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An Improved Space Time Trellis Code Based MIMO OFDM With Kalman Filter For Rectification Of BER and SNR

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Abstract: *Multiple-Input Multiple-Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) systems have gained significant popularity in modern wireless communication due to their ability to enhance data throughput and reliability. However, they are susceptible to performance degradation in the presence of noise and fading channels. To address this challenge, this research proposes an innovative approach that combines Space-Time Trellis Codes (STTC) with a Kalman filter for improving Bit Error Rate (BER) and Signal-to-Noise Ratio (SNR) in MIMO OFDM systems .Our proposed approach synergizes these two powerful techniques, incorporating STTC into MIMO OFDM and leveraging the Kalman filter for real-time channel estimation and equalization. This results in a substantial improvement in BER and SNR performance, making the system more reliable and efficient, even in challenging wireless environments. Through extensive simulation and experimentation, we demonstrate the effectiveness of our method by comparing it to conventional MIMO OFDM systems. The results clearly show a significant reduction in BER and improvement in SNR, thereby enhancing the overall quality of service in wireless communications*

Key Words: *Space-Time Trellis Code (STTC), Filter, Inter-Carrier Interference, Bit Error Rate (BER), Signal To Noise Ratio (SNR) And Wireless Fading Channe.*

1. INTRODUCTION:

OFDM refers to orthogonal frequency division multiplexing, a kind of multicarrier modulation in which the transmitted bitstream is split up into many channels. These feeds are broken up and sent through individual channels. Sub-channel selection is made in such a way that each orthogonal sub-channel has its own unique bandwidth. When compared to the coherence bandwidth of the channel, this bandwidth is very small. The amount of ISI (inter-symbol interference) in these systems is negligible. OFDM is often used in extremely high-data-rate wireless networks. Of course, OFDM systems aren't without their problems. Because of its special qualities, the OFDM system is used in a wide range of wireless applications and standards. OFDM is a multi-carrier modulation technology used for signal transmission across wireless channels. Using OFDM, a channel with frequency-selective fading may be transformed into a set of sub-channels with flat fading. As a consequence, the receiver's structure in the communication services is simplified. The waveforms of the sub-carriers include time-domain orthogonals. The spectral components of the signal, which are associated with different subcarriers, tend to overlap within the frequency domain. The available bandwidth is used extremely effectively inside OFDM systems. Inter-channel interference (ICI) is not a problem in these setups. The OFDM systems feature a combined high data rate and lengthy symbol duration. Multiple subcarriers with a low data rate are combined to achieve this. Short symbol-length signals in the existing multipath channel may be used to get rid of the ISI.

1.1. MIMO OFDM :

Future broadband wireless systems will have to provide a greater data rate and better performance. To improve upon the other compared channels, which comprise time- and frequency-selective measurement with him, the memo and OFDM systems are integrated. This produces the necessary effective system. Since multipath propagation mitigation is not performed within the MIMO oh and the signal equalisation can be avoided with the help of OFDM, the presence of MIMO helps in enhancing the capacity and diversity of the structure for the determined After Effects that are placed within the real world. Even if the transmitter doesn't know the channel's characteristics, they can nevertheless achieve extremely high spectral efficiency. There are some good MIMO -OFDM advancements introduced, such as the multi user MIMO MU-MIMO, the higher-order MIMO utilisations, and many other systems, that help to realise the theoretical channel capacity in situations where the channel state information (CSI) is present within the transmitter. This results in the assignment of different sized signal relations to different subset areas, which leads to communication channel loss.

WM and Palace Metro Police Station area networks are implemented with the aid of this system, and with it, the locations issues are also taken into account on the network, just like current network-based wireless locations method in the below figure 1.1 shows MIMO-OFDM architecture. A literature survey on different coding techniques in MIMO –OFDM using different filters

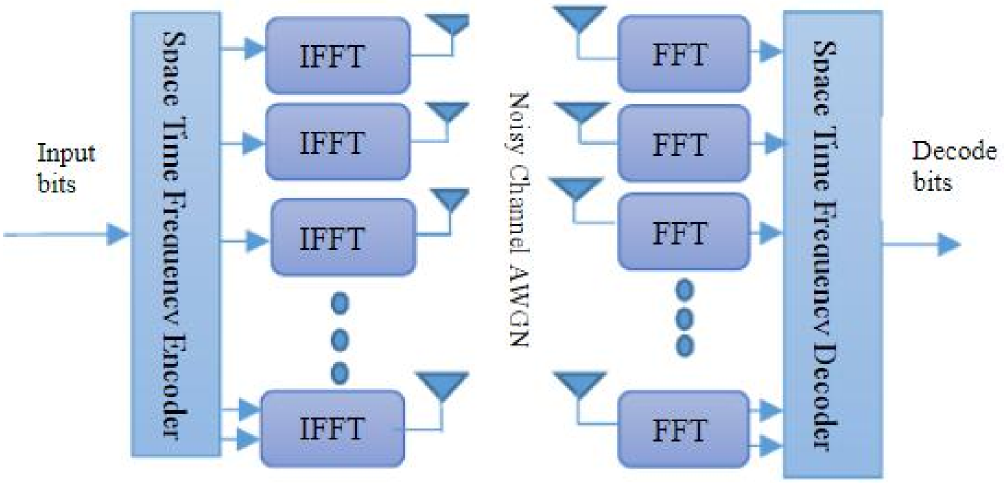

Figure 1 MIMO-OFDM

2. LITERATURE REVIEW:

Arslan Khalid et.al. (2023)- This study demonstrates that Space-Time Block Coded (STBC) Orthogonal Frequency Division Multiplexing (OFDM) may be used to accommodate larger data rates without degrading the quality of the transmitted signal across a multipath fading channel. Traditional STBCs include the likes of Orthogonal STBCs (OSTBCs), Non-Orthogonal STBCs (NOSTBCs), and Quasi-Orthogonal STBCs (QOSTBCs), with more than two transmit antennas, none of them achieve both maximum diversity order and unity coding rate concurrently. The authors of this study implement Highest Rank Distance (MRD) codes into their STBC-OFDM system designs as a means of dealing with this problem. The direct-matrix-building method may be used to construct binary expanded finite field MRD-STBCs for an arbitrary number of transmitting antennas. An MRD-based STBC-OFDM system is developed using MRD-STBCs constructed on top of Phase-Shift Keying (PSK) modulation. Although it suffers from somewhat worse error performance than standard OSTBC-OFDM, the MRD-based STBC-OFDM system performs better than both NOSTBC and QOSTBC-OFDM. When compared to OSTBC-OFDM, it offers 25% greater throughput with more than two transmit antennas. Smaller gains in accuracy come at the cost of longer processing times and more computing complexity [01].

Chennapragada Padmaja et.al. (2023) - In this study, we combine the Chaotic Grey Wolf Optimizer with a Genetic Algorithm to predict the performance of Turbo-Coded MIMO-OFDM frequency-division channel systems. The BER performance is enhanced because the maximum correlation of the channel is decreased in the frequency domain using the proposed turbo code. Independently utilising the Chaotic Grey Wolf Optimizer (CGWO), the channel is evaluated using the LS-MMSE before merging it with a genetic algorithm to scale the ideal channel for reducing error. The LS channel estimation-specific turbo-codes used for decoding and encoding. The proposed method is evaluated using a number of different metrics, including bit error rate, mean squared error, channel estimation, computational expenditure, overhead, and symbol error rate. The proposed method achieves reduced computational costs of 99.67%, 98.38%, 92.34%, and 97.45%, and lower bit error rates of 98.33%, 89.34%, and 83.45%, respectively, when compared to previous methods such TSO-CE-TC-MIMO-OFDM, MFPA-CE-MIMO-OFDM, OSBS-CEA-MIMO-OFDM, and IAMO-CE-MIMO [02].

B.M.R. Manasa et.al. (2022) - In this research work Major difficulties for MIMO-OFDM systems are synchronisation between the receiver and the transmitter and accurate recovery of channel state information (CSI). Blind, pilot-aided, and semi-blind channel estimating are only some of the estimation procedures that may be used to recover channel state information. However, there are a number of problems with such systems that severely restrict their use. That's why we're doing this research: to lay down the groundwork for how the MIMO-OFDM system uses the

Channel Estimation (CE) process. The fundamental goal of this study is to analyse and categorise the many channels of literature devoted to the topic of channel estimation and simulation. In addition, the importance of evaluating performance with the many tools at your disposal is emphasised [03].

Balajee Sharma et.al. (2022) - In this research work an emerging concept, the modulation index, involves the pairing of extra data bits with resource indices under different transmission circumstances. subcarriers, slots, and antenna gain. The OFDM-IM presented in this research is shown to be an improved frequency-domain IM method over traditional OFDM. This research proposes a deep neural network (DNN)-based channel estimation approach for fading noisy channels, and the system is trained using synthetic data. When compared to traditional channel estimation methods, DNN excels in several ways, especially in the presence of distortion, fading, and interference. The channel state may be analyzed and estimated by the DNN in any condition. In this work, we test both the presence and absence of cyclic prefix conditions in our simulations. The investigation shows that DNN is superior to other estimators [04].

Houda Harka et.al. (2022) - In this research work When it comes to 5G communications structures, MIMO-OFDM is a must-have technology. There is no one-stop-shop literature review that compiles all the important questions that need answering about such systems. This in-depth review study analyses the present status of research on MIMO-OFDM systems and discusses their implications. MIMO waveforms and MIMO-OFDM channel estimates are two areas that have been extensively studied. We briefly go through the MIMO-OFDM equalization methods and the latest advancements in MIMO hardware and software. In the literature, few authors have taken on the difficult task of estimating and modelling MIMO channels for various MIMO systems. The present work on channel estimation and the equalisation approach for MIMO-OFDM systems have not been reviewed, however, to the best of our knowledge. This paper thus provides a valuable resource for future researchers by analysing the most up-to-date algorithms in the area. Moreover, a few potential directions for future study are highlighted. [05].

Deepika et.al. (2021) – This study uses a Kalman filter to analyse MIMO OFDM performance. In this research, a Kalman filter is used to improve the signal-to-noise ratio and bit error rate of the space-time trellis code (STTC) technique. The simulation and results sections of MIMO OFDM pale in comparison to those of the proposed method. The presented method has been demonstrated to improve the signal-to-noise ratio and the bit error rate, and it has found use in 5G and other next-generation technologies. Kalamn filters will be vital to the next generation of communication infrastructure. Kalman filters may help advance MIMO, Tz, and Wi-Max communication and networking technologies. The presented method employs Wi-Fi [8] and Wi-Max to improve functionality [06].

Divneet Singh Kapoo et.al. (2020) - In this research work Multimedia-based applications will be the main driving force behind wireless communication networks both now and in the future. It also requires a massive amount of data transfer in the form of audio and video material, which might be difficult to do without the availability of high-speed 5G networks. In order to enable high data rates and capacities without compromising the functionality of wireless systems, it has been determined that the combination of spatial-coding methods with multicarrier transmission is an effective solution. Orthogonal-frequency-division multiplexing (OFDM) has become a dominant force in multicarrier communication. OFDM is distinguished by its ability to divide the available bandwidth into a number of orthogonal narrowband subchannels (overlapping) in order to transform a frequency-selective channel into a collection of frequency-nonselective flat-fading submethods. In addition, the use of several antennas for wireless communication produces spatial-domain subchannels, whereby a number of independent yet time- and frequency-coherent channels are created. Providing high-data-rate services for online customers eliminates the need for extra capacity thanks to spatially-coded OFDM systems' ability to boost the signal-to-noise ratio (SNR) at the receiver. Spatial-coded orthogonal multiplexing with frequency division (OFDM) systems rely heavily on channel-state information (CSI) [07].

N. Rashmi et.al. (2020) – In this study, we investigate how to enhance the SCM-OFDM interleave technology. We begin by transmitting data using the SCM-OFDM scheme at a range of signal-to-noise ratios (SNRs). As the most complex aspect of the SCM-OFDM interleave, scramble rule generation must be fine-tuned to increase system efficiency via the non-contiguous organisation of data. To that end, this research provides a combination of two methods, the Rider Optimisation Algorithm (ROA) and the Group Searching Optimisation (GSO), to produce the most effective scrambles. It has been decided to call this new hybrid algorithm "GSO Bypass-Based ROA" (GB-ROA). The same optimised scrambling techniques are employed in the deinterleaver at the receiving end, and the mean error between the transmitted and received data is determined using all of the data. The generation of scramble rules is repeated till the mean error is minimised. After that, we compare the suggested model to certain tried and true techniques [08].

Table 1: Comparison of Different ECG signal Filters

S.NO	Ref./Year	Authors	Title	Method

1	[01]/2023	Arslan Khalid et.al.	Application of maximum rank distance codes in designing of STBC-OFDM system for next-generation wireless communications	construction method
2	[02]/2023	Chennapragada Padmajaa et.al.	Turbo-Coded Mimo-OFDM Channel Estimation Using the Chaotic Grey Wolf Optimizer and Genetic Algorithm	Genetic Algorithm
3	[03]/2022	B.M.R. Manasa et.al.	A systematic literature review on channel estimation in MIMO-OFDM system: performance analysis and future direction	Channel State Information
4	[04]/2022	Balajee Sharma et.al.	Channel Estimation and Equalization Using FIM for MIMO-OFDM on Doubly Selective Faded Noisy Channels	System Models and Techniques
5	[05]/2022	Houda Harkat et. al.	A Survey on MIMO-OFDM Systems	Efficient Radio Managing Method
6	[06]/2021	Deepika et.al.	An Improved Space Time Trellis Code Based MIMO OFDM with KALMAN filter for Rectification of BER and SNR	STTC Technique
7	[07]/2020	Divneet Singh Kapoor et.al.	Spatially-Coded OFDM Wireless Systems Employable in 5G Communication Networks	Employ Certain Coding Techniques
8	[08]/2020	N. Rashmi et.al.	A new optimised interleaver design for high-dimensional data transmission in SCM-OFDM system	High-Dimensional Data Transmission

3. PROPOSED METHOD:

The STTC method takes into account deep fading channels in an effort to decrease the bit error rate. The static method of decreasing the network's SNR value is used for the deep fading channel. An enhanced technique, space-time trellis code-based MIMO OFDM with Kalman filter, was developed to address the aforementioned research gap or difficulty

Transmitter (Tx) End:

The suggested method's encoder is located in the transmitter end. Trellis code, which is based on convolution code, is applied to a previously generated random data set or data matrix. They are used to transform information into a binary code. Use interleaving to limit the amount of miscommunication between two messages. Modify the message's format and activate the binary-to-decimal conversion procedure. Decimal data should be massaged using quadrature amplitude modulation (QAM), and a pilot bit should be included.The last step in processing data frames is to perform the inverse fast Fourier transform (IFFT) using the pilot's selected window size. Finally, the encrypted data bites' signal-to-noise ratio is measured before being sent on to the channel-by-channel estimation system using adaptive white Gaussian noise (AWGN).

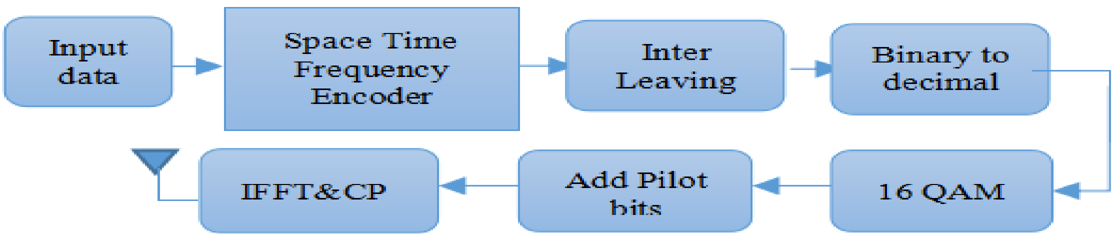

Figure 2: Encoder End

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4. SIMULATION AND RESULT:

Simulation and Result:

Here, we'll talk about our simulations and the outcomes of this new approach. This study analysed a modified Space-time trellis code (STTC) method using a kalman filter to boost signal-to-noise and bit-error ratio performance. Use a core I 5 CPU, 8GB of RAM, a 512GB solid-state drive (SSD), and a 2GB graphics card in a simulated environment provided by the Matrix Laboratory (MATLAB). When evaluating the effectiveness of the job at hand, the signal-to-noise ratio is a crucial metric

Bit Error Rate (BER):

The equations used to establish BER will be used to evaluate the effectiveness of the offered effort. Here, the BER is often presented as a normalised carrier-to-noise ratio measure with either the Eb/N0 or Es/N0 component. Although SNR is often shown as Eb /N0, we must first convert the decibels to a normal ratio before we can really use them. If the SNR is changed to m dB, then Eb/N0 = 10m/10. The bit error rate (BER) as a function of the AWGN channel's Eb/N0 is given by:

$$P_S 16\,QAM = \frac{3}{2}\, erfc\left(\sqrt{\frac{E_s}{10N_0}}\right) \quad 1$$

The bit error rate for Gray-coded 16QAM in Additive White Gaussian Noise is calculated by combining the two formulae above –

$$P_b, 16\,QAM = \frac{3}{2K}\, erfc\left(\sqrt{\frac{KE_s}{10N_0}}\right) \quad 2$$

Figure 4 below displays the bit error rate of MIMO OFDM without the use of a Kalman filter. Bit error rate at 5 dB, 10 dB, and 15 dB noise ratios are shown in Figure 3. The MIMO OFDM with Kalman filter is shown in Figure 4, and a comparison of the two is presented and discussed in Figure 5

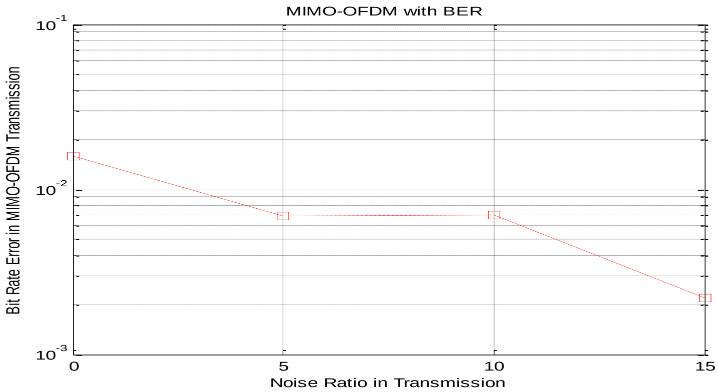

Figure 3: MIMO OFDM Bit Error Rate (BER)

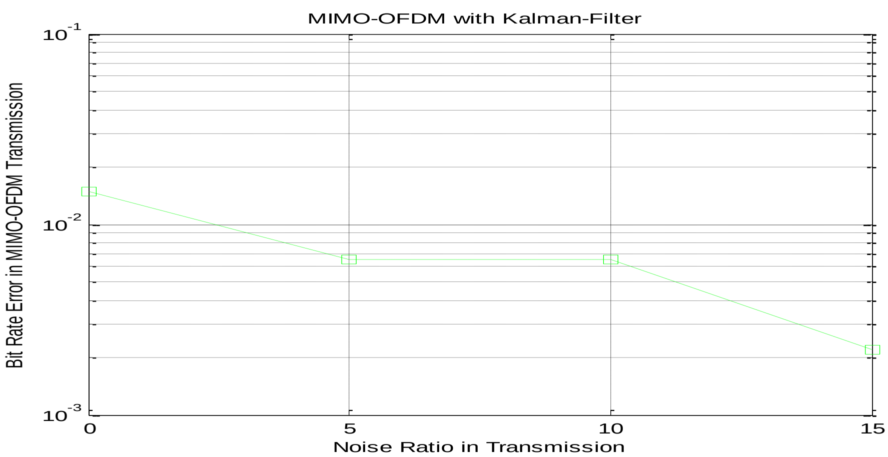

Fig. 4 MIMO OFDM Bit Error Rate (BER) with Kalman Filter

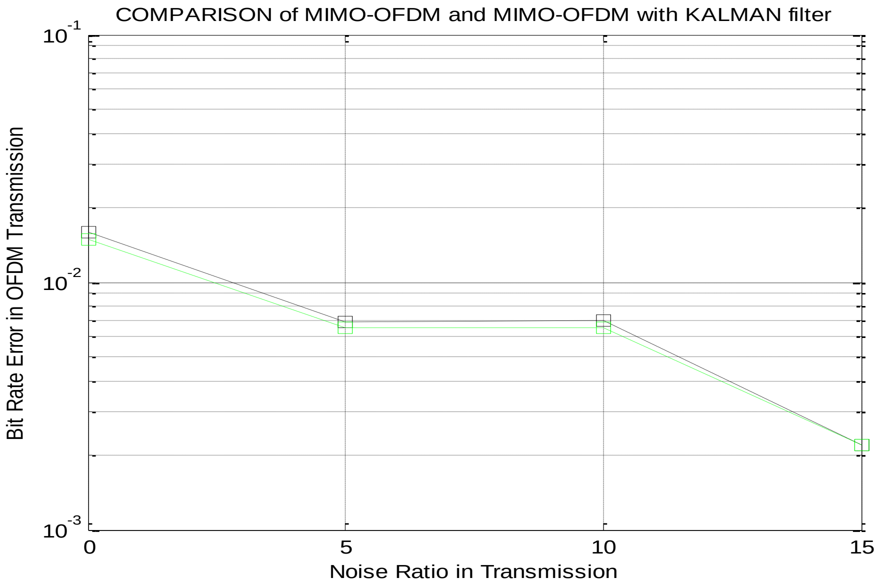

Figure 5: Comparison of MIMO OFDM and MIMO OFDM with KALMAN filter

TABLE 2. MIMO OFDM

S. No.	Noise Ratio	BER –MIMO OFDM	BER MIMO OFDM with Kalman Filter
01	5	0.0065	0.0069
02	10	0.0068	0.007
03	15	0.0022	0.0022

The differences between MIMO OFDM and MIMO OFDM with a Kalman Filter are laid out in detail in fig 5 and table 2. According to the results shown above, MIMO OFDM enhanced with a Kalman filter performs better than conventional MIMO OFDM

5. CONCLUSION:

In this research, the authors analysed MIMO OFDM's performance using a KALMAN filter. In this research, we provide a novel Space-time trellis code (STTC) technique using a Kalman filter to improve SNR and BER performance. The offered technique outperforms MIMO OFDM in the part on simulation as well as results. To reduce bit error rate as well as enhance signal to noise ratio, this approach is also employed in 5G.

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