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Review and Survey of Optimum Clustered Pilot Sequence for Of dm Systems under Rapidly Time-Varying Channel

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Abstract

As channel time-variation increases, orthogonality among subcarriers in an orthogonal frequency division multiplexing (OFDM) symbol can be destroyed because of the relatively long symbol period, whereupon intercarrier interference (ICI) appears. The grouping pilot tones into a number of equally

Spaced clusters can yield better channel estimation against the doubly selective channel than placing each pilot tone in an equally spaced manner. To enhance the better channel estimation various techniques are engaged. This review paper demonstrates some commonly engaged techniques to fabricate OFDM with reduce ICI and high performance since last few decades.

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I. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) has been adopted in many standards, such as digital TV and Digital Video Broadcasting-Terrestrial (DVB-T). Orthogonality among the subcarriers in the OFDM system can be destroyed because of the relatively long symbol period, where intercarrier interference (ICI) and hence an irreducible error floor can occur [2]. The rapidly time-varying channel environment can make even the channel estimation difficult due to the presence of the ICI [3]. The channel estimator of the minimum MSE will be derived by applying the maximum likelihood (ML) rule and the optimum pilot sequence of the minimum MSE can be obtained by solving a nonlinear least square (NLS) problem and that the optimal clustered pilot sequence is independent of a signal-to-noise ratio (SNR) and a Doppler rate.

An optimal clustered pilot sequence can be precalculated and prestored for a given pair of SNR and Doppler rate; hence, the complexity of the proposed system can be as low as that of the randomly chosen cluster pilot system in [4]. The proposed optimum or suboptimum sequence cannot influence the ICI in the data tones. To achieve significant improvement from better channel estimation many techniques are used and some of them are explained further in review this paper.

II. Techniques Of Optimal Design And Placement Of Pilot Symbols For Channel Estimation

The problem of designing and placing pilot symbols for the estimation of frequency-selective random channels is considered for both single-input single-output (SISO) and multiple-input multiple-output (MIMO) channels. In this section techniques for better Channel Estimation are explained Particle swarm optimization [5], the Cramér–Rao Bound (CRB)[6], Bayesian Cramer-Rao Bound (BCRB)[7] are mainly used for channel estimation.

2.1. Particle swarm optimization

In PSO, simple software agent called as particles that represent as potential solutions are placed in the search space of function and evaluate the objective function at their current location. Particle swarm optimization used for the optimization of location and (or) power of pilot tones. Each particle searches for better position in the search space by changing velocity according to rules that is mentioned as follows-

Each particle i has $x_i = (x_i^1, x_i^2, \ldots, x_i^D)$ position vector and $v_i = (v_i^1, v_i^2, \ldots, v_i^D)$ velocity vector, where D is dimension of solution space. Initially, velocity and position of particles are generated randomly in search space. At each iteration, the velocity and the position of particle
i on dimention d are updated as shown below

$$v_i^d(t+1) = wv_i^d(t) + c_1 r_i^1(t)\left(\text{pbest}_i^d(t) - x_i^d(t)\right) + c_2 r_i^2(t)\left(\text{gbest}^d - x_i^d(t)\right)$$

$$x_i^d(t+1) = x_i^d(t) + v_i^d(t+1)$$

$$\text{pbest}_i^d = (p_i^1, p_i^2, \ldots, p_i^D)$$

$$\text{gbest}^d = (p^1, p^2, \ldots, p^D)$$

Where is the previous best position of particle i is the best position among all particles, *r*1 *i* and *r*2 *i* are uniformly distributed numbers in the interval [1, 0], c1 and c2 are cognitive and social parameters and w is inertia weights that are used to maintain momentum of particle [8-10]. The inertia weight w is employed to control the impact of the previous history of velocities on the current velocity, thereby influencing the tradeoff between global and local exploration abilities of the flying points. Inertia weight w is linearly decreased from wmax to wmin according to

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{\text{iteration}_{\max}} \times \text{iteration}$$

The PSO algorithm steps have been applied as illustrated in Figure 1, the particles that represent pilot positions are initialized at random values between 0 and 127 for the system which has 128 subcarriers, and 0 and 63 for the system which has 64 subcarriers. If the fitness of particle's current position is better than its previous best position, the velocity and position of particle are updated. These processes are repeated till the stopping criteria are carried out that are 3000 iterations and 1000 iterations for the systems which have 128 subcarriers and 64 subcarriers, respectively. After the fixed number of iterations, best global particles are chosen as pilot tones positions. Besides, the powers of pilot tones are optimized as mentioned above. However for this purpose, the particles called as power of pilot tones are initialized at random values between 0 and 1. PSO also avoids exhaustive searches to optimize pilot tones location.

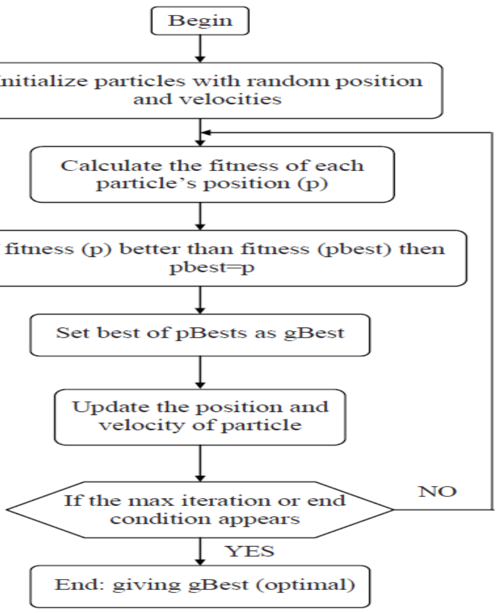

Figure 1- PSO algorithm flow diagram

2.2 Cramér–Rao Bound (CRB)

The Cramer-Rao bound (CRB) for data-aided channel estimation for OFDM with known symbol Padding .The pilot symbols used to estimate the channel are distributed over the guard interval and OFDM carriers, in order to keep the guard interval length as small as possible. An analytical expression for the CRB is obtained by performing a proper linear transformation on the observed samples. At low SNR, the CRB corresponds to the low SNR limit of the CRB obtained in [11], where it is assumed that the influence of the data symbols on the channel estimation can be neglected. At high SNR, the CRB is determined by the observations that are independent of the data symbols. The CRB depends on the number of pilots and slightly increases with increasing guard interval length, but is essentially independent of the FFT size and the used pilot sequence.

The length of the guard interval is typically small as compared to the FFT length the number of known samples is typically too small to obtain an accurate estimate for the channel. To improve the channel estimation, the number of pilot symbols must be increased. This can be done by increasing the guard interval length, which is not favorable as this will reduce the OFDM system efficiency or by keeping the length of the guard interval constant and replacing in the data part of the signal some data carriers by pilot carriers. The guard interval consisting of ν known samples is inserted after each OFDM symbol figure 2, resulting in the time-domain samples si during block i:

$$\mathbf{s}_i = \sqrt{\frac{N}{N+\nu}} \begin{pmatrix} \mathbf{F}^{+}\mathbf{a}_i \\ \mathbf{b}_g \end{pmatrix}$$

Where F is the N × N matrix corresponding to the FFT operation, i.e.

$$\mathbf{F}_{k,\ell} = \frac{1}{\sqrt{N}} e^{-j2\pi\frac{k\ell}{N}} \quad \text{and} \quad \mathbf{b}_g = (b_g(0), \ldots, b_g(\nu-1))^T$$

Corresponds to the v known samples of the guard interval.

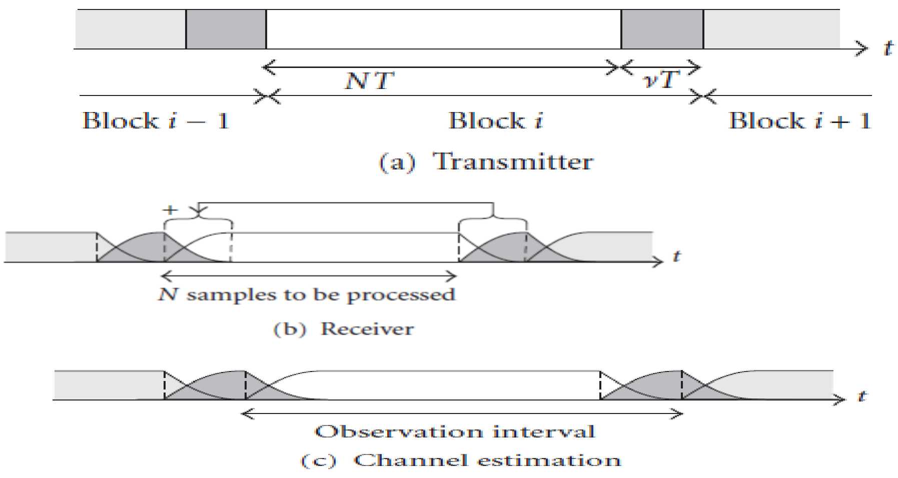

Figure 2: Time-domain signal of OFDM: (a) transmitted signal, (b) received signal and observation interval for data detection, and (c) observation interval for channel estimation.

To estimate the channel, we assume M pilot symbols are available. As we select the length of the guard interval in function of the channel impulse length and not in function of the precision of the estimation, only v of the M pilot symbols can be placed in the guard interval. This implies that M – v data carriers are replaced by pilot carriers.

2.3. Bayesian Cramer-Rao Bound

The Bayesian Cramer- Rao bound (BCRB) for the dynamical estimation of multi-path Rayleigh channel complex gains in OFDM systems. This bound is derived in high Doppler scenarios [12] for time-varying complex gains within one OFDM symbol, assuming the availability of prior information. The benefit of using the a priori information and, the past and the future observations for the complex gains estimation. Let

$\hat{\mathbf{c}}(\mathbf{y})$ denotes an unbiased estimator of **c** using the set of measurements **y**. The estimation of **c** can be considered following two main scenarios off-line and on-line. The receiver waits until the whole observation frame,

$$\mathbf{y} = [\mathbf{y}_{(1)}{}^T, ..., \mathbf{y}_{(n)}{}^T]^T,$$
$$\mathbf{c} = [\mathbf{c}_{(1)}{}^T, ..., \mathbf{c}_{(K)}{}^T]^T$$

has been received in order to estimate.In the sequel, the BCRB will be considered within the context of both the off-line and the on-line scenarios. The BCRB has been proposed in [13] such that:

$$\mathrm{E}_{\mathbf{y},\mathbf{c}}\left|(\hat{\mathbf{c}}(\mathbf{y})-\mathbf{c})(\hat{\mathbf{c}}(\mathbf{y})-\mathbf{c})^H\right| \quad \geq \quad \mathbf{BCRB}(\mathbf{c})$$

$$\alpha = [\alpha_{(1)}{}^T, ..., \alpha_{(K)}{}^T]^T,$$

the estimation of the complex gains . Actually, α is related to **c** as:

$$\alpha = \mathcal{Q}\mathbf{c} + \xi$$

where $\mathcal{Q} = \mathrm{blkdiag}\left\{\mathbf{Q}^T, ..., \mathbf{Q}^T\right\}$ is a $KLv \times KLN_c$ matrix and $\xi = [\xi_{(1)}^T, ..., \xi_{(K)}^T]^T$ with $\xi_{(n)} = \left[\xi_1^{(n)T}, ..., \xi_L^{(n)T}\right]^T$. Hence the estimation of α can be stated by: $\hat{\alpha} = \mathcal{Q}\hat{\mathbf{c}}$.

By neglecting the cross-covariance terms between the errors $\alpha_{\mathbf{pol}} - \hat{\alpha}$ and ξ, we can write:

$$\mathrm{E}\left|(\hat{\alpha}-\alpha)(\hat{\alpha}-\alpha)^H\right| = \mathrm{E}\left|(\hat{\alpha}-\alpha_{\mathbf{pol}})(\hat{\alpha}-\alpha_{\mathbf{pol}})^H\right| + \mathrm{E}[\xi\xi^H]$$

where $\alpha_{\mathbf{pol}} = \mathcal{Q}\mathbf{c}$. the BCRB for the estima-

The BCRB for the estimation of α from the BCRB for **c** as:

$$\mathbf{BCRB}(\alpha) = (\nabla_{\mathbf{c}}\alpha_{\mathbf{pol}})\mathbf{BCRB}(\mathbf{c})(\nabla_{\mathbf{c}}\alpha_{\mathbf{pol}}^T) + \mathrm{E}[\xi\xi^H]$$

Due to this the channel is estimated and it also improves the performance of the channel.

III. Comparision Between Different Techniques

So objective function of PSO,The effects of Doppler shifts on designing pilot tones are also investigated the optimized pilot tones derived by particle swarm optimization outperforms the orthogonal and random pilot tones significantly in terms of MSE and BER. This approach has less computational complexity.
CRO is used to derived and minimized with respect to pilot symbols and their placement. The basic principle of optimal placements is to concentrate higher power symbols in the midamble positions of a packet while placing symbols with lower power at two ends. It makes the design of optimal pilot sequence simpler. Whereas BCRB are useful when analyzing the performance of complex gains estimator and it uses the benefit of the past and the future OFDM symbols in channel estimation process, whereas most methods use only the current symbol.

IV. Conclusion

Channel Estimation in OFDM is major limitation; to improve/enhance performance of the system many enhancement techniques are used. This paper shows the review and survey of various such techniques used for enhancing the performance by channel estimation of OFDM. Out of all techniques specified above in this paper PSO and BCRB Technique yield maximum channel estimation.

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