12] Meyr, H., Moeneclaey, M. and Fechtel, S. A., Digital Communicatio Receivers. John Wiley and Sons, 1998.

[13] Li, Y., Seshadri, N. and Ariyavisitakul, S., “Channel Estimation for OFDM systems with transmitter diversity in mobile wireless channels.” IEEE J. Select. Areas Communication (March 1999): pp. 461-470.

[14] Moher, M. L. and Lodge, J. H., “TCMP- a modulation and coding strategy for Rician fading channels,” IEEE Trans. Communication Technology. (December 1967): pp.805-813.

[15] Aghamohammadi, A., Meyr, H., and Asheid, G., “A new method for phase synchronization and automatic gain control of linearly modulated signals on frequency flat fading channels,” IEEE Trans. Communication Technology. (January 1991): pp.25-29.

[16] Cavers, J. K., “An analysis of Pilot symbol assisted modulation for Rayeigh fading channels.” IEEE Transaction on Vehicular Technology. vol. 40(4), (November 1991):pp. 686-693.

[17] Moon, JAe Kyoung and Choi, Song In., “Performance of channel estimation methods for OFDM systems in multipath fading channels.” IEEE Transaction on Communication Electronics. vol.46, (February 2000): pp. 161-170.

[18] Tufvesson, F., Faulkner, M., Hoeher, P. and Edfors, O., “OFDM Time and Frequency Synchronization by spread spectrum pilot technique.” 8th IEEE Communication Theory Mini Conference in conjunction to ICC’99, Vancouver, Canada, (June 1999): pp. 115-119.

[19] Tufvesson, F. and Hoeher, P., “Channel Estimation using Superimposed pilot Sequences,” IEEE Trans. Communication (March 2000).

[20] Moon, T. K., “The Expectation Maximixzation Algorithm.” IEEE Signal Processing Magazine. vol. 13, (November 1996): pp. 47-60.

[21] Xiaoqiand, Ma., Kobayashi, H. and Schwartz, Stuart C., “An EM Based Estimation of OFDM Signals.” IEEE Transaction Communication. (2002).

[22] Edfors, O., Sandell, M.,Van de Beek, J. J., Wilson, S. K. and Boriesson, P. O., “Analysis of DFT-based channel estimators for OFDM.” Vehicular Technology Conference. (July 1995). 47

[23] Coleri, S., Ergen, M., Puri, A. and Bahai, A., “Channel Estimation Techniques based on Pilot Arrangement in OFDM systems,” IEEE Transaction on Broadcasting. (September 2002).

[24] Edfors, O., Sandell, M., Van de Beek, J. J., Wilson, S. K. and Boriesson, P. O., “OFDM Channel Estimation by Singular Value Decomposition.” IEEE Transaction on Communication. vol. 46(7), (July 1998): pp. 931-939.

[25] Wang, X., Ray Liu, K. J., “OFDM Channel Estimation based on time frequency polynomial model of fading multipath channels.” IEEE Transaction on Communication. (June 2001).

[26] Julia Fernadez-Getino Garcia, M., Edfors, O. and Paez-Borrallo, Jose M., “Frequency offset correction for coherent OFDM in mobile cellular systems.” Proceedings of IEEE. (2001).

[27] Tufvesson, F. and Maseng, T., “Pilot Assisted Channel Estimation for OFDM in Mobile Cellular Systems,” Proceedings of IEEE Vehicular Technology Conference, Phoenix USA, (May 1997):pp. 1639-1643.

[28] Hieh, MEng-Han and Wei, Che-Ho, "Channel Estimation for OFDM Systems based on COMB-Type Pilot arrangement in frequency selective fading channels." IEEE Transaction Communication. (1998).

[29] Van de Beek, J. J., Edfors, O., Sandell, M., Wilson, S.K., and Borjesson, P. O., "On Channel Estimation in OFDM Systems." Proceedings IEEE 45th Vehicular Technology Conference. Chicago, IL., (July 1995): pp. 815-819.

[30] Fazel, K. and Fettwis, G., "Performance of an efficient parallel Data Transmission System." IEEE Transaction Communication Technology. (December 1967): pp. 805-813.

[31] Warner, W. and C. L. Leung C. L., "OFDM/FM frame synchronization for mobile radio data communication." IEEE Transaction on Vehicular Technology. vol. 42, (August 1993): pp. 302-313.

[32] Cimini, L. J., "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing." IEEE Transaction Communication. vol. 33, no. 7, (July 1985): pp. 665–675. 48

[33] Li, Y., "Pilot-symbol-aided channel estimation for OFDM in wireless systems." IEEE Transaction Vehicular Technology. vol. 49, no. 4,(Jul. 2000).

[34] Bahai, A. R. S. and Saltzberg, B. R., Multi-Carrier Digital Communications: Theory and Applications of OFDM. Kluwer Academic/Plenum, 1999.

[35] Cai, Xiaodong and Giannakis, Georgious B., "Error Probability Minimizing Pilots for OFDM with M-PSK Modulation Over Rayleigh-Fading Channels." IEEE Transaction.Vehicular Technology. vol. 53, no.1, (January 2004): pp. 146-145.