Research Article

On the Performance of Wireless Video Communication Using Iterative Joint Source Channel Decoding and Transmitter Diversity Gain Technique

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1. Introduction

Generally, multimedia communication systems require high data rate, which also results in high demand for transmission power and available bandwidth. Therefore, to transmit wireless multimedia information over limited available bandwidth, high compression efficiency is required. The H.264/AVC codec is a predominant wireless multimedia compression standard because of high compression capabilities required for heterogeneous communication networks and applications [1]. Predictive coding technique and variable-length coding (VLC) increase the H.264/AVC codec compression efficiency required for transmission system, but it also makes the transmitted bitstream more prone to the error [2]. Even a single error in the received bitstream reduces the decoding ability to recover the correct codeword. The predictive coding technique also results in propagating the channel error to its next neighbour video frame. In a wireless system, because of limited bandwidth and varying behaviour of the channel, it makes the video transmission
2. Related Works

Abdullah et al. in [11] debate that H.264/AVC wireless video transmission has problems such as need of higher data networks and error proneness. The study gets its motivation from the use of ultrawide bands for usage of audio-visual signals. The simulations of various scenarios explain the importance of hierarchical and adaptive modulation schemes in various combinations for better video reconstruction. The results from the simulations show a 15 dB increase in PSNR and an increase of 20 dB when added with the various wireless channel adaptive modulation techniques. Nasruminallah et al. in [12] compare three different bandwidth efficient and flexible transceivers for video transmission system using iterative decoding and the simulated Rayleigh channel. The considered three schemes include self-concatenated convolutional, convergent serial concatenated coding, and nonconvergent serial concatenated schemes. Extrinsic information transfer (EXIT) charts show that the SECC scheme exceeds in performance as compared to the CSCOC and NCSCOC schemes. The BER and PSNR curves also demonstrate that the SECC scheme performs better for video transmission using iterative decoding. Kadhim et al. in [13] discuss real-time high-quality video transmission with reliability and delay constraints. The typical error protection techniques for example forward error correction and also the automatic repeat request result in the degradation of the video. This paper introduces a partial reliability-based real-time streaming (PERES) technique which is a solution to the application layer that executes partial reliable transfer. The proposed technique consists of acknowledgement and negative acknowledgment system for video transmission and scheduling algorithms with network adaptive algorithms and reliability adaption. Jyan et al. in [14] propose the design of the H.264 video transmission medium for stationary or mobile user, using the JM tool packet employing the optimization, error protection, and adaptation techniques along the way. The system uses both standard-definition television (SDTV) and high-definition television (HDTV) to input format videos. A complete simulation model with encoder, channel, and decoder is developed. The BER and PSNR values are analysed with varying schemes as GOP, QP, reference frames, and subpixel motion estimation, and the results are shown as graphs. Hadi et al. in [15] present the joint photographic expert group (JPEG2000) image transmission using unequal error protection (UEP) in the presence of polar codes. The proposed transmission scheme achieved better results by using the polarization property of channel codes without significant modification in the overall system. They proposed a joint source channel decoding by using the belief propagation algorithm. The proposed scheme takes the error-resilience tool advantage of the JPEG2000 decoder, which reduces the complexity of system. The experimental results manifest that our designed system has better results as compared to the conventional equal error protection for polar codes. Mhamdi et al. in [16] propose the JPEG2000 image transmission for ISCD using concatenated codes. In this scheme, flexibly UEP is deployed to split the data into several layers so that important source information gets more
protection as compared to less important information. This technique provides better protection along with better decoding performance. The good performance of the designed system is evaluated in the term of a PSNR gain of 10 dB and better subjective quality. The author also presented an adaptive rate allocation scheme which gives better result as compared to static strategy. Hosany suggests in [17] the generalized framework for UEP to evaluate the error performance for rate-compatible puncture convolutional (RCPC) codes and the concatenated Reed-Solomon codes. The transmission system uses 8 PSK modulation schemes in the existence of the Rayleigh fading noise. The designed system uses the MATLAB Simulink and provides better performance with 5 dB difference but increases the overall computational complexity of the system. Chaoui et al. present in [18] the image transmission using joint source channel decoding scheme with arithmetic coding (AC) and resilience technique. The AC technique is very useful in detecting any error occurred in wireless transmission. In the proposed scheme, the JSCD combines the error-detection information feedback of AC decoder with error-free information feedback of the AC decoder. In case of erroneous segment, bit reliabilities are calculated in performing bit back tracking. Bitstream of AC decoder is input to the iterative MPA algorithm, and the result shows 4 to 8 dB better performance as compared to separate source channel model. Balsa proposes [19] the analog JSCD system designed for still images transmission. The proposed system results are compared with digital images such as JPEG and JPEG without entropy. The designed systems show better performance from its alternatives on the basis of the structure similarity (SSIM) index and time required for image transmission. This system does not need to transmit the metadata information, and at the receiver end, analog data is always processed. The proposed analog scheme confirms computational capabilities, low power consumption, and a negligible delay.

3. H.264/AVC

Multimedia transmissions require high compression efficiency owing to limited bandwidth and battery power constraint of wireless systems. Every multimedia application has specific stipulations in terms of compression efficiency, video quality, computational complexity, error resilience, and delay [20]. The H.264/AVC coding scheme is a best solution for such broad-ranged multimedia applications. H.264/AVC is originated as a result of combined efforts of the ITU-T video-coding expert group (VCEG) and International Organization for Standardization (ISO) moving picture experts group (MPEG). The first draft of H.264/AVC was presented in 1999 and after changes in design new draft of this standard was finalized in 2003, which is used for all multimedia application ranging from HD video storage to mobile services. The main goal of introducing this standard is to design a low bit rate and network-friendly video codec that could support a large number of multimedia applications. H.264/AVC delivers better results in terms of robustness in transmission, coding efficiency, and rate distortion efficiency as compared to the predecessor video codecs. H.264/AVC is an efficient video codec design that provides the best performance in real-time communication applications like video conferencing and nonreal-time communication applications like digital television broadcast and video streaming [2].

3.1. H.264/AVC Data Partitioning (DP). Every slice of a macroblock is further subdivided into three partitions based on the importance of data transmission. Data partitioning (DP) is one of the H.264/AVC error resilience techniques in which instead of transmitting the entire video bitstream as a single block video slice, the coded bitstream is partitioned into three slices [2]. The coded information of a macroblock (MB) may be encoded into different video streams called partitions. Each partition has a different sensitivity level. The H.264/AVC video codec supports three different partitions that are types A, B, and C which are discussed below.

(i) Type A partitions contain the header information, motion vectors, MB types, and quantization parameters. This partition contains the most sensitive and vulnerable information coded video. If the partition A is corrupted, then B and C are not useful, and the entire partition is counted as a corrupted slice. In such cases, the decoder uses an error concealment technique by using a previously decoded frame of the corresponding video segment [21].

(ii) Type B partition carries MB coefficients and MB coded block patterns (CBP) bits of intraframe and represents the chunk of nonzero transform coded coefficients within the block. Bitstream is recovered from errors in the intraframe encoding image regions for certain MBs by switching off interface prediction. In intraframe coding, the encoding rate is few fractions of MBs, so that is why in this partition, each slice encodes the fewest number of bits [21].

(iii) Type C partition holds the interframe motion-compensated error residual (MCER), interframe CBP bits, and uses motion-compensated prediction for encoding MBs bits. In H.264/AVC, the intraframe prediction mode is used for intraframe CBP and intraframe MCER bits for encoding MBs [21].

In the H.264/AVC video codec, partition A is the most vital and essential chunk of video bitstream. In the absence of partition A, it is not possible to decode partitions B and C. Intraframe macroblock information is added in the presence of partition B, with partition A to reconstruct the slice. Similarly, in the presence of partition C with partition A, the reconstructed MCER slice is attached to the motion-compensated slice [21].

4. Transmission Mechanism

The proposed transmission mechanism comprising sphere packing (SP) modulation and differential space-time spreading (DSTS) channel diversity gain technique is presented as follows.
4.1. Sphere Packing (SP). Sphere packing (SP) modulation is used for modulated symbols to keep the maximum possible Euclidean distance between the modulated symbols. Space-time block code (STBC)-based orthogonal design of size (2 x 2) for two transmitted antennas are represented as follows.

\[ G_2(x_1, x_2) = \begin{bmatrix} x_1 & x_2 \\ x_2^* & x_1^* \end{bmatrix}, \]  

where \( x_i^* \) represents the complex conjugate of \( x_i \), while column and rows of the above equation represents the spatial dimensions and temporal dimension for two consecutive time slots of two antennas. This scheme consists of two complex modulated symbols \( (x_1, x_2) \) that are examined by SP modulation-based orthogonal design for transmission in \( T = 2 \) time slots from two antennas. The signal is transmitted with \( L \) precise space-time signal in consecutive \( T = 2 \) time slots from the two antennas \( (x_1, x_2) \), \( i = 0, 1, 2 \cdots L - 1 \), where the SP-modulated symbol is represented by \( L \). The aim of jointly designed \( x_1 \) and \( x_2 \) in SP modulation is to enhance the error resilience feature of the system by producing the best minimum Euclidean distance to the remaining \( L - 1 \) permissible transmitted space-time signals [22].

4.2. Differential Space-Time Spreading (DSTS). The space-time coding (STC) scheme is used to exploit the autonomous fading of the signal of two antennas and create an effectual diversity technique to mitigate the shortcomings of wireless channel. The aim of the STC scheme is to attain a significant power gain and diversity as compared to the single input-single output (SISO) scheme. Space-time block codes (STBC) are a type of STC, proposed by Alamouti [23]. STBC works on a block of data and provides better diversity gain. The STBC technique requires channel estimation and uses coherent detection. Due to the channel estimation technique, the channel experiences an increase in the complexity and cost of the receiver. During transmission, high transmission power is required due to the overhead of fast fading, which increases the number of training symbols. In comparison to this scheme, differential space-time spreading (DSTS) is constituted, which does not require any channel estimation technique. DSTS is a specific scheme for the low-complexity MIMO system by using a noncoherent detection method.

The DSTS system gives low complexity, with a trade-off around 3 dB performance loss, as compared to the complex coherent receivers. DSTS consists of two main components that are differential encoder and space-time spreading encoder. In DSTS encoder, the mapped symbols are differentially encoded first and subsequently using STS; they are spread as shown in Figure 1 [23, 24].

At time \( t = 0 \), the arbitrary dummy reference symbols \( v_0^1 \) and \( v_0^2 \) are passed to the STS encoder from where these are transmitted via two antennas to the receiver side. Equations (2) and (3) show that the symbols \( v_1^1 \) and \( v_1^2 \) are differentially encoded as follows [25].

\[ v_1^1 = \frac{x_1 \times v_{l-1}^1 + x_2 \times v_{l-1}^{2*}}{\sqrt{(|v_{l-1}^1|^2 + |v_{l-1}^{2*}|^2)}} \]  
\[ v_1^2 = \frac{x_1 \times v_{l-1}^2 - x_2 \times v_{l-1}^{1*}}{\sqrt{(|v_{l-1}^1|^2 + |v_{l-1}^{2*}|^2)}} \]

The differentially encoded symbols are passed to the STS encoder, where symbols are spread assisted by spreading codes \( c_1 \) and \( c_2 \) and forwarded to antenna for transmission as shown in Figure 2. The spreading code ensures that after using the code concatenation rules, both spreading codes \( c_1 \) and \( c_2 \) are orthogonal as represented in Equation (4) and (5).

\[ c_1^f = [c c]. \]  
\[ c_2^f = [c - c]. \]

The differentially encoded symbols split into two substreams, and the two successive symbols are subsequently spread to both antennas for transmission as shown in Figure 2 and represented in Equations (6) and (7).

\[ y_1^1 = c_1 \times v_1^1 + c_2 \times v_1^{2*}, \]  
\[ y_1^2 = c_1 \times v_2^1 - c_2 \times v_1^{1*}. \]
second antennas is represented by \( h \) with received signal \( r_t \) channel with a variance of \( \sigma \) symbols of successive time slots as shown in Equations (11) and (10). Codes \( c_1 \) and \( c_2 \) are correlated with received signal \( r_t \), and two data symbols denoted by \( d^1_t \) and \( d^2_t \) are received. \( H \) represents the Hermitian matrix.

\[
d^1_t = r_t \times c^H_1 = h_1 \times y^1_t + h_2 \times y^2_t + n_t,
\]

\[
d^2_t = r_t \times c^H_2 = h_1 \times y^1_t + h_2 \times y^2_t + n_t.
\]

Differential decoding is achieved by using received data symbols of successive time slots as shown in Equations (11) and (12). The Gaussian random variables having zero mean complex value are denoted by \( N_1 \) and \( N_2 \) having a variance of \( \sigma_N^2 \).

\[
d^1_t \times d^1_{t-1} + d^2_t \times d^2_{t-1} = (|h_1|^2 + |h_2|^2) \times \sqrt{|y^1_{t-1}|^2 + |y^2_{t-1}|^2} \times x_t + N_t,
\]

\[
d^1_t \times d^2_{t-1} - d^2_t \times d^1_{t-1} = (|h_1|^2 + |h_2|^2) \times \sqrt{|y^1_{t-1}|^2 + |y^2_{t-1}|^2} \times x_t + N_t.
\]

The above equation shows that signal fading \((h_1 \text{ and } h_2)\) independently works in each transmitter. The proposed technique assures to obtain a diversity gain by the use of a low-complexity algorithm. The space-time spreading operation requires no extra spreading code for transmitting symbols from two antennas in the same time slot.

5. System Overview

In our experimental setup, 300 frames of the H.264-encoded “Akiyo” video sequence are considered for simulation. The diagram of our designed video transmission scheme is presented in Figure 3. The H.264/AVC codec is employed for encoding the video pattern at the transmitter side as shown in Figure 3. The input video sequence has been fragmented by the demultiplexer into three bitstreams, namely Stream A, Stream B, and Stream C. Each stream output contains partition A, B, and C bitstreams in a sequential concatenated manner of all slices of each frame. The output bitstream \( x_a \), \( x_b \), and \( x_c \) from demultiplexer are mapped by
using a source bit coding (SBC) scheme into bit strings. Here, 
\( B = b_a + b_y + b_c \), and \( a = 1, 2, \ldots, b_a, b = 1, 2, \ldots, b_y, c = 1, 2, \ldots, b_c \).
The bit interleaver \( \Pi \) is used after SBC encoder to interleave 
the mapped bitstreams and results into \( x_a, x_y, \) and \( x_c \). 
The interleaver within each partition does not affect and extend 
the video sequence, but it improves the performance of the 
itative decoder. Then, the bit strings are encoded with 
different code rates by the RSC codes, while output streams 
after channel encoding are represented by \( y_a, y_y, \) and \( y_c \). 
The bitstreams after encoding through RSC error protection 
codes are multiplexed and concatenated into a single bit 
stream \( y \). The SP mapper is used to transmit the H.624/AVC 
bistream with the DSTS encoder using two transmitter 
anenas. The main goal of iterative joint source and channel decoding 
(IJSD) is to aid inner and outer decoders in iterative manner 
to find the maximum possible extrinsic information. SBC uses 
the residual and artificial redundancy from the encoded 
bit pattern of video for extraction of extrinsic information. Rate – 1 SBC is not capable to achieve better performance 
gain due to limited redundancy of encoded bitstream. In the 
H.264/AVC video, to achieve better performance gain in 
the presence of IJSCD, we add redundant source-coded 
bits of video, and the method is referred to as the source bit 
coding (SBC). The SBC scheme is a new approach created 
in the presence of deinterleaver. The deinterleaver helps the 
SBC decoder module to utilize the residual redundancy. The 
SBC decoding uses a zero-order Markov model for generating 
extrinsic information as shown in Equation (13).

\[
P[\hat{y}_{(n,k)} | y_{(n,k)}] = \prod_{i=1}^{n} P[\hat{y}(i)_{(n,k)} | y_{(n,k)}]. \tag{13}
\]

Received \( n \)th bit of the \( k \)th symbol is represented by \( \hat{y}_{(n,k)} \), 
and \( P[\hat{y}^{\text{ext}}_{(n,k)} | y^{\text{ext}}_{(n,k)}] \) expresses the extrinsic channel output 
information as represented in Equation (14).

\[
P[\hat{y}_{(n,k)}^{\text{ext}} | y_{(n,k)}^{\text{ext}}] = \prod_{i=0, j=k}^{n} P[\hat{y}(i)_{(n,k)} | y_{(n,k)}]. \tag{14}
\]

The channel output information and a priori information 
of the \( k \)th symbol give the values of resultant extrinsic LLR as 
represented in Equation (15).

\[
\text{LLR}[\hat{y}(\lambda)_{(n,k)}] = \log \left\{ \frac{\sum_{y^{\text{ext}}_{(n,k)}} P[\hat{y}^{\text{ext}}_{(n,k)} | y(\lambda)_{(n,k)} = +1] \cdot P[\hat{y}(i)_{(n,k)} | y_{(n,k)}]}{\sum_{y^{\text{ext}}_{(n,k)}} P[\hat{y}^{\text{ext}}_{(n,k)} | y(\lambda)_{(n,k)} = -1] \cdot P[\hat{y}(i)_{(n,k)} | y_{(n,k)}]} \right\}. \tag{15}
\]

### 6. Iterative Joint Source and Channel Decoding

The main goal of iterative joint source and channel decoding 
(IJSD) is to aid inner and outer decoders in iterative manner 
to find the maximum possible extrinsic information. SBC uses 
the residual and artificial redundancy from the encoded 
bitstream of video for extraction of extrinsic information. Rate – 1 SBC is not capable to achieve better performance 
gain due to limited redundancy of encoded bitstream.

| SBC type        | Symbols in decimal | \( d \) |
|-----------------|-------------------|-------|
| Rate – 1 SBC    | [0,1]             | 1     |
| Rate – 2/3 SBC  | [0,3,5,6]         | 2     |
| Rate – 3/4 SBC  | [0,3,5,6,10,12,15] | 2     |
| Rate – 4/5 SBC  | [0,3,5,6,10,12,15,17,18,20,23,24,27,29,30] | 2     |
| Rate – 5/6 SBC  | [0,3,5,6,10,12,15,17,18,20,23,24,27,29,30] | 2     |
| Rate – 6/7 SBC  | [0, 3, 5, 6, 10, 12, 15, 17, 18, 20, 23, 24, 27, 29, 30] | 2     |
| SBC             | 75, 77, 78, 80, 83, 85, 86, 89, 90, 92, 95, 96, 99, 101, 102, 105, 106, 108, 111, 113, 114, 116, 119, 120, 123, 125, 126 | 2     |

This table shows the different SBC schemes with corresponding symbols and their respective distances \( d \).
Table 1), which is discussed with reference to their EXIT outer curves (as presented in Figure 4). Firstly, it can be observed from the bit mapping presented in Table 1 that all the considered SBC codes of Table 2 ensure the minimum Hamming distance, i.e., $d_H = 2$. As a result, the presented optimized mapping of $m$ to $n$ bit symbols are capable to reach point $(I_A, I_B) = (1, 1)$ of the perfect convergence of the EXIT charts.

### 7. EXIT Chart Analysis

The inner EXIT characteristic curves of SBC scheme with Rate $-1, 2/3, 3/4, 4/5, 6/7$ of Table 1 are presented in Figure 4. Figure 4 shows that the EXIT curve for the SBC scheme having code rate $< 1$ meets at the top-right corner $(I_A, I_B) = (1, 1)$ of the perfect convergence of the EXIT chart. Contrary to this, the Rate $-1$ SBC scheme falls short of reaching the perfect convergence point. It is important to note that both rate $< 1$ and Rate $-1$ SBC scheme maintain an identical bit rate budget for all the employed combinations of outer SBC and inner RSC codes of Table 2. This convergence property of the SBC scheme with rate $< 1$ is due to the incorporation of artificial residual redundancy in the SBC coding process. Therefore, logically it is clear that rate $< 1$ SBC is potentially capable to take the maximum advantage of the iterative decoding mechanism by exchanging the beneficial mutual information to achieve lower BER. On the other hand, EXIT curves for SBC scheme with Rate $-1$ fail to reach and meet at the top-right corner and are not capable to gain any advantage of

| S. No. | Outer code (code rate) | Inner code (code rate) | Overall system (code rate) |
|-------|------------------------|------------------------|---------------------------|
| 1     | SBC Rate $-1$          | RSC Rate $-1/2$        | Rate $-1/2$               |
| 2     | SBC Rate $-2/3$        | RSC Rate $-3/4$        | Rate $-1/2$               |
| 3     | SBC Rate $-3/4$        | RSC Rate $-2/3$        | Rate $-1/2$               |
| 4     | SBC Rate $-4/5$        | RSC Rate $-5/8$        | Rate $-1/2$               |
| 5     | SBC Rate $-5/6$        | RSC Rate $-3/5$        | Rate $-1/2$               |
| 6     | SBC Rate $-6/7$        | RSC Rate $-7/12$       | Rate $-1/2$               |

**Figure 4:** EXIT outer characteristics of different rate SBC coding schemes.

**Table 2:** Code rate of the different proposed error protection schemes.
Figure 5: EXIT characteristics curves with Rate $\frac{2}{3}$ SBC outer code and Rate $\frac{3}{4}$ RSC inner code.

Figure 6: EXIT characteristics curves with Rate $\frac{3}{4}$ SBC outer code and Rate $\frac{2}{3}$ RSC inner code.
Figure 7: EXIT characteristics curves with Rate $4/5$ SBC outer code and Rate $5/8$ RSC inner code.

Exit characteristic curves with,
- Rate $4/5$ SBC outer curve
- Rate $5/8$ RSC inner curves from 0 to 15 dB

Figure 8: EXIT characteristics curves with Rate $5/6$ SBC outer code and Rate $3/5$ RSC inner code.

Exit characteristic curves with,
- Rate $5/6$ SBC outer curve
- Rate $3/5$ RSC inner curves from 0 to 15 dB
the iterative decoding procedure. With reference to the EXIT outer curves of Figure 4, generated for the different SBC schemes of Table 1, their EXIT characteristic curves along with the corresponding inner RSC curves are presented in Figures 5–9. The presented EXIT characteristic curve shows that the open EXIT tunnel approaches closer to point \((I_A, I_B) = (1, 1)\) of the perfect convergence while employing lower rate SBC as compared to the relatively high rate SBC scheme for the same \(E_b/N_0\) value. More specifically, considering an \(E_b/N_0\) value of 4 dB, the open EXIT tunnel for \(R_{-2/3}\) SBC with \(R_{-3/4}\) RSC reaches to point \((I_A, I_B) = (0.72, 0.85)\) as presented in Figure 5. Similarly, the EXIT tunnels for \(R_{-3/4}, 4/5, 5/6, 6/7\) SBC with corresponding RSC code \(R_{-2/3}, 5/8, 3/5, 7/12\) of Table 2 reach to points \((I_A, I_B) = (0.6, 0.85), (0.47, 0.8), (0.38, 0.8)\), respectively. Hence, it can be concluded that the open EXIT tunnel feature of the SBC as the outer decoder and RSC as the inner decoder is more promising while considering a lower rate SBC of Table 2.

8. System Performance and Results

This part of the paper deals with the explanation of the performance outcome for the suggested schema. The “Akiyo” video pattern [1] contains a quarter common intermediate format (QCIF) of 45 frames, and each frame is 176x144 pixels. The video uses the H.264/AVC JM 19 video codec for encryption, and it is encoded with 64 kbps bit rate for our test sequence at 15 frames per second. Every single QCIF frame is divided into nine segments, and every segment consists of a row of 11 MBs within each QCIF frame. The resultant video sequence contains an intracoded “I” frame, and then 44 predicted frames “P” are placed such that the IPPP

| Systems parameters                  | Value                  |
|-------------------------------------|------------------------|
| Source coding                      | H.264/AVC              |
| Frame rate (fps)                    | 15                     |
| Bit rate (kbps)                     | 64                     |
| No. of MB’s/slice                   | 11                     |
| No. of slices/frame                 | 9                      |
| Intraframe MB update/frame          | 3                      |
| Channel coding                      | RSC                    |
| Overall code rate                   | \(\frac{1}{2}\)         |
| MIMO scheme                         | DSTS                   |
| Modulation scheme                   | SP (L = 16)            |
| Number of transmitters              | 2                      |
| Number of receivers                 | 1                      |
| Spreading code                      | Walsh code             |
| Spreading factor                    | 8                      |
| Number of users                     | 4                      |
| Channel                             | Correlated Rayleigh fading |
| Normalized Doppler frequency        | 0.01                   |
Figure 10: EXIT chart and simulated decoding trajectory of Rate $\frac{2}{3}$ SBC scheme of Table 2.

Figure 11: EXIT chart and simulated decoding trajectory of Rate $\frac{3}{4}$ SBC scheme of Table 2.
Figure 12: EXIT chart and simulated decoding trajectory of Rate $\frac{4}{5}$ SBC scheme of Table 2.

Figure 13: EXIT chart and simulated decoding trajectory of Rate $\frac{5}{6}$ SBC scheme of Table 2.
Figure 14: EXIT chart and simulated decoding trajectory of Rate $6/7$ SBC scheme of Table 2.

Figure 15: BER performance curves of the coding scheme presented in Table 2.
PP... frame sequence is considered in which the “I” frame is repeated after 45 frames within a 3-second duration at 15 frames per second. The intracoded frame has additional benefits in controlling error propagation, so that is why our considered video sequence has a special pattern of “I” and “P” frames. Details about the system parameters of this proposed experimental scheme are presented in Table 3. Flexible macroblock ordering (FMO) and various reference frames utilization, employed for the interframe motion compensation, with additional computational complexity do not have processing performance in a low bit rate video telephony video sequence. Therefore, they were not considered for our H.264/AVC-coded video stream. Source bitstream contains limited residual redundancy. The Monte Carlo simulations were carried out using 45 frames of the “Akiyo” video sequence; experiments were repeated for 260 times, and the average results are considered. SBC with Rate – 1 mapping has limited residual redundancy in the coded stream, and therefore, the number of iterations is limited to \( I = 3 \). For SBC with \( r < 1 \), as presented in Table 1, the mapping obeys the necessary and sufficient condition to reach the upper-right corner of the EXIT chart, and hence, the number of iterations is fixed to \( I = 5 \). The performance of the various error protection schemes with diverse SBC coding rate was evaluated with the overall same video rate and code rate. From the perspective of H.264/AVC coding, it is pertinent to know that when the frames of low-motion video clips are corrupted due to loss of partition A, the corresponding partitions B and C are not usable, and hence, they are also dropped and the previously decoded frame is used for concealment. A mechanism of motion-compensated prediction is utilized to conceal the lost segment of the future frames. However, a scenario where partition A is received correctly, with loss of partition B of the corresponding video segment, will result in loss of intraframe-coded MB information contained in partition B and hence will result in loss of quality of the corresponding video sequence. The decoding trajectories for the Rate – 2/3, 3/4, 4/5, 6/7 SBC schemes of Table 2 are recorded at \( E_b/N_0 = 4 \) dB as shown in Figures 10–14. Performance analysis of the designed systems using the SBC mapping Rate – 2/3, 3/4, 4/5, 6/7 and Rate – 1 on the basis of achievable BER and PSNR is shown in Figures 15 and 16, respectively. The SBC Rate – 2/3 scheme, with highest redundancy incorporation capability, results in the best BER performance as compared to the other coding schemes of Table 2. Furthermore, it is also observed that the Rate – 1 SBC scheme along with Rate – 1/2 RSC as inner coding scheme results in worst BER performance, due to its nonconvergence capability in the iterative decoding process. Moreover, it is also observed that owing to best BER performance of the
Rate – 2/3 SBC coding scheme, it results in its best PSNR performance, relative to the counterpart coding schemes of Table 2, as shown in Figure 16. More specifically, the Rate – 2/3 SBC scheme results in $E_b/N_0$ gain of 1.5 dB at the PSNR degradation point of 1 dB as compared to the Rate – 6/7 SBC scheme having an equivalent overall bit rate. Furthermore, it is also observed from Figure 15 that the proposed Rate – 2/3 SBC scheme results in $E_b/N_0$ gain of 24 dB, with reference to the benchmark SBC coding scheme, at the PSNR degradation point of 1 dB. Furthermore, it is important to note that both the Rate – 2/3 and Rate – 1 SBC coding schemes are having an identical overall code rate.

9. Conclusion

In this research work, data-partitioned H.264/AVC video bitstream is transmitted using the iterative joint source and channel decoding (IJSJD) scheme. The performance of different diverse-rated SBC outer-coding schemes was investigated in combination with RSC inner codes, while keeping the overall bit rate budget constant. The source- and channel-coded video stream is SP modulated and transmitted using the DSTS-assisted transceiver. It was demonstrated that the designed IJSJD scheme using the Rate – 2/3 SBC scheme gives better BER performance due to incorporation of high level of redundancy in the source bitstream. The convergence behaviour of the presented IJSJD error protection schemes is investigated with the aid of the EXIT charts. The experimental result shows that our Rate – 2/3 SBC-assisted error protection scheme with high redundancy incorporation capability gives better results with about 1.5 dB $E_b/N_0$ gain at the PSNR degradation point of 1 dB as compared to Rate – 6/7 SBC-assisted error protection scheme while maintaining the overall bit rate budget constant. Furthermore, it is also concluded that the proposed Rate – 2/3 SBC-assisted scheme results in $E_b/N_0$ gain of 24 dB at $E_b/N_0$ degradation point of 1 dB with reference to the Rate – 1 SBC benchmark scheme.

Data Availability

The authors approve that data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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