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Channel Estimation and Signal Detection for 5G Using Multi-Carrier Communication

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ABSTRACT: This project presents our initial results in deep learning for channel estimation and signal detection in cyclic prefix-orthogonal frequency-division multiplexing (CP-OFDM) systems. In this project, we exploit deep learning to handle wireless CP-OFDM channels in an end-to-end manner. Different from existing CP-OFDM receivers that first estimate channel state information (CSI) explicitly and then detect/recover the transmitted symbols using the estimated CSI, the proposed deep learning based approach estimates CSI implicitly and the transmitted symbols are recovered directly. From our proposed system, the deep learning based approach can address channel distortion and detect the transmitted symbols with performance comparable to the minimum mean square error (MMSE) estimator. The proposed approach adopts the repetitive signal structure of CP-OFDM, such as the cyclic prefix (CP), which can be used for synchronization purpose. After gaining insights into the log-likelihood (LL) function, the originally derived ML estimation results in a high computational cost. To suppress the STO (Sampling Timing Offset) and CFO (Carrier Frequency Offset), we address the synchronization problem in non-continuous CA scenario and propose a block type pilot based synchronization algorithm. The pilot pattern used here is Linear Constant Frequency Zero Autocorrelation (LCFZA) sequence, which is also exploited in multi-carrier advanced standard. Different bands could experience different synchronization errors, since the proposed method is a parallel processing. Simulation results show the proposed method can significantly improve smooth performance and has system performance when synchronization errors vary.

KEYWORDS: CP-OFDM(Cyclic Prefix-Orthogonal Frequency Division Multiplexing), LMMSE(Linear Minimum Mean Square Estimator), CSI(Channel State Information), LL(Log-Likelihood), STO(Sampling Timing Offset), CFO(Carrier Frequency Offset), LCFZA(Linear Constant Frequency Zero Autocorrelation) sequence.

I. INTRODUCTION

Driven by the rapid escalation of the wireless capacity requirements imposed by advanced multimedia applications (e.g., ultrahigh-definition video, virtual reality, etc.), as well as the dramatically increasing demand for user access required for the Internet of Things (IoT), the fifth-generation (5G) networks face challenges in terms of supporting

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large scale heterogeneous data traffic. Waveforms have been consistently and fundamentally shaping the development of wireless communications. The OFDM waveform specified in LTE has a rather low spectral decay rate. Consequently, concurrent transmissions in different subbands must be precisely synchronized in time (and frequency) if they are not to interfere strongly with each other[3].so CP-OFDM, constitutes a promising technology of addressing the aforementioned challenges in 5G networks by accommodating several users within the same orthogonal resource block. By doing so, significant bandwidth efficiency enhancement can be attained over conventional orthogonal multiple-access (OMA) techniques. This motivated numerous researchers to dedicate substantial research contributions to this field. In this context, we provide a comprehensive overview of the state of the art in power domain multiplexing-aided CP-OFDM, with a focus on the theoretical CP-OFDM principles, multiple-antenna-aided CP-OFDM design, on the interplay between CP-OFDM and cooperative transmission, on the resource control of CP-OFDM, on the coexistence of CP-OFDM with other emerging potential 5G techniques and on the comparison with other CP-OFDM variants. We highlight the main advantages of power-domain multiplexing CP-OFDM compared to other existing OFDM techniques. We summarize the challenges of existing research contributions of CP-OFDM and provide potential solutions. Finally, we offer some design guidelines for CP-OFDM systems and identify promising research opportunities for the future.

II. PROPOSED SYSTEM

In wireless CP-OFDM systems, the time-varying channel is often estimated by algorithms based on pilot symbols. However, it needs statistical prior knowledge that is not easily obtained. Therefore, the pilot tones have to be close enough to satisfy the sampling theorem. we explore optimal training sequences in OFDM systems and we analyze the number of pilot symbols required to satisfy the sampling theorem. In high speed wireless communications, Orthogonal Frequency Division Multiplexing (OFDM) has become a popular modulation method. By partitioning a wideband fading channel into flat narrowband channels, OFDM is able to minimize the detrimental effects of multipath fading using a simple one-tap equalizer. OFDM is a worthy candidate for high data rate transmission with forward error correction (FEC) methods over wireless channels. In this project the system throughput of a working OFDM system has been further improved by adding turbo coding. Proposed system is to be done over additive white Gaussian noise (AWGN) and impulsive noise (which is produced in broadband transmission) channels. In this paper Bit Error Rate performance of OFDM, QPSK, and 16-QAM System over Rayleigh fading channel is analyzed. LMMSE-FDE with colored noise samples is proposed and the BER performance is evaluated by simulation to show that significant performance improvement can be achieved [4]. Finally simulations of OFDM signals are carried with Rayleigh faded signals to interpret the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) and Signal to noise ratio (SNR).

III. ADVANTAGES OF PROPOSED SYSTEM

- Ensure planned coverage for each service.
- Ensure required connection quality.
- Optimize the system usage in run time.
- Maximum Capacity utilization
- Low Bit error rate
- High Signal to Noise ratio
- Reduced ISI (Inter Signal Interference)
- ICI reduction
- Frame Error Rate reduction

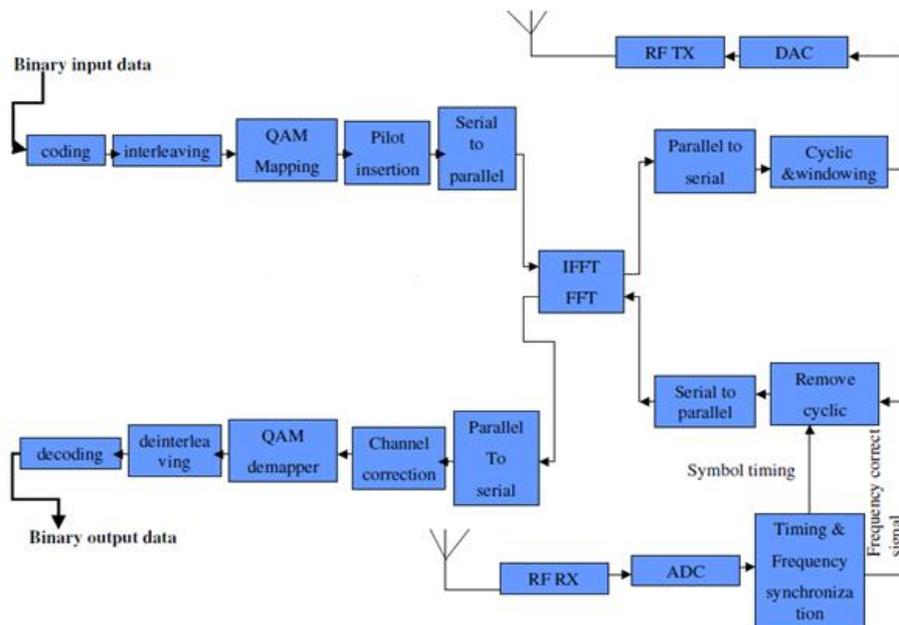
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IV. PROPOSED BLOCK DIAGRAM



A. Input data:

Generation of binary input data with respect to 9.6KHz Baudrate.

B. Convolutional encoder:

Encoders and decoders working on permuted versions of the same information. The Convolutional encoder can be represented by their generator polynomials. The Convolutional encoding is a continuous process where the output depends on the K previous inputs of the encoder.

C. Quadrature amplitude modulation (QAM):

QAM is an analog as well as digital modulation scheme. It transports two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are added, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation. A finite number of at least two phases and at least two amplitudes are used. In the digital QAM case, since the amplitude of the modulated carrier signal is constant, PSK modulators are often designed using the QAM principle, but not considered as QAM. In digital telecommunication systems, QAM is used extensively as a modulation scheme. Arbitrarily high spectral efficiencies can be attained with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel.[5] It can be summarised that BER performance of QAM modem is depend to M-ary number of QAM.

D. Serial to parallel conversion and parallel to serial conversion:

This is a modest method to convert a serial data that have been entered to the circuit into parallel one. The inverse parallel to serial can be done in a similar manner. A serial-in/parallel-out shift register is corresponding to the serial-in/serial-out shift register in that it shifts data into internal storage elements and shifts data out at the serial-out, data-out, pin. It is distinct in that it makes all the internal stages available as outputs. Therefore, a serial-in/parallel-out shift register changes data from serial format to parallel format. If four data bits are shifted in by four clock pulses through a

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single wire at data-in, below, the data becomes available simultaneously on the four Outputs QA to QD after the fourth clock pulse.

E. IFFT:

FFT and IFFT are both two linear transformations on signals and are the reverse of each other. Hence applying FFT on a signal x followed by IFFT will replicate x . Similarly, applying IFFT on the same signal x followed by FFT will again replicate x . Therefore, as a fact, it does not matter whether you apply FFT (IFFT) at transmitter as long as you apply the reverse transform; i.e. IFFT (FFT) at the receiver. The query becomes then why we use IFFT at transmitter and not FFT. Be sure that signals need to be modulated by say N-QAM of the orthogonal subcarriers.

F. Pilot data insertion:

Pilots are used to route the residual phase error if present after frequency correction. Without this correction the constellation points starts rotating either +ve or -ve angle. It is very much sensitive at higher constellation. Pilot sequences are the un-modulated data we are transmitting along with the data. Pilots are used for synchronization and Channel estimation purposes. Channel estimation is the main thing we need to concentrate for improving the channel capacity. More the number of pilots more efficiently we can estimate the channel and increase the capacity. But as pilots increases overhead increases. so the selection of pilots is such that tradeoff should be considered between spectral efficiency and pilot symbols. In IEEE 802.11 OFDM standard we are using 64 sub-carriers per OFDM symbol in these 64, 48 are for data and 4 are Pilot and remaining are for zero-padding. This paper proposed an interference-free pilot insertion technique for channel estimation in a non-orthogonal multicarrier system[6].

G. Cyclic prefix extension:

Cyclic prefix is frequently used in conjunction with modulation in order to retain sinusoids' properties in multipath channels. It is well known that sinusoidal signals are eigenfunction of linear, and time-invariant systems. Therefore, if the channel is assumed to be linear and time-invariant, then a sinusoid of infinite duration would be an eigenfunction. However, in practice, this cannot be achieved, as real signals are always time-limited. So, to mimic the infinite behavior, prefixing the end of the symbol to the beginning makes the linear convolution of the channel appear as though it were circular convolution, and thus, preserve this property in the part of the symbol after the cyclic prefix.

H. DAC:

A digital-to-analog converter (DAC, D/A, D2A or D-to-A) is a function that transforms digital data (usually binary) into an analog signal (current, voltage, or electric charge). An analog-to-digital converter (ADC) execute the reverse function. Unlike analog signals, digital data cannot be transmitted, manipulated, and stored without degradation, albeit with more complex equipment. But a DAC is needed to convert the digital signal to analog to drive an earphone or loudspeaker amplifier in order to produce sound (analog waves).

I. Channalization:

Additive white Gaussian noise (AWGN) is a basic noise model used in digital communication theory to mimic the effect of many random processes that occur in nature. The modifiers denote specific characteristics:

'Additive' since it is added to any noise that might be intrinsic to the information system.

'White' mention the idea that it has uniform power across the frequency band for the information system. It is comparable to the color white which has uniform emissions at all frequencies in the visible spectrum.

'Gaussian' since it has a normal distribution in the time domain with an average time domain value of zero.

J. Equalizer:

Equalizer designs the filter to minimize error, where e is the error signal, which is the filter output minus the transmitted signal. It focuses on a subclass of equalization algorithms that minimizes the Linear Mean Square Error (LMMSE) between the desired and estimated signal.

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V. APPLICATION

1. Wi-Max(Worldwide Interoperability for Microwave Access)
2. LTE(Long Term Evolution)
3. IoT(Internet of Things)

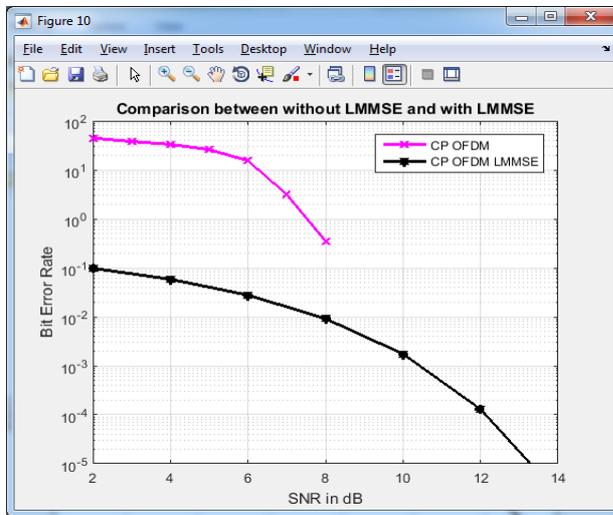


Fig.1. Comparison between without LMMSE and with LMMSE

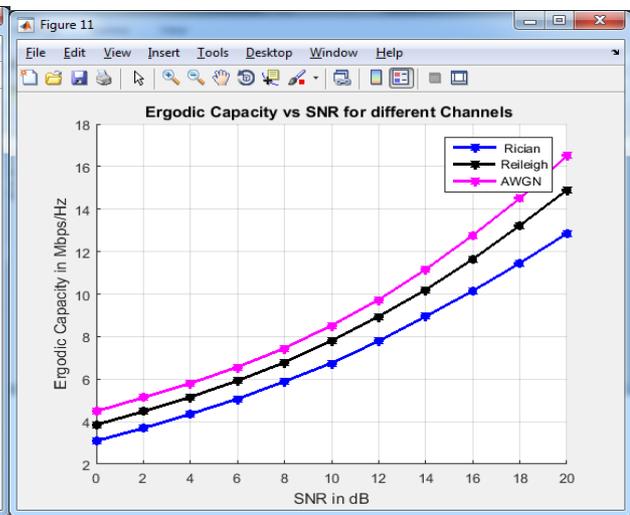


Fig. 2. Ergodic capacity vs SNR for different Channels

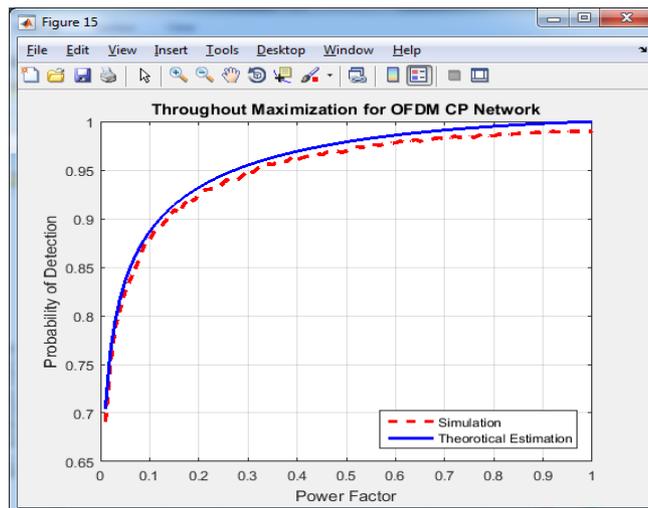


Fig. 3. Throughput maximization for OFDM CP Network

VI. CONCLUSION

In this work, we presented a new channel estimation method for high-mobility CP-OFDM systems for 5G. The estimation complexity is reduced by the proposed channel model by utilizing the position information. The pilot symbol and the placement are jointly designed by the proposed algorithm to minimize the system average coherence. Simulation results demonstrate that the proposed method achieves better performances than existing channel estimation

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methods over high-mobility channels. Furthermore, the proposed scheme is feasible for many current wireless OFDM communication systems.

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