DETERMINISTIC TECHNIQUES FOR BLIND ESTIMATION IN ORTHOGONAL FREQUENCY DIVISION MULTIPLEXED SYSTEMS

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Certificate

This is to certify that the dissertation entitled 'Deterministic Techniques for Blind Estimation in Orthogonal Frequency Division Multiplexed Systems', being submitted by Ms Anubala ~~Susan~~ Varikat, is in fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Electrical Engineering of the Indian Institute of Technology, Delhi. This is a record of the candidate's own work carried out by her under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree or diploma.

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Abstract

In this thesis, we have attempted to develop some techniques for the blind estimation and synchronization of OFDM systems with a view to improve their performance specially while working with short data records. Since most statistical techniques necessarily use large data sizes, and hence a large number of data blocks in the case of OFDM systems, we have investigated the use of deterministic techniques for this purpose. Almost all techniques presented here use some special features / properties of OFDM signals. Our studies have led us to several new algorithms for blind estimation of OFDM systems. A brief summary of the major results of the thesis is given below.

We first present brief overviews of OFDM, and of current trends in the blind estimation of OFDM systems. We also present a brief introduction to the work described in this thesis. The work described in the thesis falls roughly into three categories: the blind estimation of multiple output OFDM systems in the frequency domain, the blind estimation of single output OFDM systems in the time domain, and the blind synchronization of multiple output OFDM systems.

Some basic issues related to the blind estimation of OFDM systems are considered next. Since a SISO OFDM system with cyclic prefix cannot be blindly estimated deterministically, we explore ways of working with SIMO OFDM systems, and incorporating the effect of the cyclic prefix into the algorithm so as to obtain better estimation.

Here, we present the basic SIMO OFDM system model with which we are concerned in most of the dissertation. We also present the problem formulation in the frequency domain. The ML solution to the problem is derived, which is complex and hard to implement. We develop a simple ad-hoc cross-relations based method for channel estimation, the FDCR method, that gives perfect performance in the absence of noise, but is sub-optimal in the presence of noise. The necessary and sufficient conditions for the identifiability of the system arre derived. Next, the FDCR method is used in an iterative framework exploiting the finite nature of the channel and the finite alphabet property of the input, to approximate the ML-solution to the problem. The method, which we call the FDML method, is simply implemented, and is seen to give good performance. The approach utilizes only two blocks of OFDM symbols for the estimation.

Next, we propose a new scheme for least squares frequency domain symbol estimation in OFDM systems, which we call the FDSE technique. The necessary and sufficient conditions for identifiability are derived. We show how the presence of precoding in the system could be used effectively with the FDSE technique for improved estimation, and also for estimation of the SISO system. The precoding introduces redundancy into the system, and there is a tradeoff between throughput and performance. Our simulation results show that the FDSE method performs slightly worse than the FDCR method proposed earlier. The proposed precoding-based methods perform better than existing precoding-based schemes.

Next, an approach for blindly estimating OFDM systems with space-time coding is considered. A transmission scheme with two transmit antennas and either two receive antennas or a single receive antenna with oversampling, and a constant modulus input, is proposed. A method of blindly estimating the system, on the lines of the FDSE technique presented earlier in the thesis, is proposed. We derive a necessary identifiability condition. The method gives perfect performance in the absence of noise. Simulation results indicate the

improvement in performance obtained by the introduction of ST coding into the OFDM system.

The blind estimation of SIMO systems has certain drawbacks, such as the requirement for co-prime channels. We therefore consider the blind estimation of zero-prefix SISO OFDM. We propose and study a scheme that could be effective in certain restricted scenarios. The equalization technique, which we call the ZPCR method, uses cross relations between two blocks of OFDM symbols, and can work with only two blocks, as compared to the existing ZPSS method, which requires as many blocks as the block size, for identifiability. We derive the necessary and sufficient conditions for identifiability. The method gives perfect performance in the absence of noise. However, at lower values of SNR, it fails to have wide applicability as the performance deteriorates with increasing block size, and saturates as the block size is increased, so that for any given SNR, the performance cannot be improved beyond a certain point by increasing the size of the observation window.

Finally, we propose a scheme for the joint blind synchronization and estimation of OFDM systems. The approach is to use an existing symbol estimation method in conjunction with a blind algorithm, based on the presence of either the cyclic prefix or precoding in the system, for removing the effects of frequency offset. Frame timing can also be determined using the scheme. Simulation results indicate that the method has comparable performance to existing schemes. The cp-based method proposed here performs better than existing cp-based schemes. The method based on precoding is seen to perform slightly worse than existing virtual-carriers based schemes, but is likely to give better symbol error rate performance due to the joint symbol and frequency estimation, that also exploits the precoding. Our simulations indicate that the proposed method effectively removes the effect of the frequency offset upon the symbol estimation.

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