Channel Estimation for DS-CDMA Rake Receiver using Sparse Recovery Approach

Rajendrakumar Govinda Zope, Balasaheb Shrirangrao Agarkar

Abstract: ***In the literature of direct-sequence code-division multiple-access (DS-CDMA), for issues related to channel estimation, some exclusive architectures have been proposed, which are characterized by known channel noise statistics and noise observation. But in reality, the channel parameters are frequently assessed utilizing training sequences that lead to difficulty in obtaining the channel noise statistics. Channel estimation quality has been proved to play an important role in the performance of rake receiver. This paper addresses the issues of optimizing DS–CDMA rake receiver channel estimation equipped with an Iterative least square sparse recovery (IL²SR) channel estimator. Moreover, the ambient noises corrupt the signal received and multiple-access interference further aggravates it. Because of this observation noises become hard to acquire. Hence this paper proposes as an iterative least square structure for channel estimation algorithm in rake receiver employed in DS-CDMA communication systems. Further, examination of blind channel estimation problem for rake-based DS-CDMA communication framework having multi-path fading channels with time variation is also attempted. The validity of the proposed techniques has been verified through results obtained from simulation for different channel parameters and spreading codes. Further exploration has been carried out with execution of the IL²SR with Rake receiver in DS-CDMA framework for multi-path fading channels. It is found that better performance is obtained with this framework under various channels with different spreading codes. The proposed system is compared with Kalman based techniques and it was found that DS-CDMA framework under additive white gaussian noise (AWGN)channel with IL²SR receiver reveals better outcomes in terms of bit error rate (BER). Also, there has been improvement in video quality while using the proposed IL²SR receiver with increase in the values of ratio of signal to noise ratio.***

Keywords: ***DS-CDMA, Iterative Least Square Sparse Recovery (Il²sr), Rake, Multipath Channels.***

I. INTRODUCTION

Direct-sequence code-division multiple access (DS-CDMA) is one among the excellent multiple access techniques for communication systems of the fourth and fifth generation. Therefore, nowadays it is highly recommended by many researchers. DS-CDMA, having large signal bandwidth, turn-out to be highly suitable for transmission over multipath fading channels as it authorises high resolution of diverse multipath. The choice of well-known rake receiver structure is highly recommended for the efficient and reasonable single user detection in the first generation of universal mobile telecommunications system (UMTS) handsets. In fact, the rake receiver is inferred from multi-path channel model with each rake finger assigned to individual multipath ideally, maximizing the quantity of received signal energy. A pre-requirement is that the rake has matching record about the current channel parameters which include, path location (in the delay domain), number of paths and current attenuation (complex-valued).

Rake receiver are often employed in DS-CDMA for combining, the multi-path signals. As such the rake receiver is some sort of a radio receiver designed with the objectives of countering the impact of multipath fading. This is achieved using several sub-receivers called fingers. In other words, several correlators are assigned to different multi-path fading components. Multiple correlators named fingers are utilized in the rake receiver for achieving diversity gain. Such fingers are to be deferred at least by one chip duration. Each of these fingers produces a decision variable through extraction of one of the distinguishable multi-path components. All the decision variables corresponding to different fingers are combined for generation of final decision variable. For this, the method of maximal ratio combining is employed. This demands the familiarity of fading coefficients. Rake receiver performance in frequency selective channel is described in [1–3]. These performances are obtained with multi-path channel coefficients. In [4-5] adaptive rake receivers' performance is analyzed, on which further improvement can be done by increasing number of fingers greater than multipath components.

These types of rake receivers are named as generalized rake receiver. In [7] such type of rake receiver which employs adaptive finger placement and computation is explained. The nature of wireless communication systems is that their channel is time varying in nature usually. For such systems, in order to approximate the fading coefficients, adaptive channel estimation is essential. For expelling the fading effect at a particular finger, channel estimation is performed at each and every finger.

One significant job in implementing each digital receiver is synchronization i.e., to estimate and compensate the relevant channel parameters. The notion of assessing these parameters and after that utilizing them as if they were the true values is called synchronized detection and it is used virtually in implementation of every digital receiver. In this case, it is essential to evaluate necessary channel parameters and tracking of the same throughout the transmission.

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In a CDMA receiver, during the examination of the synchronization tasks, there is necessity of high-resolution multipath acquisition and tracking algorithms for channels which show small delay spreads i.e., with closely spaced multi-paths, it was recognized and solved by Iterative least square sparse recovery along with rake receiver.

This paper explores the execution of IL^2SR in DS-CDMA framework with rake receiver for multi-path fading channels. Bit error rate (BER) equation in closed form is derived for binary phase shift keying (BPSK) for different spreading codes and fading channels.

In Code Division Multiple Access spreading codes are used for expanding the bandwidth of the modulated signal to the higher transmission bandwidth. These codes assist in identifying which all different user signals are using identical transmission bandwidth in the multiple-access system. A pseudorandom noise (PN) generator or another specially designed code generator, like, "Kasami code, gold code, Walsh Hadamard code" [8], [9] are used to generate the spreading codes.

An exhibition of DS-CDMA is characterized by multi-carrier code multiple access (MC-CDMA). With DS-CDMA, spreading arrangement is utilized to spread the data in the time space. Interestingly, with MC-CDMA, information is spread over various sub-transporters utilizing a spreading succession in the recurrence space [19]. A reasonable all-advanced recipient that engineers most maximum likelihood sequence estimation (MLSE) would be ideal as far as the BER is concerned. It is unfeasibly complex when there is considerable inter symbol interference (ISI), and requires a costly and power hungry rapid simple to-computerized analog/digital converter (ADC) due to the enormous data transfer capacity [20].

II. SYSTEM MODEL

This paper adopts a model similar as in [10,11,12]. Consider a binary DS-CDMA communication framework which has "k" multiple access users. The transmitted base-band signal of the k-th user is given as follows:

$$x_k(t) = \sqrt{A_k} \sum_{n=-\infty}^{\infty} b_k(n)\ s_k(t - nT_s) \qquad (1)$$

here A_k : transmitted bit energy,

$b_k(n)$: modulated information symbol of the "k-th" user chosen randomly from set $\{-1, +1\}$

T_s : symbol duration, and

$s_k(t)$ represents transmitted waveform given as,

$$s_k(t) = \sum_{i=0}^{N} \tilde{c}_k(i)\psi(t - iT_c) \qquad (2)$$

where N: spreading gain, $\tilde{c}_k(i)$: spreading code of the "k-th" user with period N, and $\psi(t)$ is the real transmitted monocycle waveform shape in the time interval $0 \le t \le T_c$, that is, $\psi(t) = 0$ if $t \notin [0, T_c]$,.and has energy (1/N).

It is assumed that the multipath channel is comprised of L resolvable propagation path and additionally the channel coefficients are time-invariant; then, the channel impulse response for the kth user can be given by,

$$H_k(t,\tau) = \sum_{i=0}^{L-1} h_k^1(n)\ \delta(t - lT_c), nT_s \le \tau \le (n+1)T_s \qquad (3)$$

where, complex valued fading coefficient $h_k^1(n)$ is presumed to be invariant at a symbol duration.

Therefore, the received signal component from the kth user can be represented as,

$$\tilde{y}_k(t) = x_k(t) * H_k(t,\tau) \qquad (4)$$

where $*$ denotes the convolution operator.

The total signal at the receiver is superposition of K users signal in presence of additive white gaussian noise (AWGN) is given by,

$$\tilde{r}(t) = \sum_{k=1}^{K} \widetilde{y_k}(t) + \tilde{v}(t) \qquad (5)$$

where $\tilde{v}(t)$is a White Gaussian noise having zero mean.

The discrete-time signal is formed by sampling the yield of the chip-matched filter at chip rate. By collecting N successive samples, the channel yield from the kth user at the nth symbol can be communicated as

$$y_k(n) = [\tilde{y}_k(nN)\tilde{y}_k(nN+1) \ldots .\tilde{y}_k(nN+N-1)]^T$$
$$= b_k(n)C_k^0 h_k(n) + b_k(n-1)C_k^1 h_k(n-1) \qquad (6)$$

where $h_k(n)$ - parameter collection of all multipath components and is given by,

$$h_k(n) = \left[h_k^0(n)h_k^0(n) \ldots h_k^{l-i}(n)\right]^T \qquad (7)$$

and C_k^0 and C_k^1 are the signature matrices with dimension N x L of form,

$$C_k^0 = \begin{bmatrix} c_k(0) & 0 & \cdots & 0 \\ c_k(1) & c_k(0) & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ c_k(L) & c_k(L-1) & \cdots & c_k(0) \\ \vdots & \vdots & \cdots & \vdots \\ c_k(N-1) & c_k(N-2) & \cdots & c_k(N-L) \end{bmatrix} \qquad (8)$$

$$C_k^1 = \begin{bmatrix} 0 & c_k(N-1) & \cdots & c_k(N-L+1) \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & c_k(N-1) \\ 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & 0 \end{bmatrix} \qquad (9)$$

where

$$c_k(i) = \begin{cases} \frac{\sqrt{A_k}}{N}\bar{c}_k(i), & 0 \le i \le N-1 \\ 0, & \text{otherwise} \end{cases} \qquad (10)$$

For a synchronous CDMA forward channel, the received total discrete-time signal of all users is,

$$r(n) = [\tilde{r}(nN)\tilde{r}(nN+1) \ldots \tilde{r}(nN+N-1)]^T$$
$$= \sum_{k=1}^{K} y_k(n) + v(n) \qquad (11)$$

III. ITERATIVE LEAST SQUARE SPARSE RECOVERY

Here an Iterative least square sparse recovery (IL^2SR) is presented with a novel preconditioner to solve the L_1-norm regularized least square issue for non-negative sparse signal reconstruction.

We proposed to reconstruct an unknown signal $x \in \mathbb{R}^N$ from its linear observation:

$$b = Ax + n \in \mathbb{R}^M \qquad (12)$$

where $A \in \mathbb{R}^{MxN}$. ,and $n \in \mathbb{R}^M$ is the noise.

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Typical least square method involves abundant measurements ($M \geq N$ and A has full rank N) to recover $x^* = (A^T A)^{-1} A^T b$. Recently, compressive sensing techniques can reconstruct x from numerous fewer measurements ($M \leq N$) as long as the signal is sparse by solving the following basis pursuits denoising problem (BPDN) as,

$$\min_{x \in R^N} \frac{1}{2} \|Ax - b\|^2 + \tau \|x\|_l \qquad (A1)$$

where $\tau > 0$ is a given regularization weight, $\|x\|_2 := \sqrt{\sum_{i=1}^N x_i^2}$ and $\|x\|_1 := \sqrt{\sum_{i=1}^N |x_i|}$ denote the L_2 and the L_1 norms of x, respectively.

This paper considers received signals $x \geq 0$. Explicitly including the constraint in equation (A1) limits the solution search space in non-negative reconstruction. Moreover, if x does have negative components, a common optimization method lets $\hat{x} = [x^+; x^-] \in \mathbb{R}^{2N} \geq 0$ and $\hat{A} = [A, -A] \in \mathbb{R}^{Mx2N}$, where $x_i^+ = \max(x_i, 0)$ and $x_i^- = \max(-x_i, 0)$,the $Ax = \hat{A}\hat{x}$ and $\|x\|_1 = \|\hat{x}\|_1$, and subsequently equation (A1) can be solved with respect to $\hat{A}$ and $\hat{x} \geq 0$. Therefore, we only need to consider the following variant of equation for $x \geq 0$,

$$\min_{x \in \mathbb{R}^N} \frac{1}{2} \|Ax - b\|^2 + \tau e^\tau x \ \text{ such that } x \geq 0 \qquad (A+)$$

The optimization problem shown in equation. (A+) is convex having only linear constraints and fulfills Slater's condition. Hence, its optimal solutions are found by solving its Karush-Kuhn-Tucker (KKT) system as,

$$A^T Ax - s - A^T b + \tau e = 0 \qquad (13a)$$
$$XSe = 0 \qquad (13b)$$
$$(x, s) \geq 0 \qquad (13c)$$

where $X := \text{Diag}(x)$ and $S := \text{Diag}(s)$ and Diag ( ) denote diagonal matrices created from primal variable x and dual variable x and dual variable s, respectively, and 0 and *e* denote an all zero or all one vector whose dimension shall be clear from context, respectively. The IL^{2}SR explains a modified KKT system which easily substitutes equation (13b) in the original KKT system by,

$$XSe = \sigma\mu e$$

where $\mu := x^T s/N$ goes to 0 when converges, and $\sigma \in [0,1]$is a centering parameter. A σ closer to 1 will guide search direction more towards the interior $(x, s) > 0$. Starting from a point (x, s), the Newton direction for the modified KKT system can be computed as,

$$A^T A\Delta x - \Delta s = r_d \qquad (14a)$$
$$S\Delta x + X\Delta s = r_c \qquad (14b)$$

where, r_d stationarity residual and complementary slackness residual r_c can be represented as,

$$r_d := s - \nabla h(x) \qquad (15a)$$
$$r_c := \sigma\mu e - XSe \qquad (15b)$$

Here, $\nabla h(x) = A^T Ax - A^T b + \tau e$ is the gradient of the objective function $h(x)$: $\frac{1}{2}\|Ax - b^2\| + \tau e^\tau x$.

In Algorithm 1the IL^{2}SR with predictor-corrector steps is presented. As mentioned in [22], the IL^{2}SR framework is additionally use as it is found to be the most effective interior point methods (IPMs) [23]. New initialization is used with simpler and effective σ values, new preconditioner and adaptive tolerance in preconditioned conjugate gradient (PCG) for obtaining faster convergence [22]. More flexible values of x, s is permitted in this work which violate equation (13a) at initial set up and following iterations.

Algorithm 1: Iterative least square sparse recovery (IL^{2}SR) Framework

Inputs: choose$(x^0, s^0) > 0$ from Section A, stop accuracy ∈ (e.g., $1e^{-6}$), and maximum iteration number k_{max}.

for $k = 1,2, \dots, k_{max}$ **do**

Perform Prediction Step: set$\sigma \leftarrow 0.001$.

$$(x^k, s^k, \alpha_p, \alpha_d) = \text{UPDATE}(x^{k-1}, s^{k-1}, \sigma)$$

If $\min(\alpha_p, \alpha_d) \leq 0.1$ **then**

Perform correction Step: set $\sigma \leftarrow 0.99$

$$(x^k, s^k, \alpha_p, \alpha_d) = \text{UPDATE}(x^{k-1}, s^{k-1}, \sigma)$$

if $\mu_k \leq \in h(x^k)$ and $\|r_d^k\|$ **then**

Break

Output: x^k

function $\text{UPDATE}(x^{k-1}, s^{k-1}, \sigma)$

Compute $\Delta x, \Delta s$ with σ, x^{k-1}, s^{k-1} use Section B

Compute α_p, α_d with $x^{k-1}, s^{k-1}, \Delta x, \Delta s$ use Section C

Update $(x^k, s^k) \leftarrow (x^{k-1} + \alpha_p \Delta x, s^{k-1} + \alpha_d \Delta s)$.

return $(x^k, s^k, \alpha_p, \alpha_d)$

A. Initial Point

A well-chosen initial point $(x^0, s^0) > 0$ that is close to the optimal solution (satisfies equation (13)) can significantly lessen the total computation time of the algorithm. Following steps to compute $(x^0, s^0) > 0$ are used that nearly satisfies equation (13a) & makes x_i and s_i balanced, which works well in practice. The least squares solution of minimum norm are found for $Ax = b$ as $x^\alpha = A^T(AA^T)^{-1}b$ to keep both $\|Ax - b\|^2$ and $\|x\|$ small. Then we compute $\delta^\alpha = \max(0, -x_{min}^\alpha)$ where x_{min}^α signifies the minimum element of x^α, and adjust $x^\alpha \leftarrow x^\alpha + \delta^\alpha e$ to make x^α non-negative. Then we compute $\delta^c = \max(0, (\epsilon_0 x_{max}^\alpha - x_{min}^\alpha)/(1 - \epsilon_0))$ where $\epsilon_0 = 0.001$ and x_{max}^α denotes the maximum element of x^α , and update $x^b = x^\alpha + \delta^b e$ so that x^b is strictly positive and its components are not too balanced: $x_{min}^b / x_{max}^b \geq \epsilon_0$. Then we compute $\delta^\alpha = \max(0, -\nabla h(x^b)./ A^T A e))_{max})$ which is used to update $\nabla h(x^b)$to be non-negative, where ./ denotes element-wise division for two vectors, and updated $x^0 = x^\alpha + \delta^c e > 0$ and $s^0 = \nabla h(x^0) \geq 0$. Finally, we compute $\delta^d = \max(0, (\epsilon_0 s_{max}^0 - s_{min}^0)/(1 - \epsilon_0))$,and adjust $s^0 = s^0 + \delta^d e$ so that $s^0 > 0$ is balanced: $s_{min}^0 / s_{max}^0 \geq \epsilon_0$. The above computational cost is subjugated by the first step $b\,(AA^T)^{-1}$, that can be solved iteratively using PCG or directly, considering *A* has special structure. In either case, the computational cost is no more than one iteration Algorithm 1. Note our initial point may not satisfy equation (13a), as s^0 - $h(x^0) \neq 0$ if $\delta^d > 0$ in the last step.

B. Newton Step with PCG

Evaluate $(\Delta x, \Delta s)$, by Δs being eliminated at first and then solve for Δx from

$$(D^{-1} + A^T A)\,\Delta x = c \qquad (16)$$

where

$$D := XS^{-1} \qquad (17a)$$
$$c := r_d + X^{-1} r_c = \sigma\mu X^{-1} e - \nabla h(x) \qquad (17b)$$

Using Equation (16), the preconditioner $M = P^T P$ is used to transfer it to an equilibrium equation as

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$$(P^{-T}(D^{-1} + A^TA)P^{-1})\,(P\Delta x) = P^{-T}c \qquad (18)$$

The preconditioner M meaningfully affects the efficiency of PCG. It should be effortlessly approximate and invertible $(D^{-1} + A^TA)$ well to make $P^{-T}(D^{-1} + A^TA)P^{-1}$ well-conditioned. The strategy of good preconditioner is typically problem specific. The diagonal approximation of A^TA is good for diagonal matrices, and the $\frac{M}{N}\, I\, A^TA$ approximation [22] works where $AA^T = I$ and A satisfies *RIP* well.

Convolution with a non-negative point spread function (PSF) is very much applied in various communication applications and is of special interest. A convolution related matrix A has circulant structure, having eigenvalue decomposition of A^TA. The eigenvalue decomposition is assumed as,

$$A^TA = V\Lambda V^T = \sum_{i=1}^{N} \lambda_i\, v_i v_i^T \qquad (19)$$

where the eigenvalues $\lambda_1 \ge \lambda_2 \ge \lambda_3 \ge \cdots \ldots \lambda_N$. If the PSF has most energy concentrated in low frequency, we may use the first few or even one columns of V to approximate A^TA as $\lambda_i v_i v_i^T = V V^T$ where $v = \sqrt{\lambda_i} v_i$. The inverse of this preconditioner is computable by Sherman Morrison formula as

$$M^{-1} = (D^{-1} + v v^T)^{-1} = D - \frac{Dv\, v^TD}{1 + v^TDv} \qquad (20)$$

With support of preconditioner, search direction from previous iteration is been fed (or 0 for the first iteration) as the primary point of PCG. It stops when a maximum number of iteration (e.g.,101) is reached or when it finds a solution within relative tolerance $tol_{CG} = max\,(0.001, min\,(0.1, (\mu + \|rd\| / \|b\|\ ))$, which prefers more accurate Newton direction when approaching the optimal solution.

After getting Δx, we can compute Δs from equation (14a) or equation (14b),

$$\Delta s = A^TA\Delta x - r_d \qquad (21a)$$

$$\Delta s = D^{-1}\Delta x + X^{-1} r_c \qquad (21b)$$

Those two equations result in different Δs as Δx only satisfies equation (16) approximately. We chose to compute Δs by equation (21b) so that equation (14b) is fulfilled exactly to promote longer step size α_d instead using equation (21a). By making this choice, equation (13a) may be violated even after a full step size $\alpha_p = 1, \alpha_d = 1$

C. Step Size

The step sizes (α_p, α_d) are calculated as suggested by [24]. We first find x_p^{max} that makes $x + x_p^{max}\,\Delta x \ge 0$. If $\Delta x \ge 0$, then we set $x_p^{max} = +\infty$;otherwise $x_p^{max} = \min_{\Delta x<0} - \frac{x_i}{\Delta x_i}$. Then we compute $\alpha_p = \min\,(1, \alpha_p^{max}\ )$,where $\gamma \in [0.9.1.0]$ to make the updated x strictly positive. In this paper we have chosen $\gamma = 0.99$ for all the computations. The calculation of α_d is similar to that of α_p.

IV. PROPOSED IL2SR RAKE RECEIVER FRAMEWORK

The architecture framework of the proposed IL^{2}SR rake receiver is shown in figure 1.

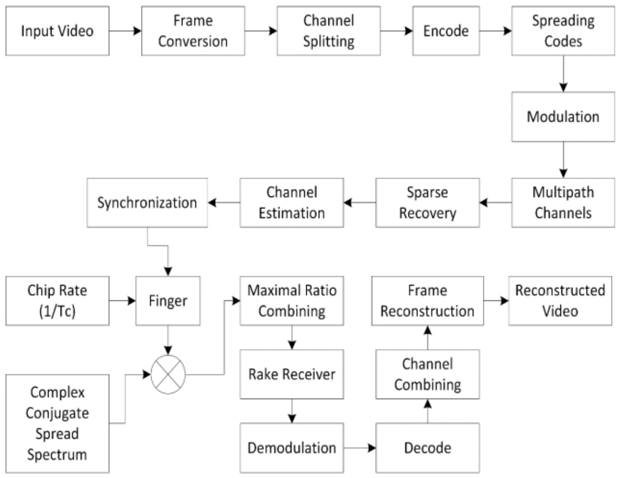

Figure 1. Proposed IL^{2}SR rake receiver framework

Color videos are made from Human Action recognition videos from KTH data-set for multimedia transmission which utilizes DS-CDMA application [25,26]. RGB color format is used for all videos. The video resolution is 180 x 144 pixels and video length for experimentation is 10 seconds. Using binary coder color video is changed over to binary information array as a first step. Reshaping of the binary data of the RGB channel is carried out and code sequence is applied. PN code, gold code and Walsh code have been selected for experimentation. The coded bits are then modulated. The BPSK modulation scheme has been taken for testing system reliability. The uplink is considered where K users transmit binary DS-CDMA signals over an asynchronous multi-path Rayleigh fading channel with AWGN. The received information from different users is exposed to independent multi-path fading channels and AWGN. Prioring to the decoding stage at the receiver side, channel is assessed using Iterative least square sparse recovery with a rake combiner [26]. BER is calculated after decoding to conclude with the accuracy of the proposed method.

A. Results and Inference

In these simulation experiments, color video size 180 × 144 pixels have been used. The MATLAB code is executed for simulation purpose. Few simulations are meant for assessing the proposed IL^{2}SR rake receiver performance:

1. Proposed IL^{2}SR rake receiver with different fading channels

BER has been estimated by contrasting the signal transmitted with received signal and processing the number of bits that have errors to total number of bits received. The BER is typically communicated as far as in terms of SNR (signal to noise ratio). Emphasis of the validity of the technique proposed by simulation results obtained for the different channels. BER examination for proposed IL^{2}SR rake receiver and Kalman filter rake (KFR) receiver for AWGN and Rayleigh fading channel is as shown in figure 2. By increasing the SNR (dB), the BER tends to decrease and reaches closer to zero for AWGN and Rayleigh fading channel. In addition, it is observed that in fading environment, the AWGN channel offers great outcomes contrasted to Rayleigh channel.

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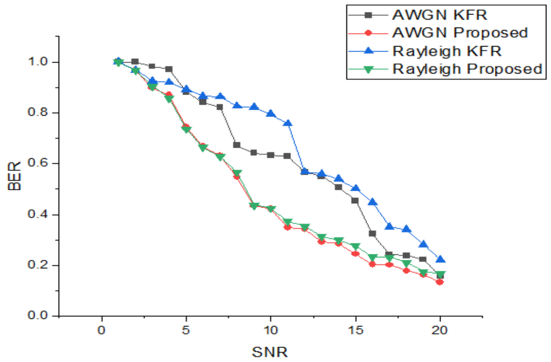

Figure 2. Comparison of BER for different channels

It is found that BER gradually reduces for proposed than the KFR receiver. Similarly, it is found that average BER is 0.157071 and 0.133743 respectively for KFR and IL^2SR for AWGN channel and average BER is 0.222636 and 0.166931 respectively for KFR and IL^2SR for Rayleigh fading channel when the SNR value is 20 dB. Therefore, it can be inferred that DS-CDMA framework under AWGN channel with IL^2SR receiver reveals better outcomes.

2. Proposed IL^2SR rake receiver with various spreading codes

For validation of the proposed technique is featured by simulation results got for various codes. Figure 3 shows average BER comparison for proposed and KFR receiver for PN, Gold, and Walsh codes. It can be concluded from the numerical figures that, there is an improvement in the received video quality with the increase of SNR values using proposed IL^2SR 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 with KFR and average BER is 0.168398 for gold code,0.133405 for PN code and 0.187921 for Walsh code with IL^2SR when the SNR value is 20 dB.

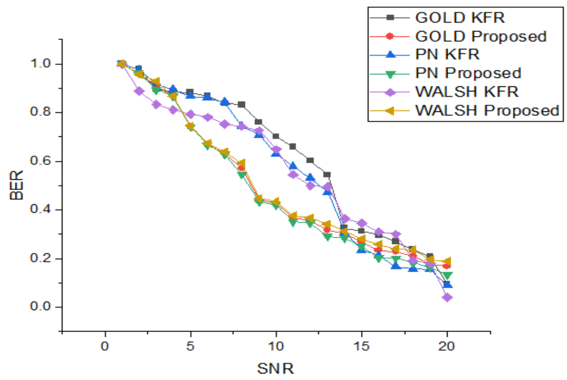

Figure 3. BER Comparison for Various Coding Sequences

V. CONCLUSION

The paper describes a cellular DS-CDMA framework which uses the Rake receiver along with IL^2SR to provide diversity of pathways. The distributing sequence, utilizing specific distributing codes, multiplies the input information signal in the proposed model, while the resulting signal is subjected to multipath propagation. Different numbers of Rake fingers are utilized to recover multipath components, while IL^2SR strategy blends the Rake finger outputs. BER Rake receiver yield is estimated for different Rake fingers (less than or equal to multiple path numbers), using various spreading sequences, for single-user and multi-user situations. Results from simulation demonstrate that if number of users increases then BER efficiency deteriorate, while increasing numbers of Rake fingers the system provide the performance improvement. Similarly, it can be demonstrated that differences between delays in the channel path and projected delays in the Rake receiver result in deterioration of BER efficiency. The performance of the IL^2SR with Rake receiver in DS-CDMA framework for multipath fading channels is investigated. The system gives better performance under different channels and with various spreading codes. After comparing the proposed system with Kalman based techniques, it was found that DS-CDMA framework under AWGN channel with IL^2SR receiver reveals better outcomes in terms of BER.Also, the received video quality has been enhanced with proposed IL^2SR receiver with the increase of SNR values.

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