

# Two-Phase Video Encoding for Disaster Management Video Transmission

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*Received: 19 June 2025 | Revised: 12 July 2025 | Accepted: 23 July 2025*

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## ABSTRACT

In disaster management scenarios, efficient video transmission poses significant challenges due to the limitations of existing encoding techniques. This study addresses these challenges by introducing a novel Two-Phase Video Encoding (TPVE) method tailored for disaster management video transmission. TPVE employs a two-phase design, reducing video bits through low-rank approximation in the initial phase, followed by additional compression using an optimized Huffman encoding in the second phase. The introduction of a parallel version of Huffman encoding with reduced coding length speeds up the encoding process, ensuring reduced Bit Error Rates (BERs) and higher coding efficiency. TPVE is particularly effective in Mobile Ad-Hoc Network (MANET) environments with Orthogonal Frequency-Division Multiplexing (OFDM) frames surrounded by noise and interference, and it outperforms Existing Video Encoding (EVE). Results reveal TPVE's superior BER and encoding efficiency, demonstrating a remarkable 65.06% BER improvement for a MANET Edge Device (MED) antenna size of 32 and an outstanding 88.08% improvement for a size of 64. These findings establish TPVE as a transformative solution, significantly enhancing reliability, reducing storage requirements, optimizing bandwidth utilization, and ensuring superior encoding efficiency in disaster management video transmission.

*Keywords-disaster management; video transmission; encoding; Huffman; MANETs*

## I. INTRODUCTION

Disaster management is a critical facet of safeguarding communities against the devastating impacts of natural or man-made catastrophes. In recent years, the increasing frequency and intensity of disasters have posed significant challenges to emergency response teams [1]. One key aspect of disaster management is efficient and real-time video transmission, which plays a pivotal role in gathering crucial information,

coordinating rescue efforts, and aiding decision-making processes [2]. However, several issues and challenges persist in the realm of video transmission during disaster management. The foremost challenge revolves around ensuring uninterrupted and high-quality video transmission in the midst of chaotic disaster scenarios [3]. Bandwidth constraints, network congestion, and infrastructure damage often hinder the seamless flow of video data [4]. Additionally, the diversity of devices and formats used for video capture can complicate

interoperability and integration across various emergency response systems [5].

The encoding process emerges as a solution to enhance video transmission efficiency during disaster management [6, 7]. By converting raw video data into compressed formats using encoding techniques, the amount of data transferred can be minimized without compromising essential information. This not only aids in overcoming bandwidth limitations but also facilitates faster and more reliable dissemination of critical visuals to command centers and response teams [8]. The pressing need for an effective encoding process in disaster management lies in its potential to streamline communication and enhance situational awareness during crises. Rapid and reliable video transmission ensures that decision-makers receive real-time information, enabling prompt and effective response strategies. As disasters continue to pose complex challenges, investing in technologies that improve video transmission through encoding processes becomes imperative for building resilient and adaptive disaster management systems.

In disaster management, efficiently transmitting video data is essential for effective response and recovery. However, the existing model has struggled to provide a balance between preserving video quality and optimizing storage and bandwidth efficiency, presenting a critical gap in disaster communication infrastructure [9]. This conventional approach leads to inflated storage requirements and excessive bandwidth usage, hindering the rapid and reliable transmission of crucial video information during emergencies. In this context, this work addresses the pressing challenges by proposing an innovative efficient video encoding technique tailored explicitly for disaster management applications. The proposed model emerges as a solution to the inherent shortcomings of traditional video encoding methodologies. It strategically addresses the delicate balance required in disaster scenarios, where resource constraints and the urgency of communication demand a more robust approach. The model uses an advanced compression algorithm and an adaptive encoding strategy to optimize the storage and bandwidth utilization of video data without compromising vital details. This adaptability ensures that the encoded video content remains compact, facilitating more efficient transmission even in resource-constrained and unpredictable disaster-stricken environments.

The contributions of this work are as follows:

- Introduction of a novel video encoding technique aimed at reducing the overall bit requirement for wireless communication.
- Two-phase design involving low-rank approximation in phase 1 and further compression using an improvised Huffman encoding in phase 2.
- Acceleration of the video encoding process through the introduction of a parallel version of Huffman encoding with reduced coding length.
- Assurance of a lower Bit Error Rate (BER) coupled with higher coding efficiency, addressing challenges in wireless

communication often faced by Mobile Ad-Hoc Network (MANET) devices.

## II. LITERATURE SURVEY

In [10], a novel adaptable video transfer process was introduced with the aim of ensuring optimal video resolution. The initial concept of the car terminal included the incorporation of a data feedback connection. Upon examining the wait time for the car recipient buffering, in addition to its prospective variance pattern, the device provided feedback in the form of assessment and forecasting. Consequently, the encoded Quantization Parameters (QP) for the video were modified by the recipient. Simulation findings demonstrate that the method's video compression rates exhibit appropriate adaptability to the fluctuating bandwidth conditions observed in diverse networks. The utilization of this technique optimized the allocation of wireless bandwidth resources and successfully mitigated video interruptions, thereby guaranteeing a satisfactory video Quality-of-Experience (QoE).

In [11], an approach was devised to facilitate the evaluation and comparison of various techniques employed in video compression within the context of Wireless Multimedia Sensor Networks (WMSNs). This work enabled the assessment of various compromises inherent in present methods and identified unaddressed areas of research. In [12], a test-based approach was employed to ascertain the optimal video levels that can be accommodated within a specific network condition. The changes in variables for viewing adaptable video across a wireless connection were calculated utilizing the simulated approach. The derivation from the adjusting variables was based on several key factors, including node movement, link connectivity, and the movement level of the video clips. These variables were carefully selected as decisive factors to effectively determine the appropriate strategies for adaptation. The testing was conducted utilizing the OMNeT++ tool, an extensively utilized simulation framework for network research. For encoding and decoding adaptable video streams, the researchers employed the Joint Scalable Video Module (JSVM), a well-established software tool specifically designed for this purpose.

In [13], authors presented a comprehensive analysis of the conventional study approach employed in the domain of transmitting multimedia protocols for networked communications. The study provided an overview of the essential open research concerns pertaining to the advancement of a multimedia transmission approach capable of facilitating uninterrupted communication, regardless of challenging traffic situations [14]. In [15], authors introduced a pioneering architecture that enabled transcoding in virtual-reality video cache and transmission. The architecture was specifically designed to cater to the requirements of edge-enhanced wireless connections in the coming years. The study introduced an edge collaborative caching method that leveraged multi-agent reinforcement learning techniques. The primary objective of this approach was to enhance the effective use of storage and computing resources, ultimately leading to a reduction in service interruption.

In [16], authors addressed the scenario in which the data storage and computation abilities provided by Edge Service Providers (ESPs) exhibit randomness and temporal variations. This variability can arise from factors such as internal workloads. The significance of this variability lies in the fact that a content provider lacks the capacity to ascertain the precise accessibility of resources through an ESP during the process of assertive content positioning. The analysis involved thorough modeling and a comparison with other models.

In [17], the primary objective was to improve the accessibility of streaming video networks. To achieve this, the authors focused on creating a model for forecasting that could estimate various crucial factors, including video streaming effectiveness, necessary energy usage, and required bandwidth. The foundation of their approach was built upon video codec variables, which played a pivotal role in overall system performance. A modeling analysis was conducted to estimate the energy used, perceived video quality, and required memory bandwidth for the multimedia codec. This analysis relied on the video quality and quantization variables. The findings suggest it is possible to construct a precise approach that serves the intended objective.

In [18], authors introduced a novel approach called Cost-and Delay-aware Light-weight Transcoding at the Edge (CD-LwTE). This approach was specifically designed to address the challenges of HTTP Adaptive Streaming (HAS) within the framework of delay and cost considerations. The primary objective of the CD-LwTE approach was to efficiently save the most favorable search outcomes as records for every bit rate of video parts. These saved records were utilized at the edge servers to significantly reduce the duration and computing power needed for encoding operations. The performance of CD-LwTE was thoroughly examined in a range of situations encompassing diverse video materials, encoding applications, encoding environments, and resources accessible at the boundary. The empirical findings indicate that the method employed resulted in a noteworthy reduction of up to 97% in conversion time.

For the purpose of facilitating cross-layer routing over MANETs, Self-Attention-based Conditional Variational Auto-Encoder Generative Adversarial Networks (SACVAEGAN-MCLD-MANET) were suggested in [19]. The goal aspects of movement, Data Success Rate (DSR), and leftover energy consumption for communication were considered by SACVAEGAN when selecting the best course of action. When contrasted with present techniques, the suggested solution offered a 19.60% greater packet delivery ratio with a 13.46% reduction in latency.

In [20], authors suggested that energy-efficient utilization of resources is significant for lowering energy consumption and increasing the lifetime of interactions between devices. Less power was used for interaction, which helped reduce negative environmental effects. This was made possible by the suggested effective use of resources. The approach achieved impressive results: an energy distribution of 92.97%, a bandwidth distribution of 87.79%, a channel distribution of 88.43%, a total delay of 25.47%, an overall data transfer rate of 94.33%, and a network speed of 90.99%.

### III. PROPOSED METHODOLOGY

#### A. System Model

This work introduces a novel video encoding technique that reduces the total number of bits required to communicate over wireless channels from source to destination. A two-phase design has been developed. In phase 1, the actual video bits are reduced by employing low-rank approximation. In phase 2, the low-rank approximated bits are further compressed using the proposed improved Huffman encoding. To speed up the video encoding process, a parallel version of Huffman encoding with reduced coding length is introduced in this work. The proposed improvised Huffman coding utilizes a parallel encoding strategy to reduce coding length and speed up processing. Unlike conventional Huffman coding, it minimizes tree traversal complexity by optimizing codeword length distribution. The proposed Two-Phase Video Encoding (TPVE) method assures lesser BER with higher coding efficiency. MANET devices usually communicate with other devices using multi-channel communication, so the Orthogonal Frequency-Division Multiplexing (OFDM) frames are affected by noise and interference from neighboring devices.

#### B. Storage and Bandwidth Efficient Video Encoding Technique

The MANET Edge Device (MED) possesses multiple antennas represented by parameter  $O$ . The MED receives video frames from different MANET devices; thus, the total bits  $a_o$  collected by  $o$ -th antenna are given as follows:

$$a_o[p] = \sum_w z_w[p] * j_{o,w}[p] + y_o[p] \quad (1)$$

where  $o \in \{1, 2, \dots, O\}$  and  $p \in \{0, 1, 2, \dots\}$ . The variable  $z_w$  represents the OFDM bits that are assigned to the  $w$ -th MANET user. Similarly,  $j_{o,w}$  denotes the noise characteristic of the channel, which is assigned to every  $w$ -th MANET user and  $o$ -th antenna. Additionally,  $y_o$  represents the Gaussian noise that exists within the  $o$ -th antenna. The  $*$  denotes the mathematical operation of convolution. Equation (2) describes the obtained video bits which are denoted using matrix  $A \in \mathbb{E}^{P*O}$ . In (2),  $P$  denotes the overall number of video bits accounted for the compression process, whereas  $O$  denotes the size of the MED antennas.

$$A = \begin{bmatrix} a_1[0] & a_2[0] & \dots & a_o[0] \\ a_1[1] & a_2[1] & \dots & a_o[1] \\ \vdots & \vdots & \ddots & \vdots \\ a_1[P-1] & a_2[O-1] & \dots & a_o[P-1] \end{bmatrix} \quad (2)$$

and the columns of matrix  $A$  are obtained as follows:

$$a_k = [a_k[0] \quad a_k[1] \quad \dots \quad a_k[P-1]]^U \quad (3)$$

The columns denoted by  $a_k$ , where  $k$  belongs to the set  $\{1, 2, \dots, O\}$ , demonstrate a notable level of correlation between themselves. In order to estimate the matrix  $A$ , a low-rank calculation approach was employed, which can be represented by the following equation:

$$A = A_0 + G \quad (4)$$

The matrix denoted as  $A_0$ , belonging to the space  $\mathbb{E}^{P*O}$ , represents a matrix that has undergone low-rank evaluation,

resulting in the elimination of any noise present. The evaluated matrix represents a composition of data regarding the input video order, which is expressed as streams of bits  $a$ , along with the channel's behavior, denoted as  $k$ . Additionally, the matrix  $G$ , belonging to the set  $\mathbb{E}^{P \times O}$ , determines an accurate noise matrix using a Gaussian depiction. Utilizing (4), the size of the video bits decreases and is subsequently communicated to the MANET Gateway Server (MGS) by means of the currently accessible channel. Subsequently, the video bits undergo a decompression process in order to acquire matrix  $A$ , which is then decoded through an inverse manner using the MGS. The primary objective of this study is to employ a low-rank calculation approach in order to decrease the dimensions of matrix  $A$ . This approach results in a reduced amount of video data being transmitted across MANETs. The variable  $A_0$  in (4) characterizes a low-rank matrix having dimensions  $P \times O$ . To facilitate comprehension, it is assumed that  $P$  is significantly larger than both  $O$  and  $N$ . Hence, from this, the matrix  $A$  is denoted as follows:

$$A'' = \underset{\text{Rank}(\hat{A})=N}{\text{argmin}} \|A - \hat{A}\|_F \quad (5)$$

Equation (5) utilizes the Frobenius norm, denoted as  $\|\cdot\|_F$ , for obtaining the actual matrix  $\hat{A}$ , which is achieved using the equation:

$$A'' = W_N \beta_N X_N^J \quad (6)$$

with:  $W_N = [w_1 \ w_2 \ \dots \ w_N]$ ,  $X_N = [x_1 \ x_2 \ \dots \ x_N]$ , and  $\beta_N = \text{Diag}[\alpha_1 \ \alpha_2 \ \dots \ \alpha_N]$ .

The variable  $A''$  is represented using Singular Value Decomposition (SVD) [21]. SVD is a mathematical technique that decomposes  $A''$  to form the conjugated transpose of a matrix  $(\cdot)^J$ , wherein  $x_j \in \mathbb{E}^P$  represents the right-hand eigenvectors,  $w_k \in \mathbb{E}^P$  represents the left-hand eigenvectors, and  $\alpha_N$  represents the singular values arranged diagonally. The establishment of rank  $N$  can be achieved by utilizing an accurate noise matrix as described in [22] and [23]. Utilizing SVD, the TPVE initially acquires a set of  $N$  key elements denoted as  $X_N$ , which resemble  $N$  eigenvectors. Subsequently, these key elements are multiplied with the matrix  $X_N$  to carry out the transformation of matrix  $A$ . The video-bit vector  $a_k$ , which is obtained, relates to the initial space of  $O$  representations. This vector is then transformed to a new dimension of  $N$ , which exhibits a high degree of decorrelation with the given video sequences. The matrix  $R_N$ , denoted as  $R_N \in \mathbb{E}^{P \times N}$ , represents a matrix that has been tailored and can be formulated as follows:

$$R_N = AX_N = W_N \beta_N \quad (7)$$

The variable  $R_k$ , in which  $k$  belongs to the set  $\{1, 2, \dots, N\}$ , represents the  $k$ -th column of  $R_N$ . Each column, denoted as  $R_k$ , is a video-bit vector that has been decorrelated. The matrix  $R_N$  is subsequently subjected to compression employing an enhanced Huffman coding technique [24] in order to achieve a more compact representation. This results in the generation of a predicted low-rank matrix  $A''$ , which is then transmitted to the Multiple-Input Multiple-Output (MIMO) MGS utilizing the currently accessible communication channel. The variable  $U_x^H$

represents the total length, measured in bits, that comprises the codeword assigned for the  $x$ -th bit. On the other hand,  $V_x$  denotes the rate or frequency at which the  $x$ -th bit occurs and needs to be encoded. In the context of constructing a binary structure for codewords, the notation  $U_x^H$  is commonly used to denote the number of sublevels associated with every bit in a distinct coded tree. The measurement of the coded word traversal  $CT(H)$  for a specific coded tree is defined as follows:

$$CT(H) = \sum_{x=1}^K V_x \times U_x^H \quad (8)$$

In (8),  $K$  denotes the overall bits that need to be encoded. Also,  $H$  represents the Huffman tree and its respective Code-Word Length (CWL), which is defined using  $U_x^H$ . The  $U_x^H$  is defined as the likelihood of occurrence of the  $x$ -th bit and its given code word  $W$ , i.e.,  $U_x^H = f(P_x^H, W_x^H)$ . The overall encoded frame of  $K$  bits is given by the following equation:

$$TBL(H) = \sum_{x=1}^K K \times V_x \times U_x^H \quad (9)$$

In the context of a binary tree representation, it is worth noting that a 4-bit code such as 0100 corresponds to a leaf-node located at the fourth level inside the tree. This particular code can be identified as the representation of the particular set of 4 bits. The primary objective within the suggested approach is to reduce the total bit length  $TBL$  associated with the process of encoding, thereby enhancing its efficiency. In (9), the variables  $K$  and  $V_x$  represent the number of bits and their frequency of occurrence, respectively. It is important to note that both  $K$  and  $V_x$  are stable throughout the analysis and depend on the specific dataset being considered. The implementation of effective Code-Words (CWs), denoted as  $U_x$ , has the potential to significantly decrease the  $TBL$  of a given system, thereby improving its overall efficiency. The goal of the suggested approach can be succinctly defined as:

$$\min_{\forall x \in K \text{ establish } U_x} TBL(H) \quad (10)$$

Consider that the  $H_{huffman}$  denotes the current Huffman code tree [25] and the optimal code tree of Huffman is represented as  $H_{optimal}$ . For achieving the best encoding process, it is required to prove that  $TBL(H_{optimal}) < TBL(H_{huffman})$ , which is described using the following equation:

$$\sum_{x=1}^K K \times V_x \times U_x^{H_{optimal}} < \sum_{x=1}^K K \times V_x \times U_x^{H_{huffman}} \quad (11)$$

In (11),  $K$  and  $V_x$  are considered constant. Therefore, (11) can be modified as follows:

$$\sum_{x=1}^K U_x^{H_{optimal}} < \sum_{x=1}^K U_x^{H_{huffman}} \quad (12)$$

From (12), the following conclusion is achieved:

$$\sum_{x=1}^K f(P_x^{H_{optimal}}, W_x^{H_{optimal}}) < \sum_{x=1}^K f(P_x^{H_{huffman}}, W_x^{H_{huffman}}) \quad (13)$$

According to (13), the quantity of CWs in  $W_x^{H_{optimal}}$  is determined to be 71, whereas the total count of CWs in  $W_x^{H_{huffman}}$  is found to be 183. The largest size of the Huffman

tree, denoted as  $H_{huffman}$ , is observed to be 13, whereas the largest size of the optimal tree, denoted as  $H_{optimal}$ , is observed to be 12. The duration needed to travel  $H_{huffman}$  trees is significantly longer than that of  $H_{optimal}$  because of the presence of a broader spectrum of CWs and their comparatively longer typical lengths in comparison to the suggested CWs. Based on the available evidence, it is reasonable to infer that the time complexity of the  $TBL$  algorithm utilizing the optimal heuristic, denoted as  $TBL(H_{optimal})$ , is lower than the time complexity of the  $TBL$  algorithm with the Huffman heuristic, denoted as  $TBL(H_{huffman})$ . Therefore, the expected low-rank matrix  $A''$  after performing compression using the proposed optimal Huffman is gathered at the MGS and is represented as follows:

$$A'' = R_N X_N^J = W_N \beta_N X_N^J \quad (14)$$

The complete size of video bits sent using MANET is denoted as follows:

$$ON + PN \quad (15)$$

The compression effectiveness of the overall video bits being transmitted using the presented TPVE approach is evaluated as follows:

$$\mathcal{CR}_P = \frac{O \cdot P}{N[O+P]} \quad (16)$$

where the ranked matrix  $A_0$  consists of the actual video frames which contain noise. Therefore, the removal of  $(O - N)$  helps discard the noise. Further, the performance of noise removal is given by reformulating the given video sequence matrix  $A''$  and is represented by the following equation:

$$A'' = A_0 + \delta \quad (17)$$

In (17),  $\delta$  represents the error detected in the form of matrix after the low-rank calculation. The variable  $\delta$  is a composite measure that encompasses the errors arising from two sources: the disappearance of video frame data and the residual noise generated by the application of low-rank calculation. The TPVE approach is anticipated to exhibit excellent results through the reduction of BER and the enhancement of encoding efficiency, which is discussed in the next section.

### C. Inverse Huffman Decoding Process

To recover the original video frames from the compressed bitstream, the decoding process begins at the receiver end, more precisely at the MGS. In the first step, the low-rank approximation matrix that was compressed during the encoding phase is reconstructed using inverse Huffman decoding. To guarantee consistency in bitstream interpretation, the inverse Huffman decoding makes use of the same codebook created during the encoding stage.

According to (13), the original video matrix is reconstructed using SVD components that were preserved during encoding after the low-rank matrix has been recovered:

$$M = U \cdot \Sigma \cdot V^T \quad (13)$$

where  $M$  is the reconstructed video matrix and  $U, \Sigma, V^T$  are the SVD components retained during encoding. The system

efficiently recovers the video frames while eliminating any remaining noise by multiplying the decomposed SVD matrices  $(U, \Sigma, V^T)$ . Because the noise components that are not part of the low-rank matrix are not reintroduced during reconstruction, this two-phase decoding technique guarantees a lower BER. The procedure is appropriate for real-time disaster management video transmission scenarios since it is designed to run in parallel in both Huffman decoding and matrix reconstruction to minimize latency.

### D. Complexity Analysis

The low-rank approximation using SVD with complexity  $O(n^3)$  and improved Huffman coding with complexity  $O(n \log n)$ , where  $n$  is the size of the video-bit matrix, are the two main factors influencing the computational complexity of the suggested TPVE method. The concurrent implementation of Huffman coding greatly reduces encoding time, even though two-phase encoding has a higher computational overhead than single-phase techniques. The extra computational expense is justified by the performance gains in encoding efficiency, BER, and Symbol Error Rate (SER).

## IV. RESULTS AND DISCUSSION

The SIMITS simulator [26, 27] was employed to evaluate this study, particularly for the development of the Radio Propagation (RP) model. The integration of the RP model was carried out within the One Simulator [9], a versatile platform for network simulations. Table I outlines the key network parameters considered for the simulations, providing a comprehensive overview of the values utilized in the experimentation process. The SIMITS simulator, known for its capabilities in modeling radio propagation scenarios, played a crucial role in enhancing the fidelity of the RP model. This integration within the One Simulator framework allowed for a thorough evaluation of the proposed methodology under diverse network conditions, ensuring the robustness and reliability of the RP model across various scenarios. Higher bandwidth is necessary to maintain real-time transmission quality and reliability in MANET environments under fluctuating signal conditions, even when the information size is relatively small.

TABLE I. SIMULATION PARAMETERS

Network parameter	Value
Network size	50 km × 50 km
Number of MANET nodes	10, 20, 40, and 80
Number of MRT	1 per region
Modulation scheme	QAM-64
Mobility of MANET nodes	3 cycles per frame
Coding rate	0.75
Bandwidth	27 Mbps
Data channel size	6
Control channel size	1
Dynamic network controller per MRT	1
Time slot size	8 μs
Message information size	27 bytes
Radio propagation mobility model	Adaptive radio propagation such as expressway, city, and semi-urban
MAC used	EMAC and AMAC

**A. Bit Error Rate vs Signal-to-Noise Ratio**

The BER is a metric that measures the accuracy of video bit recovery in relation to the total number of bits transmitted in a wireless network. A lower BER value signifies superior performance. In our experiments, as presented in Figures 1 and 2, we varied the Signal-to-Noise Ratio (SNR) from -4 to +4, focusing on MEDs with antenna sizes of 32 and 64. Figures 1 and 2 depict the BER outcomes of our proposed TPVE against the Existing Video Encoding (EVE) technique [23].

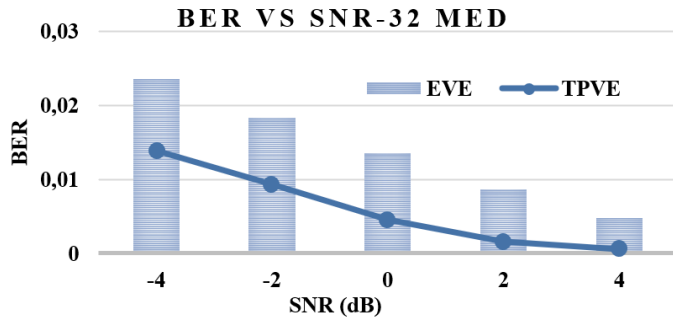


Fig. 1. BER vs SNR for a MED with 32 antennas.

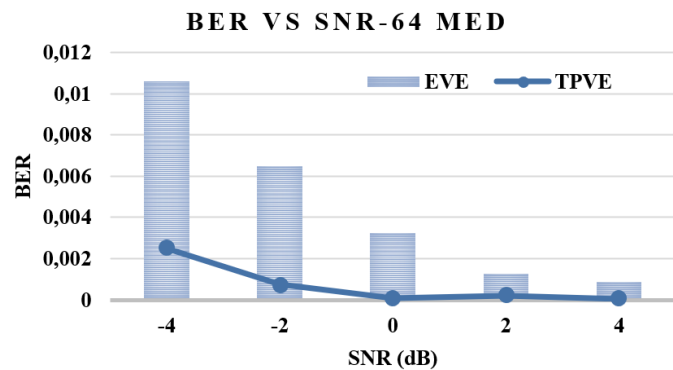


Fig. 2. BER vs SNR for a MED with 64 antennas.

Notably, for a MED antenna size of 32, TPVE showcases a 65.06% improvement in BER performance over EVE, demonstrating its efficacy in scenarios with varying SNRs. Similarly, for a MED antenna size of 64, TPVE exhibits an impressive 88.08% improvement in BER performance over EVE, highlighting its robustness in mitigating errors and optimizing video transmission in wireless networks.

**B. Symbol Error Rate vs Signal-to-Noise Ratio**

The SER metric assesses the accuracy of video frame recovery at the receiver, measuring the total number of incorrectly recovered video frames. A lower SER value signifies superior performance. Through experiments varying the SNR from -4 to +4, with MEDs having antenna sizes of 32 and 64, Figures 3 and 4 illustrate the SER outcomes of our proposed TPVE against the EVE technique [23].

Remarkably, for a MED antenna size of 32, TPVE exhibits a 58.88% improvement in SER performance over EVE, demonstrating its efficacy in scenarios with SNRs. Similarly, for a MED antenna size of 64, TPVE demonstrates a remarkable 86.72% improvement in SER performance over

EVE, emphasizing its capability to minimize errors and enhance the accurate recovery of video frames in wireless networks.

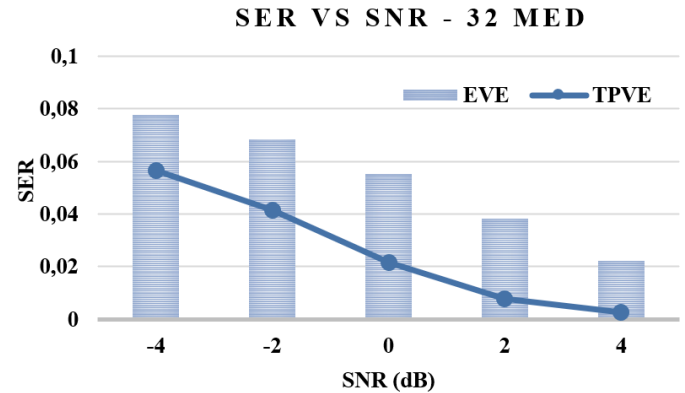


Fig. 3. SER vs SNR for a MED with 32 antennas.

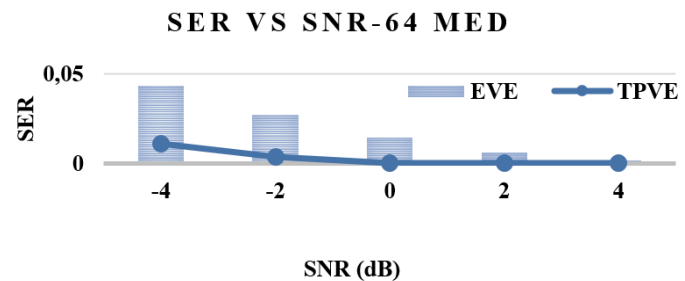


Fig. 4. SER vs SNR for a MED with 64 antennas.

The study reports a remarkable 65.06% improvement in BER performance with TPVE over EVE when the MED antenna size is 32, and an outstanding 88.08% improvement when the MED antenna size is 64. Similarly, SER performance experiences a substantial enhancement of 58.88% over EVE for a MED size of 32 and an impressive 86.72% improvement for a MED antenna size of 64. These findings, as presented in Table II, underscore the transformative impact of TPVE, positioning it as a highly effective and efficient video encoding solution for disaster management applications, offering improved performance and robustness in critical communication scenarios.

TABLE II. COMPARISON OF AVERAGE BER AND SER PERFORMANCE FOR TPVE AND EVE WITH MED ANTENNA SIZES OF 32 AND 64

Encoding model	Avg BER vs SNR (MED=32)	Avg BER vs SNR (MED=64)	Avg SER vs SNR (MED=32)	Avg SER vs SNR (MED=64)
EVE	0.0137968	0.0044828	0.0523046	0.0186328
TPVE	0.0060078	0.0007150	0.0260546	0.0031678
TPVE vs EVE improvement (%)	65.064675	88.088787	58.880995	86.728270

**C. Encoding Efficiency**

This section assesses the encoding efficiency of the proposed video encoding model in comparison to an existing

video compression model. Utilizing (16), the existing model achieves an encoding efficiency of 20.5, whereas the proposed model achieves a notably higher efficiency of 28.45. The results highlight that the proposed model not only reduces the size of video bits but also enhances BER and SER performance, emphasizing its overall effectiveness in video transmission.

## V. CONCLUSION

This study introduces Two-Phase Video Encoding (TPVE), an innovative video encoding technique designed specifically for disaster management video transmission. This approach encompasses a two-phase design: in the first phase, the actual video bits are reduced through low-rank approximation, and in the second phase, the low-rank approximated bits undergo further compression using an improvised Huffman encoding. To expedite the encoding process, a parallel version of Huffman encoding with reduced coding length is introduced. The proposed method ensures a lower Bit Error Rate (BER) and higher coding efficiency. Given that Mobile Ad-Hoc Network (MANET) devices commonly employ multi-channel communication, leading to Orthogonal Frequency-Division Multiplexing (OFDM) frames affected by noise and interference, TPVE stands as a robust solution. The results showcase TPVE's superior performance in terms of BER and encoding efficiency when compared to Existing Video Encoding (EVE).

Notably, TPVE not only addresses the challenges of video transmission in disaster management scenarios but also significantly improves reliability, reduces storage requirements, enhances bandwidth utilization, and increases overall encoding efficiency. The study reports a remarkable 65.06% improvement in BER performance with TPVE over EVE when the MANET Edge Device (MED) antenna size is 32, and an outstanding 88.08% improvement when the MED antenna size is 64. Similarly, Symbol Error Rate (SER) performance experiences a substantial enhancement of 58.88% over EVE for a MED size of 32 and an impressive 86.72% improvement for a MED antenna size of 64.

These findings underscore the transformative impact of TPVE, positioning it as a highly effective and efficient video encoding solution for disaster management applications, offering improved performance and robustness in critical communication scenarios.

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