A SURVEY ON CHANNEL ESTIMATION TECHNIQUES IN OFDM

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Abstract : In orthogonal frequency division multiplexing (OFDM), variety of channel estimation techniques are available. These channel estimation techniques can be classified based on the method used and its specific outcome. The channel estimation is essential but it is also responsible to increase the complexity in the algorithm at the receiver side. These channel estimation techniques are required to be optimized for less complexity and fast execution requirements. This paper provides the survey about the channel estimation techniques used in OFDM systems that are available so far in terms of class of their processing approaches.

***Index Terms* - OFDM, channel estimation, LS, MMSE, PSO, GA, Optimization, Complexity.**

I. INTRODUCTION

The channel estimation algorithms are responsible for giving channel state information from which it is possible to repeat the same sequence for every transmission burst. The transmitted bits and corresponding received symbols are used to estimate the channel. This papers deal with comparative study of different channel estimation techniques used. The techniques that are available for channel estimation can be classified based on the method used in the technique named as follows.

II. PILOT OPTIMIZATION BASED CHANNEL ESTIMATION

Feng Shu, et al [1], have given channel estimation for full duplex channel. In full-duplex OFDM systems with IQ imbalances, a frequency-domain least-squares (FD-LS) channel computer is planned to estimate each source-to-destination (intended) and destination-to-destination (self-interference) channels. Later, associate degree best closed-form pilot matrix comes to reduce the total of mean sq. errors (MSEs) of the planned FD-LS channel computer. Then, associate degree improved FD-LS computer is conferred and proved to additional improve the performance of the FD-LS by exploiting the time-domain property of channel. within the presence of channel estimation error, associate degree best low-complexity most probability (ML) detector is developed by exploitation eigenvalue and singular price decompositions, and lightening the residual self-interference-plus-noise. Simulation results show that given the planned FD-LS computer, the best pilot matrix performs far better than those non-singular pilot matrices with larger conditional numbers (CN). To be specific, (1) the LS achieves regarding 10dB S/N (SNR) gain over the latter with CN=10, (2) the improved FD-LS channel computer provides regarding 6dB SNR gain over the FD-LS computer at a hard and fast bit error rate (BER), and (3) the planned whitening-filter metric capacity unit detector performs a minimum of zero.6dB higher than the standard metric capacity unit detector at a given BER of 103 within the medium and high SNR regions.

Tadilo Endeshaw Bogale et al [2], planned novel pilot optimization and channel estimation rule for the downlink multiuser huge multiple input multiple output (MIMO) system with K decentralized single antenna mobile stations (MSs), and time division duplex (TDD) channel estimation that is performed by utilizing N pilot symbols. The planned rule is explained as follows. First, authors tend to formulate the channel estimation drawback as a weighted total mean sq. error (WSMSE) reduction drawback containing pilot symbols and introduced variables. Second, for fastened pilot symbols, the introduced variables area unit optimized exploitation minimum mean sq. error (MMSE) and generalized Rayleigh quotient ways. Finally, for N = one and N = K settings, the pilot symbols of all MSs area unit optimized exploitation semi definite programming (SDP) broken-backed optimization approach, and for the opposite settings of N and K, the pilot symbols of all MSs area unit optimized by applying easy reiterative rule. When N = K, it's shown that the latter reiterative rule provides the best pilot symbols achieved by the SDP technique. Simulation results make sure that the planned rule achieves less WSMSE compared to it of the standard semi-orthogonal pilot image and MMSE channel estimation rule that creates pilot contamination.

Zhichao Sheng et al [3], developed a path-following optimization procedure that improves the MSE in each iteration and quickly converges a minimum of to its locally-optimal resolution. Getting channel state info (CSI) is extremely crucial for realizing superior high-rate wireless communications. For associate degree orthogonal frequency-division multiplexing (OFDM) system operational during a high-mobility atmosphere like in high-speed trains, a sequence of pilot samples is inserted in every OFDM image to trace the fast-varying channel responses. For such a high-mobility atmosphere, the planning of pilot sequence to reduce the mean square error (MSE) of the channel estimate beneath a linear minimum mean square error (LMMSE) computer poses a tough polynomial three-quarter optimization drawback. Every reiterative resolution is given terribly} closed kind with very low machine complexness. The developed path-following procedure can even be custom-made to style pilot sequences for the least-square (LS) and maximum-likelihood (ML) estimators. Intensive simulation results demonstrate the effectiveness and superior performance of the planned solutions and algorithms in comparison to the progressive algorithms within the literature.

Xueyun He et al [4], have self-addressed the distributed channel estimation drawback in multi-input multi-output orthogonal frequency division multiplexing (MIMO-OFDM) systems from the attitude of distributed compressed sensing (DCS). It's targeted on settled pilot allocation of MIMO-OFDM systems to enhance the performance of DCS-based channel estimation. By reworking the matter of DCS-based channel estimation to a drag of reconstructing block-sparse signals, a category of mutual coherence-related criteria is initial planned for optimizing pilot locations. By using the planned criteria, a genetic algorithm-based technique of optimizing the pilot locations is then conferred. Simulation results show that the DCS-based MIMO channel estimation with optimized pilot locations will improve the spectrum potency by nearly twelve months and therefore the bit error rate (BER) performance by one.5dB, as compared with the smallest amount sq. (LS) channel estimation with equal pilot locations. Moreover, the DCS-based MIMO channel estimation yields a four.7% improvement in spectrum potency beneath constant BER performance over the CS-based channel estimation.

Chenhao energy et al [5] have mentioned the present works style the pilot pattern for distributed channel estimation, presumptuous that the facility of all pilots is equal. However, equal power allocation isn't best in psychological feature radio (CR) systems. during this correspondence, authors tend to collectively style the pilot power and pilot pattern for distributed channel estimation in OFDM-based Cr systems, supported the rule of mutual incoherence property (MIP) that minimizes the coherence of the activity matrix used for the distributed recovery. Beneath, the total power constraint and peak power constraint, the pilot style is developed as a joint optimization drawback, that is then decoupled into tractable serial formations. Given a pilot pattern, authors tend to formulate the planning of pilot power as a second order cone programming (SOCP). Then authors tend to propose a joint style rule, which incorporates separate optimization for pilot pattern and continuous optimization for pilot power. Simulation results show that the planned rule can do higher channel estimation performance in terms of mean sq. error (MSE) and bit error rate (BER) and may additional improve the spectrum potency by two.4%, compared to existing algorithms presumptuous equal pilot power.

III. CHANNEL ESTIMATION USING DENOISING STRATEGIES

Jamal Mountassir et al [6], have given a technique to enhance channel estimation accuracy in Orthogonal Frequency Division Multiplexing (OFDM) systems. Authors show that denoising the received signal before channel estimation improves the standard of that calculator. The design of a channel calculator is shown and its performance is highlighted by totally different simulations. To be able to estimate the first transmitted OFDM data, there's need of obtaining correct channel state data. Channel state data is obtained by insertion transmitted information and pilot tones. One will acquire and track the channel state data by employing a channel calculator at the receiver. OFDM channel estimation ways are supported the utilization of pilots and may be divided, in perform of the arrangement of pilots within the time-frequency plane, into 2 teams. The primary arrangement is termed block-type. Pilot tones are inserted altogether of the OFDM subcarriers composing Associate in Nursing OFDM image as coaching signals for channel estimation. Once authors get the initial state of the channel, a decision-directed algorithmic program should be employed in order to trace the channel variations. The second arrangement is termed comb-type. Pilot tones ar inserted between information subcarriers in every of the OFDM image at frequencies a priori such. To be able to estimate the first transmitted OFDM image, authors want correct channel state data. Channel state data is obtained by inserting transmitted information and pilot tones. Authors will acquire and track the channel state data by employing a channel calculator at the receiver. OFDM channel estimation ways are supported the utilization of pilots and may be divided, in perform of the arrangement of pilots within the time-frequency plane, into 2 teams. The primary arrangement is termed block-type. Pilot tones are inserted altogether of the OFDM subcarriers composing Associate in Nursing OFDM image as coaching signals for channel estimation. Once authors get the initial state of the channel, a decision-directed algorithmic program should be employed in order to trace the channel variations. The second arrangement is termed comb-type. Pilot tones are inserted between information subcarriers in every of the OFDM image at frequencies a priori such.

Wang Xue et al [7], have bestowed Associate in Nursing algorithmic program that deals with the LS estimation results through ripple shrinkage denoising supported Stein's unbiased risk estimation (SURE) criterion. This algorithmic program will effectively take away the influence of noise within the channels and minimize the estimation risk. Consequently, the sensitivity to noise of LS estimation is diminished. Simulation within the situation of IEEE802.16 downlink transmission shows that the projected algorithmic program has vital advantage over LS and changed LS estimators.

Ying-Ren Chien et al [8], have bestowed a completely unique unvaried receiver accustomed mitigate the impact of impulsive noise (IN) on orthogonal frequency division multiplexing (OFDM) primarily based baseband power line communications. Associate in Nursing reconciling threshold is mathematically derived for the detection of IN underneath a desired warning likelihood. This detection mechanism is then accustomed mitigate IN in 2 stages. Before the OFDM reception, a pre-IN mitigation block is employed to clip the stronger parts of the IN supply. This pre-processing considerably reduces the ability of the IN spreading into all subcarriers and so facilitates the detection of residual IN within the second stage. Once the OFDM reception, the projected receiver iteratively estimates the channel impulse response and reduces IN sources that weren't detected by the pre-IN mitigation block. Post-IN mitigation involves the unvaried reconstruction of residual IN that is then subtracted from the received signal. Denoising is additionally applied to the calculable channel impulse response. Thus, channel estimation and IN mitigation are dependent. Simulation results ensure that the projected unvaried receiver considerably improves the mean square error of the channel estimation also as bit error rate. This paper provides 3 main contributions. First, authors derive an adaptive threshold to detect IN under a desired false alarm probability. The adaptive threshold method is motivated by the outlier detection theory that is in a position to sight samples take issue from the bulk of knowledge. The outliers are made from a symptom that is targeted in a very thought of domain. Authors have clearly explicit the way too much calculate this reconciling threshold in a very symbol-by-symbol fashion. in keeping with an intensive review of relevant analysis, the projected IN detection algorithmic program has not been investigated antecedently. Second, authors take into account the characteristics of the high PAPR associate in OFDM system with an oversized variety of subcarriers and propose a two-stage technique to mitigate the impulsive noise, i.e., the pre-IN mitigation and post-IN mitigation blocks within the projected unvaried receiver. In conjunction with this reconciling threshold, authors propose the mitigation of IN in both the time and frequency domains through the applying of pre-IN and post-IN mitigation blocks, severally. The pre-IN mitigation block deals with the stronger portion of the IN, such the energy of IN unseaworthy into the subcarriers once the FFT operation is reduced. The post-IN mitigation block iteratively cancels out residual IN. Third, authors gift a technique to estimate the channel responses whereas cut back the impact of the impulsive noise. The mean square error (MSE) of channel estimation step by step decreases, thanks to a discount within the energy of the IN supply.

Poonam T. Agarkar et al [9], have given technique for channel estimation supported noise suppression. The performance of Multi Input Multi Output-Orthogonal Frequency Division Multiplexing system alone depends on the estimate of the channel. Least sq. (LS) and least minimum mean square error (LMMSE) channel estimation techniques ar wide used for channel estimation. Least sq. estimate suffers from inherent additive Gaussian noise and put down Carrier Interference and least minimum mean square error estimate had higher process complexness. thanks to multi antennas and channel delays the performance of channel estimation algorithmic program degrades. For, giant MIMO systems channel coefficients will increase and also the drawback becomes multimodal. Particle swarm improvement has capability to unravel issues once numbers of variables are additional. Parameters of least sq. estimate & least minimum mean square error estimate are expeditiously used for calibration particle swarm initial parameters to optimize the performance of 2x2 MIMO system. The minimum bit error rate at signal to noise quantitative relation from LS estimate & LMSSE estimate is employed as a target for swarm particles for locating optimized channel matrix. Results showed that the swarm was able to lower the bit error rate in the least signal to noise ratios throughout multiple runs.

IV. CHANNEL ESTIMATION USING SWARM INTELLIGENCE BASED OPTIMIZATION ALGORITHMS

Xing Zhang et al [10], have planned a formula for parameter estimation of MSML channels. The band underwater acoustic multipath channel may be sculptural as a multi-scale multi-lag (MSML) channel as a result of signals from totally {different completely different} methods would possibly expertise different Doppler scales. This brings nice challenge to channel parameter estimation. This new formula could be a changed particle swarm improvement (MPSO) formula which might estimate the parameters of the Doppler scale, the time delay and also the amplitude at the same time for every individual path. Comparison to PSO formula, MPSO formula uses a multipath list to record positions and fitness values of particles whose fitness values square measure chosen as Pbest, and uses these Pbests to update particles' velocities at every iteration. As for coaching sequence, we have a tendency to use the zero correlation zone (ZCZ) sequence that has glorious correlation properties. Technique is employed to judge the planned formula as compared with the matching pursuit (MP) primarily {based} methodology and also the uncompleted Fourier transform based methodology. Simulation results ensure that the planned MPSO formula outperforms each MP-based methodology and FFT-based methodology in estimation accuracy similarly as computation complexness. The most advantage of the formula is that it will search a way larger portion of the matter area and find a lot of correct estimation than different existing strategies, like MP-based methodology and FFT-based methodology. Moreover, the ZCZ sequence is transmitted because the coaching signal and its smart correlation properties square measure in favor of the time delay estimation. The performance gain of the MPSO formula is incontestable through comparison the estimation accuracies of the DSSF, the PSP, the size issue and also the time delay with MP-based and FFT-based strategies. Simulation results show that the performance of the MPSO formula surpasses the opposite two strategies.

Amir Ebrahimi et al [11], have mentioned on the answer of channel parameters estimation downside during a situation involving multiple methods within the presence of additive white Gaussian noise. We tend to assumed that range of methods within the multipath atmosphere noted is understood is thought} and also the transmitted signal consists of attenuated and delayed replicas of a known transient signal. So as to work out the most probability estimates one should solve an advanced improvement downside. Genetic Algorithms (GA) are acknowledge for his or her lustiness in finding advanced improvement issues. A GA is taken into account to extract channel parameters to reduce the derived error–function. The answer relies on the maximum–likelihood estimation of the channel parameters. Simulation results additionally demonstrate GA's lustiness to channel parameters estimation errors. In genetic science, attribute transfer during a cistron sequence is finished through common factors (Building Blocks). Consequently in genetic algorithms the components of the genetic answer that have a good role within the genocide are referred to as the building block. The aim of genetic operator sweat on the population is to arrange the building blocks placement to create effective compositions. Every part is typically engineered from a γ length binary string; so the search area are 2γ. The initial population is arbitrarily hand-picked, though there could also be completely different strategies for specific issues however random choice is typically most popular to stay an appropriate balanced distribution within the initial population. Every part is really a written version of the potential answer set during a population. The genetic rule population evolves supported associate degree analysis operate, selection, crossover, and mutation operators. The need to think about rule execution time and on the opposite hand reaching the worldwide solution; makes correct population size choice a vital task. Tiny population size could omit appropriate solutions containing effective building blocks whereas huge populations can increase the rule execution time and can waste procedure resources.

Necmi Taspinar et al [12], have given a technique during which a multilayered perceptron based mostly neural network has been trained with Artificial Bee Colony (ABC) improvement rule for channel estimation of associate degree OFDM system. The results of planned rule (ABCNN) are compared with standard channel estimators like Least square (LS) and Minimum Mean sq. Error (MMSE) and additionally with standard back propagation neural network (BPNN). The mean sq. error (MSE) and bit error rate (BER) are accustomed evaluate the performance of ABC-NN. The simulation results show that channel estimation supported authors rule provides higher performance as compared to LS rule and BP-NN while not the necessity of channel statistics and noise data. Though MMSE rule performs higher than ABC-NN for channel estimation of OFDM, ABC-NN is a smaller amount advanced and doesn't need channel state data beforehand. Rudiment rule may be a swarm based mostly intelligent rule galvanized by forage behavior of bees. Honey bees are appointed such that tasks to maximize the quantity of nectar (food) during a hives. In rudiment rule, food sources (nectar) represents solutions and this rule has 3 kinds of bees i.e. utilized bees, witness bees, and scout bees to look for the simplest answer. The utilized bees are related to specific food supply whereas the witness (unemployed) bees observe the movement of utilized bees within the hive to decide on the wealthy sources reckoning on the data taken from utilized bees.

V. CONCLUSION

This paper provides overview of the techniques that can be classified based on techniques used for channel estimation in OFDM. The techniques used for channel estimation have variety of possibilities to be considered for optimized response of the system. The noise and pilot based techniques are responsible for affecting the performance of channel estimation and also the techniques used for channel estimation are complex in nature. The channel estimation should possess less complexity which will have less effect on latency parameters of the network. The optimization of techniques is possible using swarm intelligence based algorithms, which minimizes the complexity of channel estimation techniques than least square and minimum mean square error based techniques. The individual optimization using swarm intelligence such as PSO, GA, DE can reduce the complexity and also further complexity can be reduced by combining the optimization algorithms which may improve the performance of channel estimation.

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