DOI: 10.21917/ijct.2019.0300

CROSSOVER BLEND OF KALMAN FILTER AND RAKE RECEIVER OVER MULTIPATH FADING CHANNELS IN DS-CDMA SYSTEM

Rajendrakumar Govinda Zope and Devendra Ningappa Kyatanavar
Department of Electronics and Telecommunication Engineering, Sanjivani College of Engineering, India

Abstract

Next generation, wireless system needs enormous data exchange with high caliber for the transmission of voice, information and video, such type of transmission is hard to execute without a substantial transfer speed. Keeping in mind, the end goal to accomplish such requests is multi-user Direct Sequence Code Division Multiple Access (DS-CDMA). Here DS-CDMA is considered as a framework with multi clients who need to send Colour video information. This paper recommends a new Crossover Blend of Kalman Filter and Rake (CBKFR) based spreading codes generator for multi-user Direct Sequence Spread Spectrum (DSSS) correspondence frameworks. Execution of this framework under different channels, code Sequences and modulation schemes are analysed and discussed. The performance is evaluated in terms of Bit Error Rate (BER) for various values of Signal to Noise Ratio (SNR). The obtained outcome demonstrates that the average BER is 0.32339 and 0.157071 respectively with conventional rake receiver and proposed CBKFR receiver when SNR value is 20dB. Hence it is found that the performance of the proposed CBKFR receiver is more preferable in comparison with conventional Rake receiver. Furthermore, the proposed CBKFR receiver is the most efficient and reliable for improving BER performance for DS-CDMA multipath channels.

Keywords:

DS-CDMA, Colour Video, Kalman Filter, Rake Receiver, BER, SNR

1. INTRODUCTION

Next generation, wireless system needs tremendous substance exchange with high caliber for the transmission of voice, data and video. This is hard to actualize without requiring extra bigger transfer speed. With a specific end goal to accomplish such requests, multiuser DS-CDMA is employed. In any case, it is hard to understand, different reception apparatuses at the Mobile Station (MS) as it expands its size. Also, it requires complex identification calculations at MS to relieve Multiple Access Interference (MAI) issue, for accomplishing better nature of voice, picture and video transmissions. Structure considers multi reception apparatuses at both transmitter and recipient can also be misused. The authors in [8] have proposed that downlink Multi-Carrier (MC)-CDMA system accomplishes decent variety gained by moderating the impacts of MAI in relays, MAI and Inter-Relay Interference (IRI) at the MS in goal versatile unit for cooperative communication. Rake receiver was first proposed by Price and Green in 1958 as a key innovation of spread range correspondence frameworks [3]. The name is taken from agricultural polygonal rake.

The Rake receivers are generally utilized in CDMA communication frameworks to accomplish against multipath fading. Rake takes full favourable position of the multipath signal energy. The receivers utilize a few correlators to exclusively process multipath signal segments [4], and the yield of each correlator is weighted and consolidated to enhance the receiver's signal to-noise proportion and reduction the likelihood of fading [5] Hameed et al. [9] proposed that orthogonal chaotic signals and Alamouti Multiple Inputs Multiple Outputs (MIMO) scheme are used to achieve a significant enhancement in the performance of DS-CDMA system. Simulation results demonstrated that an improvement in terms of BER performance and channel capacity are achieved when the proposed system is used compared with the traditional system that uses Walsh-Hadamard code as spreading codes. Cezary et al. [10] proposed the assessment of the signal correlation properties for various environmental conditions. Their outcomes show that depending upon the receiver speed, the adaptive selection of the delays in the various Rake receiver branches provides minimization of the correlation between the signals. Especially low levels of the signal correlation could be acquired in complex propagation environments such as urban and poor urban. Bottomley et al. [11] proposed a receiver based on Maximum Likelihood (ML) estimation is to compare conventional Rake reception, as well as approximate ML-based approaches. Ming et al. [12] suggested a recent adaptive Rake receiver based on Bayesian theory which only employed received signals to evaluate its channel parameters. Observed data are used to obtain the information of the channel impulse response. The mean and covariance of the channel impulse response that is demonstrated as a complex and uncertain Gaussian random vector are recursively assessed utilizing Bayesian theory. Niranjayan, et al. [13] proposed to minimize BER, by ML optimal combiner using an optimal linear Rake receiver to detect signals in symmetric alpha-stable noise for values of α, $0 < \alpha \leq 1$.

The rest of the paper is planned as follows. Section 2 presents a multipath channel model and a Rake receiver. Section 3 presents proposed Kalman Rake receiver. Section 4 discusses several simulation results and section 5 offers the conclusion.

2. RESEARCH METHOD

In a conventional Rake receiver, multipath propagation is abused by gathering signals from individual multipath components and coherently including them together. This summing of signals prompts the utilization of more originated energy from a transmitter. To adequately aggregate signals, an expected channel impulse response is required. Henceforth, knowledge of amplitude, relative propagation and phase delay from the most relevant multipath segments must be accessible to the receiver. Be that as it may, the estimated channel impulse response is not perfect and it varies from the true channel impulse response. The inconsistency among genuine and assessed channel impulse responses can be limited by Kalman Filter prediction. Because of channel estimation restrictions, conventional Rake receivers experience the ill effects of the different issues.

In this paper, a Crossover Blend of Kalman Filter and Rake (CBKFR) recipient approach is proposed. There are three essential commitments of this paper. To start with, as indicated by Kalman hypothesis and the base Minimum Mean Square Error (MMSE), this CBKFR does not require a pilot information stream embedded into the sequences and just uses received signals to assess its channel parameters. The mean and covariance of the channel impulse response based on Kalman Filter is displayed as a complex and uncertain Gaussian random vector. The second commitment of this paper is to propose a recursive Rake weights computation calculation, which builds the utilization of earlier data. To get the Rake weights, the mean and covariance of the channel impulse response are recursively evaluated by utilizing Kalman approach. In the recursive emphasis, a priori information is aggregated to enhance the receiver performance. Third contribution of this paper is to use this approach for real time colour video transmission. However, the Kalman approach is characterized by a lower BER.

2.1 RAKE RECEIVER WITH CONVENTIONAL ALGORITHM

Instead of solving the problem in [1], the conventional finger choice algorithm picks the M paths with biggest individual Signal to Interference Noise Ratios (SINRs), where the SINR for the l^{th} path can be communicated as

$$SINR_l = \frac{E_l\left(\alpha_l^l\right)^2}{\left(S_l^{MAI}\right)^T A^2 S_l^{MAI} + \sigma_n^2} \tag{1}$$

for l = 1,2,..,L.

where,

$E_l\left(\alpha_l^l\right)^2$ is the signal power

$\left(S_l^{MAI}\right)^T A^2 S_l^{MAI}$ is the signal interference

σ_n^2 is the mean noise power.

This algorithm is not optimal because it ignores the correlation of the noise segments of various paths. Therefore, it does not always maximize the overall SINR of the system given in [2]. For example, the contribution of two extremely correlated strong paths to the overall SINR might be worse than the contribution of one strong and one relatively weaker, but uncorrelated, path. The correlation between the multipath components is the outcome of the MAI from the interfering users in the system.

2.2 TRANSMITTER MODEL

Consider a direct sequence (DS) CDMA communication system with K active users. Let T_b is the bit period, T_c is chip period ($T_c = GT_b$), G is the processing gain and E_b is bit energy. For simplicity and without loss of generality, assumption of E_b is equal for all users. With handling the data by BPSK modulation technique, the equivalent low-pass data modulated transmitted signal of the k^{th} user is

$$S_K(t) = \sqrt{\frac{2E_b}{G}} \sum_{\lambda=-\infty}^{\infty} b^k_{\left[\frac{\lambda}{G}\right]} a^k_\lambda p\left(t - \lambda T_c\right) \tag{2}$$

where,

$b^k_{\left[\frac{\lambda}{G}\right]}$ is the binary information of the k^{th} user

a^k_λ is spreading code of the k^{th} user

[x]: denotes largest integer not greater than x

$p(t)$: is the normalized chip waveform.

For easiness, the transmitted signal pulse is assumed time limited rectangular pulse, which is a common assumption in CDMA systems, since the tails of the signal can be intended to decay rapidly. The said assumption is not away from reality. The wireless channel is demonstrated as a Wide Sense Stationary Uncorrelated Scattering (WSSUS) frequency selective Rayleigh fading one. Therefore, all received signal at the receiver front end is,

$$r(t) = \sum_{k=0}^{k-1} r_k\left(t - \tau_k\right) + \eta(t) \tag{3}$$

where,

$\eta(t)$ is a low pass equivalent process of Additive White Gaussian Noise (AWGN) with double-sided power spectral density $N_0/2$.

τ_k is the time of arrival of the k^{th} user's signal.

$r_k(t)$ is the received signal due to the k^{th} user given by,

$$r_k(t) = \int_{-\infty}^{\infty} h_k(\tau : t)\, s_k(t - \tau)\, d\tau \tag{4}$$

where, $h_k(\tau:t)$ is the channel impulse response of the k^{th} user's link at delay τ and time instant t, modeled as a complex zero–mean Gaussian random process. Its autocorrelation function is the Power Delay Profile (PDP) of the channel expressed as,

$$g(\tau) = E\{|h_k(\tau:t)|^2\} \tag{5}$$

In the case of a uniform PDP channel, Eq.(5) becomes,

$$g(\tau) = \begin{cases} \dfrac{1}{\tau_{\max}} & \tau \in \left[0, \tau_{\max}\right] \\ 0 & otherwise \end{cases} \tag{6}$$

where, τ_{max} is the maximum delay spread of the channel. When the propagation channel is depicted by an exponential PDP with decay constant τ_d, Eq.(5) gives that

$$g(\tau) = \frac{1}{\tau_d} e^{-\frac{\tau}{\tau_d}} \cdot U(\tau) \tag{7}$$

where, $U(\tau)$ is the unit step function [17].

2.3 PROPOSED MULTIPATH RAKE RECEIVER

The proposed crossover blend of Kalman filter and Rake receiver is as shown in Fig.1. The signal $s(t)$ is transmitted with multipath components through a multi-path channel, and the signal that is received $r(t)$, can be expressed as: $r(t) = s(t) * h(t) + \eta(t)$ where * is the convolution operator, $\eta(t)$ is zero-mean, white Gaussian noise with two–sided power spectral density $N_0/2$; N_0 is spectral density of the noise power and $h(t)$ is the impulse response of the channel.

The recommended indoor rake receiver was intended to construct the desired signal from many duplicates of the original information, which have different delays, phases, and amplitudes with interferences of inter-symbols and multi-accesses

$$r^u(t)=\sqrt{E^u}\sum_{t=-\infty}^{\infty}\sum_{j=0}^{N_c-1}\sum_{l=0}^{L}\sum_{k=0}^{K}\alpha_{k,l}C^u(j)b^u(i)P_T\left(t-iT_S-jT_C-T_1-\tau_{k,l}\right)+\eta(t) \quad (8)$$

where,

E^u is the transmission energy for user u

$\alpha_{k,l}$ are the multipath gain coefficients of the k^{th} ray within the l^{th} cluster

$C^u(j)$ is a random spreading code to the u^{th} user

$b^u(i)$ is BPSK symbol for the u^{th} user at the i^{th} time constant

N_c is spreading gain and is equal to the ratio of symbol duration (T_s) to chip duration (T_c)

T_1 is the delay of i^{th} cluster

$\tau_{k,l}$ is the delay of the k^{th} multipath component relative to the l^{th} cluster's arrival time (T_1)

$P_T(t)$ is the *pu* and *lse* waveform of width T_c.

As shown in Fig.1, after multiplying the received signal by the generated template signal, the $g_l(t-\tau)$, the output signal of each finger is $r_m^u(t)$ which can be written as:

$$r_m^u(t)=\int_0^T r^u(t)g_l(t-\tau)dt \quad (9)$$

where, $g_l(t-\tau)$ is the template signal and delayed by delay time (τ) to multiply with delayed copies of received signals. The weights of the rake receiver branches are picked to expand the SNR so as to work with individual signals that have the similar phase shift. Assuming that co-phasing has been accomplished, the envelope of the subsequent combined signal (Y_{tot}) can be written as

$$Y_{tot}=\sum_{m=1}^{M}a_m r_m \quad (10)$$

where, a_m is the delayed gain factor of each branch and r_m is the output signal of each finger.

The noise components in the branches are assumed to be independent, so the total noise power is given by summation of result of multiplying the signal power to the noise power for each branch by the combining gain factor.

$$Y_{tot}=\sum_{m=1}^{M}a_m SNR \quad (11)$$

where, M represent the number of rake finger, SNR is the transmitted symbol power to the AWGN power spectral density. Therefore, the SNR can be calculated as follows:

$$SNR=\frac{YE_b}{N_t}=\frac{E_b\sum_{m=1}^{M}\left(a_m r_m\right)^2}{N_0\sum_{m=1}^{M}a_m^2}=\frac{E_b\sum_{m=1}^{M}a_m^2\sum_{m=1}^{M}r_m^2}{N_0\sum_{m=1}^{M}a_m^2}=\frac{E_b}{N_0}\sum_{m=1}^{M}r_m^2 \quad (12)$$

where E_b/N_0 is energy per bit to noise power spectral density ratio.

As in the proposed rake receiver, the outputs of the correlators are weighted by using the combining algorithms, so the signals received are multiplied by the weights (w_m) which equals to k_{rm}, where k is an arbitrary constant.

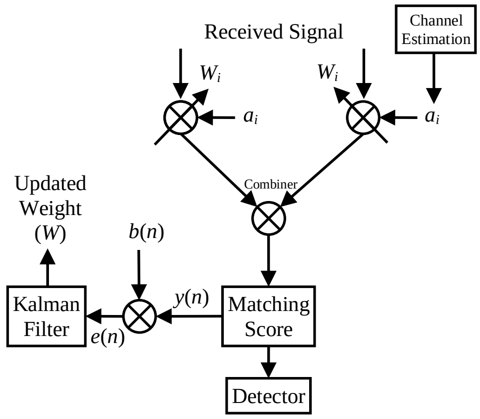

Fig.1. Proposed a crossover blend of Kalman filter and rake receiver

The proposed matched filter is connected at the output of the combiner in order to maximize the SNR with impulse response $h(T-t)$ matched to $Y_{tot}(t)$. The output of the matched filter is sampled at time $t = T$ and $0 \le t \le T$. Since output of the combiner contains the signal $s(\tau)$ and noise component $n(\tau)$, the output of matched filter will be $y(n)$. The error signal $e(n)$ is the difference between the desired signal $b(n)$ and the matching filter output $y(n)$. The error signal $e(n)$ is used to update the weight of correlaters of the rake receiver, which in turn helps in improving SNR and reducing SNR. When $b(n)$ and $y(n)$ are correlated in that case $e(n)$ is 0 and maximum mean energy extracted, it is given to the detector to take decision to generate 0 or 1 binary bits [18].

2.4 KALMAN FILTER

The Kalman filter is an optimal estimator i.e. it minimizes the mean square error. The filter works in decision feedback or training mode and utilizes the data received to update the channel matrix. The updated matrix can be used to predict the channel or perform optimal symbol detection. Here, Kalman filter-based channel predictor is used to minimize the sum of squares of the differences between the desired signal and the model filter output. Since new samples will be received in every iteration, we must update the weights of the Kalman filter by computing the results in recursive form. Distinctive feature of Kalman filter is that its mathematical formulations is described in terms of state-space concepts and also its solution is computed recursively applying without modification to stationary as well as non-stationary environments.

The Multiple Input Multiple Output (MIMO) channels exploit the random nature of radio propagation by finding independent signal paths for communication. It is based on the observation that if one radio path undergoes deep fade, another path may have strong signal. By having more than one path, both instantaneous and average SNRS at the receiver may be improved. In the state space model of 2×2 MIMO system, r is the received symbol, h is the channel matrix, s is a matrix which contains transmitted symbols, n is the AWGN noise added due to the channel impairments, A is the state transition matrix and subscript t represents the time instant. For $N_t = 2$, $N_r = 2$ the expanded state space variables are given in Eq.(13) – Eq.(15).

$$h_{t+1} = vec\left\{\left(h_{mtx}{}^{t+1}\right)^T\right\} \quad (13)$$

where, $Vec\{\}$ represents the vectorization operator (column wise), $()^T$ represents transpose of a matrix or vector.

$$A = \begin{pmatrix} a_1(p)I_{4L,4L} & a_2(I_{4L,4L}) \\ I_{4L,4L} & 0_{4L,4L} \end{pmatrix} \quad (14)$$

$$\omega_{t+1} = vec\left\{\left(\omega_{mtx}{}^{t+1}\right)^T\right\} \quad (15)$$

Table.1. Kalman filter Equations for CIR estimation

Estimation	Kalman Filter Equations
State Estimate Extrapolation	$\hat{h}_{t+1\|t} = A_t\hat{h}_{t\|t}$
Error Covariance Extrapolation	$\hat{P}_{t+1\|t} = A_t\hat{p}_{t\|t}A_t^H + Q_t$
Kalman Gain	$K_{t+1} = P_{t+1\|t}X_{t+1}^H$ $(X_{t+1}P_{t+1\|t}X_{t+1}^H + R_{t+1})^{-1}$
State Estimate Update	$\hat{h}_{t+1\|t} = \hat{h}_{t+1\|t} + K_{t+1}\|(r_{t+1}X_{t+1}\hat{h}_{t+1\|t})$
Error Covariance Update	$P_{t+1\|t+1} = P_{t+1\|t} - K_{t+1}X_{t+1}P_{t+1\|t}$

Here channel is considered as fast time varying so both h and A varies simultaneously. So, to estimate both h and A simultaneously among the various methods, Kalman filters is less complex and optimized. Kalman filter uses piece wise linear approximation of nonlinear channel model [16] [20].

For varying velocities, a matrix will be approximated by using the proportionate state transition matrices of the different regions in 2×2 MIMO channel model and then is used in Kalman filter. The Kalman filter equations [Time update(predict) and Measurement updates (correct)] which are used for Channel Impulse Response (CIR) estimation are given in Table.1, where $()^H$ represents Hermitian transpose of a vector or matrix, $()^{-1}$ represents inverse of a matrix, h is CIR(h_{11},h_{21},h_{12},h_{22}) matrix, P is the covariance matrix of channel error, Q is the state noise covariance matrix, K is the Kalman gain, R is the noise covariance matrix, X is the decoded transmitted symbols, Y is the received symbols, t denotes the time instant, $t|t$-1 denotes that the term is estimated using previous time instant term [19].

3. RESULTS AND INFERENCES

In this simulation experiments, Colour test video with AVI extension 180×144 resolutions have been used. The MATLAB code is implemented for simulation purpose. Several simulations are conducted to evaluate the performance of the proposed CBKFR receiver:

3.1 PROPOSED CBKFR RECEIVER WITH DIFFERENT MODULATION SCHEME

The BER has been measured by contrasting the transmitted signal with received signal and processing the number of bits in error over total number of bits sent for BPSK modulation. The BER is normally expressed in terms of SNR. The average BER versus SNR performance for AWGN channel using BPSK and QPSK modulation is as shown in Fig.2. By increasing the SNR, BER tends to decrease and reaches closer to zero for both the modulations. It was found that in modulation scenarios, BPSK modulation reveals good results.

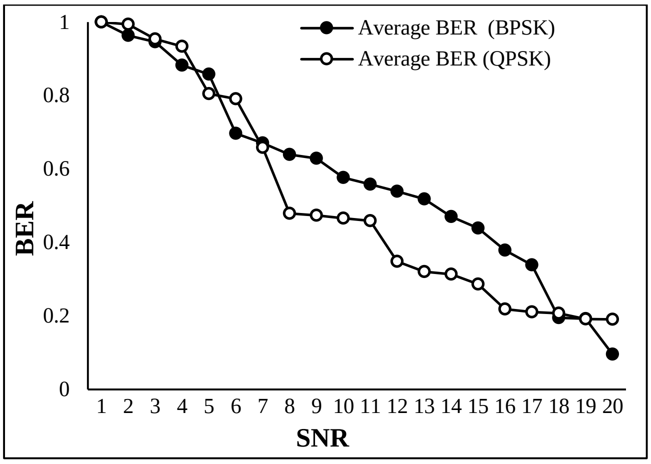

Fig.2. Average BER vs. SNR for BPSK and QPSK modulation

Table.2. Average BER for different SNRs with BPSK and QPSK modulation

SNR (dB)	Average BER (BPSK)	Average BER (QPSK)
1	1.000000	1.000000
2	0.963788	0.994571
3	0.946456	0.953766
4	0.882737	0.933939
5	0.858321	0.805269
6	0.697124	0.79114
7	0.67099	0.658628
8	0.6399	0.478794
9	0.6289	0.47424
10	0.576713	0.466407
11	0.5582	0.458714
12	0.539703	0.348322
13	0.518114	0.320451
14	0.470699	0.313557
15	0.43937	0.286678
16	0.3787	0.218138
17	0.339162	0.211045
18	0.19535	0.207049
19	0.192434	0.1915
20	0.095571	0.190938

The BER values for different SNR under AWGN channel using BPSK and QPSK modulation with proposed Rake receiver are as shown in Table.2.

From the numerical results as shown in Table.2, it is noted that, the received video quality has improved with increase in SNR values using BPSK and QPSK modulation. Also, it is found that average BER is 0.095571 and 0.190938 respectively for BPSK and QPSK modulation when the SNR value is 20dB. Hence it can be concluded that DS-CDMA system under AWGN channel with CBKFR receiver using BPSK modulation reveals good results.

4. PROPOSED CBKFR RECEIVER WITH DIFFERENT CHANNELS

Average BER versus SNR performance for AWGN and Rayleigh fading channel using BPSK with proposed rake receiver is as shown in Fig.3. By increasing the SNR (dB), the BER tends to decrease and reaches closer to zero for AWGN and Rayleigh fading channel. Moreover, it is observed that in fading environment, the AWGN channel offers good results compared to Rayleigh channel.

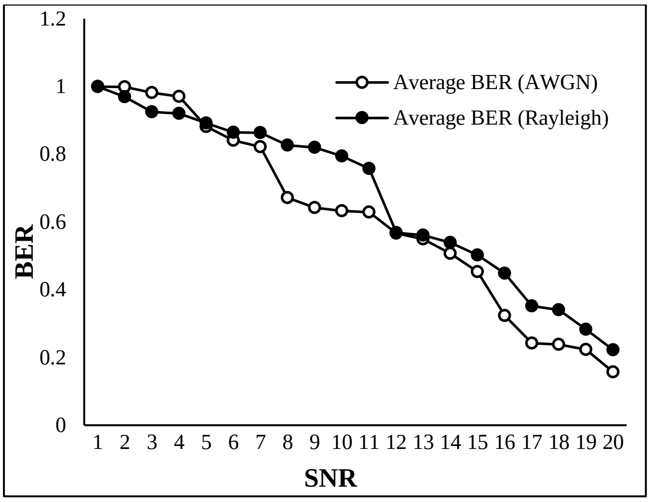

Fig.3. Average BER Vs SNR for AWGN and Rayleigh fading channel using BPSK modulation

The BER values for different SNR under AWGN and Rayleigh fading channel using BPSK modulation with proposed CBKFR receiver are as shown in Table.3.

Table.3. Average BER for different SNRs with AWGN channel and Rayleigh fading channel

SNR (dB)	Average BER (AWGN)	Average BER (Rayleigh)
1	1.000000	1.000000
2	0.999009	0.968863
3	0.981629	0.924549
4	0.970646	0.919849
5	0.881317	0.891442
6	0.840457	0.864444
7	0.82214	0.863073
8	0.671438	0.826915
9	0.641838	0.820368
10	0.63304	0.794633
11	0.628869	0.75715
12	0.56611	0.568216
13	0.549906	0.560977
14	0.507014	0.539384
15	0.453599	0.502065
16	0.323304	0.448456
17	0.242469	0.351669
18	0.238453	0.340549
19	0.223285	0.282785
20	0.157071	0.222636

From the numerical results as shown in Table.3, it can be noted that, the received video quality has improved with the increasing SNR values for AWGN and Rayleigh fading channel. Also, it is found that average BER is 0.157071 and 0.222636 respectively for AWGN and Rayleigh fading channel when the SNR value is 20dB. Again, it can be concluded that DS-CDMA system under AWGN channel with CBKFR receiver using BPSK modulation reveals good results.

4.1 PROPOSED CBKFR RECEIVER WITH DIFFERENT CODE

The average BER versus SNR performance for AWGN channel using BPSK modulation for gold code, PN code and Walsh code is as shown in Fig.4.

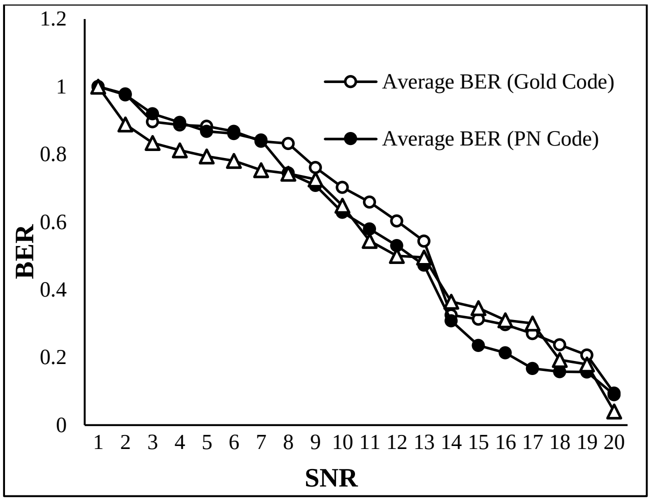

Fig.4. Average BER Vs SNR for AWGN channel using BPSK modulation with Gold, PN and Walsh

By increasing the SNR (dB), BER decreases and reaches closer to zero for gold code, PN code and Walsh code, so that the quality of the received video is improved. It is seen that average BER for Walsh code is giving good performance compared to gold and PN code when SNR is varied in the range of 1 to 10dB. Afterwards the average BER for PN code is better compared to other two codes for higher value of SNRs (11dB to 20dB).

The BER values for various SNR under AWGN channel using BPSK modulation for gold code, PN code and Walsh code with proposed CBKFR receiver are as shown in Table.4.

Table.4. Average BER for different SNRs with gold code, PN code and Walsh code

SNR (dB)	Average BER (Gold Code)	Average BER (PN Code)	Average BER (Walsh Code)
1	1.000000	1.000000	1.000000
2	0.978337	0.975571	0.888752
3	0.896617	0.919969	0.83351
4	0.887246	0.89408	0.812051
5	0.882606	0.867613	0.793988
6	0.868399	0.86122	0.781178
7	0.83835	0.842635	0.753642
8	0.832122	0.744802	0.743011
9	0.760703	0.70809	0.726532
10	0.702493	0.629081	0.648735
11	0.658783	0.57951	0.544966
12	0.603132	0.530683	0.499966
13	0.543503	0.472969	0.495481
14	0.324959	0.308069	0.364626
15	0.312581	0.235659	0.346174
16	0.29738	0.213831	0.310493
17	0.270104	0.167618	0.300447
18	0.237616	0.158356	0.193077
19	0.207369	0.156632	0.179405
20	0.095018	0.089523	0.041149

From the numerical results as shown in Table.4, it is noted that, the received video quality has improved with the increase of SNR values with proposed CBKFR receiver. Also, it is found that average BER is 0.095018 for gold code, 0.089523 for PN code and 0.041149 for Walsh code when the SNR is 20dB.

4.2 PROPOSED CBKFR RECEIVER WITH CONVENTIONAL RAKE RECEIVER

The average BER versus SNR performance for AWGN channel using BPSK modulation with conventional Rake receiver and with proposed CBKFR receiver is as shown in Fig.5. With conventional Rake receiver, it can be noted that by increasing the SNR the average BER decreases. Whereas BER is not reaching to zero, this in turn results in a few errors in the received video signal. With proposed CBKFR receiver, by increasing the SNR, BER tends to decrease and reach closer to zero, so that the quality of received video is improved. Therefore, DS-CDMA system under AWGN channel with proposed CBKFR receiver using BPSK modulation reveals good results.

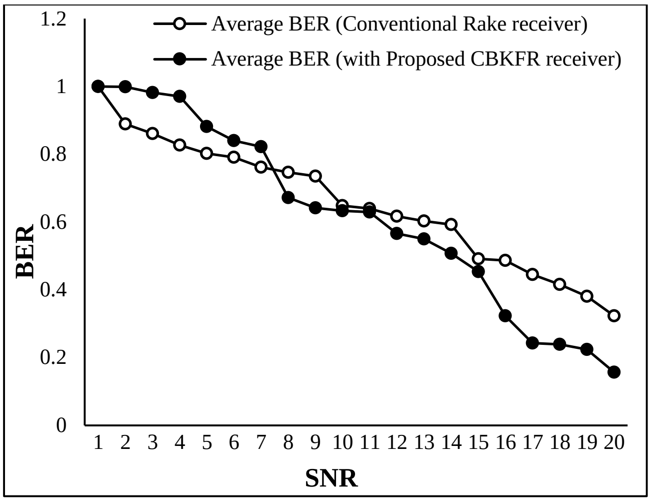

Fig.5. AWGN channel using BPSK modulation with proposed CBKFR receiver and conventional rake receiver

The BER values for various SNR under AWGN channel using BPSK modulation with conventional Rake receiver and proposed CBKFR receiver are as shown in Table.5.

Table.5. Average BER for different SNRs with conventional rake receiver and CBKFR Receiver

SNR (dB)	Average BER (Conventional Rake receiver)	Average BER (with Proposed CBKFR receiver)
1	1.000000	1.000000
2	0.889486	0.999009
3	0.86052	0.981629
4	0.826591	0.970646
5	0.802771	0.881317
6	0.790556	0.840457
7	0.761873	0.82214
8	0.746196	0.671438
9	0.735415	0.641838
10	0.648211	0.63304
11	0.6398	0.628869
12	0.616693	0.56611
13	0.602733	0.549906
14	0.592231	0.507014
15	0.49081	0.453599
16	0.486727	0.323304
17	0.445301	0.242469
18	0.415764	0.238453
19	0.38028	0.223285
20	0.32339	0.157071

From the numerical results as shown in Table.5, it is observed that, received video quality has not enhanced with increase of SNR values using conventional Rake receiver and when the value of SNR is 20dB then BER is 0.32339.

With proposed Rake receiver, it is observed that, the received video quality has improved significantly with the increasing SNR values. Also, it is found that, average BER is 0.157071 when the SNR value is 20dB Again it is concluded that. DS-CDMA system under AWGN channel with proposed CBKFR receiver using BPSK modulation reveals good results.

4.3 COLOUR VIDEO TRANSMISSION

The first frame of the original video is sent by means of the DS-CDMA system and the received video is obtained by changing the SNR of transmission channel (AWGN, Rayleigh fading), using various spreading codes (Gold code, PN code, Walsh code), BPSK and QPSK modulation, conventional rake receiver and with proposed CBKFR receiver as shown in Fig.6.

In order to try to convey video by the DS-CDMA system, we choose a colour test video loaded in its three RGB components. These components value levels are already from 0 to 255 and then converted between 0 and 1 using binary codec. The program runs with different spreading codes, various modulation schemes and transmission channels. The result shows that with CBKFR receiver, the quality of the received video enhanced.

Fig.6. Colour video received respectively with various codes, channels, modulations and with conventional rake receiver and CBKFR receiver at SNR = 20dB

5. CONCLUSION

In this work, simulation of a DS-CDMA system for transmission of colour video is performed. This paper proposes a kind of Rake receiver based on Kalman filter which can be used in the multipath fading channel with considering affected multipath interferences. Quality is assessed each time by BER estimation between the received video with original video.

The CBKFR receiver for multipath channels is derived and studied to check its BER performance in multiuser environment with AWGN and Rayleigh fading channel. The proposed framework is tested for video transmission with different codes, various modulation schemes and transmission channels. It is found that in various modulation scenarios, the BPSK modulation offered good result compared to QPSK modulation, in fading environment, the AWGN channel offer good results compared to Rayleigh fading channel. In various spreading code, the average BER for PN code is better compared to gold and Walsh code. The simulation results indicate that the average BER is 0.32339 and 0.157071, respectively with conventional rake receiver and proposed CBKFR receiver when SNR value is 20dB. Hence the performance of CBKFR receiver is more preferable in comparison with conventional Rake receiver. Furthermore, the CBKFR receiver is the most efficient and reliable for improving BER performance for DS-CDMA multipath channels.

REFERENCES

[1] E. Fisher and H.V. Poor, “On the Tradeoff between Two Types of Processing Gains”, *IEEE Transactions on Communications*, Vol. 53, No. 10, pp. 1744-1753, 2005.

[2] L. Zhiwei, A.B. Premkumar and A.S. Madhukumar, “Matching Pursuit based Tap Selection Technique for UWB Channel Equalization”, *IEEE Communication Letters*, Vol. 9, No. 9, pp. 835-837, 2005.

[3] R. Price and P.E. Green, “A Communication Technique for Multipath Channels”, *Proceedings of the IRE*, Vol. 46, pp. 555-570, 1958.

[4] T. Feng, A. Bi and T. Wu, “An Improved RAKE Receiver with Delay Adjustment”, *Proceedings of China-Japan Joint Microwave Conference*, pp. 1-4, 2011.

[5] X.F. Kang and B.P. Li, “The BER Performance Analysis and Simulation of RAKE Receiver for UWB Systems”, *Proceedings of IEEE on Workshop Advanced Research and Technology in Industry Applications*, pp. 267-269, 2014.

[6] Arie Geert Cornelis Koppelaar, Andries Pieter Hekstra, Frank Harald Erich Ho Chung Leong, Stefan Drude and Marinus Van Splunter, “Efficient Rake Receiver Finger Selection”, Available at: https://patents.google.com/patent/US9667310B2/en

[7] L.L. Yang, “A Zero-Forcing Multiuser Transmitter Preprocessing Scheme for Downlink Communications”, *IEEE Transactions on Communications*, Vol. 56, No. 6, pp. 862-865, 2008.

[8] B. Sridharan, A. Ravi, A. S. Haribhaskaran and P. Nagaradjane, “Cooperative Downlink MC-CDMA System Aided by Transmitter Preprocessing: Performance Results”, *Proceedings of IEEE International Conference on Telecommunications*, pp. 145-149, 2014.

[9] Abbas Salman Hameed, "DS-CDMA based on Orthogonal Chaotic Signals and Alamouti Scheme", *Proceedings of IEEE International Conference on Engineering Sciences*, pp. 120-125, 2018.

[10] Cezary Ziolkowski, Jan M. Kelner and Leszek Nowosielski, "Correlation Properties of Signal at Mobile Receiver for Different Propagation Environments", *Proceedings of International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering*, pp. 1024-1027, 2018.

[11] Gregory E. Bottomley and Carmela Cazza, "RAKE Reception with Channel Estimation Error", *IEEE Transactions on Vehicular Technology*, Vol. 55, No. 6, pp. 1923-1926, 2006.

[12] Ming Wang, Yubina Han and Welixing Sheng, "A Bayesian Approach to Adaptive RAKE Receiver", *IEEE Access*, Vol. 6, pp. 3648-3654, 2017.

[13] S. Niranjayan and Narman C Beaulieu, "BER Optimal Linear Combiner for Signal Detection in Symmetric Alpha-Stable Noise: Small Values of Alpha", *IEEE Transactions on Wireless Communications*, Vol. 9, No. 3, pp. 886-890, 2010.

[14] M.E.T. Roman and V.V. Koivunen, "Time-Domain Method for Tracking Dispersive Channels in MIMO OFDM Systems", *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing*, pp. 393-396, 2003.

[15] F. Tufvesson and T. Masseng, "Pilot Aided Channel Estimation for OFDM in Mobile Cellular System", *Proceedings of IEEE 47th International Conference on Vehicular Technology*, pp. 1639-1643, 1997.

[16] Bor Sen Chen, Chang-Yi Yang and Wei Ji Liao, "Robust Fast Time-Varying Multipath Fading Channel Estimation and Equalization for MIMO-OFDM Systems via a Fuzzy Method", *IEEE Transactions on Vehicular Technology*, Vol. 61, No. 4, pp. 1599-1609, 2012.

[17] Konstantinos B. Baltzis, "An Efficient Finger Allocation Method for the Maximum Likelihood Rake Receiver", *Radio Engineering*, Vol. 17, No. 4, pp. 45-50, 2008.

[18] Rashid A. Fayadh, F. Malek and Hilal A. Fadhil, "Enhancement of a Three Combining Techniques Rake Receiver Using Adaptive filter of M-Max Partial Update RLS Algorithm for DS-UWB Systems", *Journal of Next Generation Information Technology*, Vol. 5, No. 4, pp. 93-105, 2014.

[19] Vinod Gutta, Kamal Kanth, Toguru Anand, Tej Sri Venkata Saidhar Movva, Bhargava Rama Korivi, Santosh Killamesetty and Sudheesh Padmanabhan, "Low Complexity Channel Estimation using Fuzzy Kalman Filter for Fast Time Varying MIMO-OFDM Systems", *Proceedings of International Conference on Advances in Computing Communications and Informatics*, pp. 1771-1774, 2015.

[20] Greg Welch and Gary Bishop, "An Introduction to the Kalman Filter", Available at: https://courses.cs.washington.edu/courses/cse571/03wi/notes/welch-bishop-tutorial.pdf.