Research Article
Efficient Lossless Compression Based Reversible Data Hiding Using Multilayered n-Bit Localization

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We proposed an innovative reversible data hiding technique that is formulated on histogram shifting by using multilayer localized n-bit truncation image (LBPTI), namely, generated form 8-bit plane by means of efficient lossless compression. After selecting the reference point from the block, the neighbor topmost points are used to attain the data embedding without modifying the peak point; in addition, the key information regarding peak point is not mandatory in extraction end to extract the secret information. In order to make the embedded cover-image similar to the histogram of original cover-image, we exploited the localization with efficient lossless compression on lower block level to increase the embedding capacity while controlling extra bit to expand additional embedding capacity on optimum level besides sustaining the quality of cover-image.

1. Introduction

Reversible data hiding (RDH) has been widely employed in the fields of medical image, data coloring in cloud, fingerprint, authentication, military image, ownership fortification, furtive communication, image authentication, satellite image, and multimedia archive management. Various audios, videos, and images are conveyed through the Internet; on the other hand many security concerns befall at the same time; thus, it is essential to keep the information safe to transmit over the Internet. In many fields like military, communications, and medical applications, data hiding is growing very fast; in addition, military and medical applications require the whole retrieval of cover-image at the cost of secret information. Consequently, RDH overcomes the problem to recover the cover-image without any loss. The basic requirements of RDH techniques are to provide the excessive embedding capacity (EC), secure transmission of data, and preserve the quality of image that can be recuperated of any loss; as a result RDH is also useful to evade the attention of the attackers [1–6].

Tian’s method [7] proposed the variations of two neighboring pixels for embedding the secret bits in addition to simplifying the divergent expansion to use the arbitrary size of pixel blocks from pixel pairs. Wang [8] proposed an innovative reversible watermarking method in which the pixel blocks of arbitrary size were taken as embedding unit on the basis of integer transform domain. The authors of [9] proposed a method in which a parameter was chosen in integer transform to define a threshold for blocks type to write the secret bit and also gain high EC and low distortion [10–14]. The authors of [15, 16] proposed RDH scheme in which one secret bit is embedded into one pixel value while increasing the even value of pixels with reducing vertically and horizontally the direction of odd pixels value by one; moreover, RDH scheme computes the difference between neighboring pixels to explore the similar neighboring pixels to embed the secret bit by using difference histogram modification scheme [17–19].

Multilevel modification of histogram of the pixel differences was used to embed the secret bit into each block. In this method, nonoverlapping blocks were constructed by encrypting and dividing the cover-image [20–26]. The authors of [27, 28] emphasize the importance of the
magnitude of local variance to increase the EC which is based on prediction errors expansion (PEE). PEE, the histogram shifting, was exploited as combination of prediction errors on the basis of data hiding method whereas the pixels of each overlapping blocks were arranged in an ascending direction [6,29–32].

In this paper RDH scheme is proposed on localized bit-plane truncation image (LBPTI) while extending [26,33] method without using secret key bit. In addition, the topmost reference point is chosen to embed secret bits. The concomitant topmost points are used as a replacement of peak point. For the security of embedded cover-image with efficient lossless compression scheme to keep it continuous in embedded image. Furthermore, we have used n-bit plane by means of efficient lossless compression by modifying the lower level of block histogram to improve the EC. Initially, to generate a new image to extract 8-bit plane for each pixel and increase the EC, we divided LBPTI into nonoverlapping blocks to get more concentrated neighbor peak points of histogram with higher probability of zero point. The process of localization also increased the EC rapidly to encompass n-bit multilayer embedding. The remaining parts of the paper are arranged in the following order. Section 2 covers related work. Section 3 is used to expound the proposed method. Sections 4 and 5 highlight the performance analysis of experimental results and conclusion, respectively.

2. Related Work

2.1. Kim et al’s Scheme. The authors of [35] reported the high EC through high relations in adjacent pixels. The algorithms have been defined as follows.

Input: CoverImage D,
Output: StegoImage D'

Step 1. Cover-image is allocated into further subimage by using (1) with size $D_1, D_2, D_3, \ldots, D_n$.

$$D_C (x, y) = D \left( x\Delta + \left\lfloor \frac{C - 1}{\Delta} \right\rfloor, y\Delta + ((C - 1) \mod \Delta) \right)$$  \hspace{1cm} (1)

Columns and row of subimage can be signified by $(x, y)$ while $m/\Delta = 1, 2, \ldots, n/\Delta, \Delta$ are intervals of subsampling.

Step 2. Calculate the variance of subimage, $d_C(x, y)(C \neq reference\ image(r))$ using (2).

$$d_C (x, y) = D_C (x, y) - r (x, y)$$ \hspace{1cm} (2)

Step 3. By means of (3) shift the histogram.

$$d_C' (x, y) = \begin{cases} d_C (x, y) + T + 1, & \text{if } d_C (x, y) \geq T + 1 \\ d_C (x, y) - T - 1, & \text{if } d_C (x, y) \leq -T - 1 \\ d_C (x, y), & \text{otherwise} \end{cases}$$ \hspace{1cm} (3)

Step 4. Modify the histogram to insert secret bit $b$ using (4).

$$d_C' (x, y) = \begin{cases} d_C (x, y) + T + b, & \text{if } d_C (x, y) = T \neq 0 \\ d_C (x, y) - T - b, & \text{if } d_C (x, y) = -T \neq 0 \\ d_C (x, y), & \text{otherwise} \end{cases}$$ \hspace{1cm} (4)

Step 5. Analyze the stego-image by means of (5).

$$D_C' (x, y) = D (x, y) + D_C'' (x, y)$$ \hspace{1cm} (5)

2.2. Che et al’s Scheme. According to the 4-block size distribution of Fallahpour et al. [36] and Kuo et al. [34] method, the cover-image is divided into $512 \times 512$; moreover, Che-Wei Lee [37] has allocated cover-image into additional subblocks, i.e., $256 \times 256$ to $2 \times 2$, $256 \times 256$ to $8 \times 8$, and $4 \times 4$ to $2 \times 2$ as can be seen in Figures 1 and 2. For current study, block division is good idea to increase the EC to embed bits in different blocks compared with, for example, single block; however, EC is entirely dependent upon zero point [25, 38, 39]. Liu et al. [40] divided the image from $256 \times 256$, $16 \times 16$, $8 \times 8$, $2 \times 2$ and raised the embedding rate; however, the size of $256 \times 256$ to $2 \times 2$ PSNR perseveres lessening in the same way as increasing the rate of extra bits.

By utilization of sets of topmost point and zero points, histogram shifting based scheme has been presented in Ni et al. [10]:

$$H \left( l'_{(x,y)} \right) = H \left( l_{(x,y)} \right) + 1$$ \hspace{1cm} (6)

where $H(l'_{(x,y)})$ is modified grayscale value,

$$l'_{(x,y)} = \begin{cases} l_{(x,y)} + 1, & \text{if } PP < l_{(x,y)} < ZP, \\ l_{(x,y)} + m, & \text{if } l_{(x,y)} = PP, \\ l_{(x,y)}, & \text{otherwise} \end{cases}$$ \hspace{1cm} (7)

where $l_{(x,y)}$ is the original pixel grayscale value while $m$ is secret information.

The entire capacity of secret bits is equal to all the pixels that are linked with topmost points; however, in most cover-images the sum of topmost points is trivial. We need main information (topmost point and zero point) in extraction end and embedded cover-image histogram that never becomes fascinated attacker by alteration in cover-image. In this case, we have no need to retain the main information while the histogram of embedded and original cover-image is...
continuous, maintaining the security of embedded secret bits but also gaining more control on the size of extra bits on lower block level, which provides high EC and low distortion in our proposed schemes.

3. Data Embedding Algorithm

Liu et al. [40] made allocation of region $X$ and region $Y$ of cover-image into new n-bit plane truncation image from 8-bit image; moreover, region $X$ represents secret bit and $Y$ area represents extra bits, while in small block size the $EC$ increased, also increasing the extra bits which could not be accommodated in region $Y$; as a result $EC$ graph fails on trivial blocks size. We require some space for shifting the histogram regarding high probability of zero point in all blocks, while the block that is exempted from embedding procedure does not have zero point; consequently, in every blocks, if having zero point, we can set $CB = 1$ value; otherwise $CB = 0$. 

![Figure 1: Block division and histogram of image “Lena”](image-url)
The 1-bit for each blocks value of location map (LM): if $LM=1$, then hide the sensitive data in that block; otherwise block cannot be used for data hiding process. In LBPTI technique the size of cover-image $I$ is $512 \times 512$ that can be referred to as embedded regions and nonembedded $X$ and $Y$ regions, respectively. Furthermore, generating a bit-plane image LBPTI, the region of $X$ can be mined to multiple-bit plane from an 8-bit plane which can be further distributed with respect to $ZP$ into noncoinciding blocks. In case of zero point ($ZP$) occurring, set value for block $CB = 1$; otherwise set the value $CB = 0$. Moreover, when $CB$ have one value, the sensitive data will be embedded into blocks; otherwise the block will be skipped from embedding process and similarly all the blocks will be investigated from left to right and top to bottom orders. Topmost points have similar value to $(x, y)$ used to embed the secret bit $S$ (generated randomly) by alteration of $R + 1$; in addition, $R + 1$ will have 1 or 0 for all blocks skimming to generate a stego-image in successive embedding algorithm steps. As an example, 1001 is a secret bit, the entire blocks from left to right and top to bottom skinned; likewise, $R + 1$ and $ZP$ are 25 and 27, respectively, in the embedding blocks; moreover, if $R + 1 < ZP$ in this case, all 26 values will be increased by one and increase pixels value by one if $R + 1$ is 25; otherwise no modification will occur in Figures 3(b) and 3(c).

In this method we have no requisite to retain the data of topmost point and zero point to embed and remove the secret information. We used the secondary topmost position to embed the secret bit, and the primary topmost position was used as reference position. The primary topmost position is $R$, while $R - 1$, $R + 1$ are left and right secondary topmost positions in histogram.

$$I' = \begin{cases} I_{x,y} + 1, & \text{if } R + 2 \leq I_{x,y} \leq 254 \\ I_{x,y} - 1, & \text{if } 1 \leq I_{x,y} \leq R - 2 \end{cases}$$
The range from \( I \) to \( R - 2 \) of histogram moved to left hand side by \( I \) while \( R + 2 \) to 254 series of histogram moved to right hand side by one. The location of pixel is \((x, y)\), and its pixels value is \( R_{x,y} \) of cover-image \( I \); in addition, for \( I' \), the location is \((x, y)\) and pixels value is \( R'_{x,y} \) in embedded image.

A pixel value \( R - 1 \) is come across if the \( S \) secret bit is zero, and the pixels value will remain the same if the \( S \) secret bit is one, in which case pixels value will be decreased by \( I \). Once a pixels value \( R + 1 \) is encountered in this case, the secret bit \( S \) will be 0, and the pixels value remains the same if the secret bit \( S \) is one while the values of pixels are increased by one.

\[
I'_{x,y} = \begin{cases} 
I_{x,y} + 1, & \text{if } I_{x,y} = R + 1 \text{ and } E = 1 \\
I_{x,y} - 1, & \text{if } I_{x,y} = R - 1 \text{ and } E = 1 \\
I_{x,y}, & \text{if } I_{x,y} = R + 1 \text{ and } E = 0 \\
I_{x,y}, & \text{if } I_{x,y} = R - 1 \text{ and } E = 0 
\end{cases} \tag{9}
\]

The secret bit \( E = 1 \) is come upon, and the pixels value is lessen by one while secret bit \( E = 0 \) with no change in pixels value \( R - 1 \). The secret bit \( E \) is \( I \), so the pixel value is increased by one and the secret bit \( E = 0 \); besides no change will occur in pixels value \( R + 1 \). Consequently, by the side of embedding process, embedding cover-image \( I' \) is obtained and transferred to receiver side devoid of any additional information, while at the other end the secret data are excerpted lacking of any additional information. The topmost point remains the same after data embedding; formerly, according to the peak point we obtain the value of neighboring point to excerpt the secret data; furthermore, Figure 5 highlighted the original and embedded cover-image histogram in our technique. We intend to proclaim that the two foremost issues of n-bit plane of cover-image are discontinuous histogram with low embedding capacity. The n-bit localization is very useful for making additional pixels which turn into the topmost points in the form of a chain that can be used to write the secret data. On account a lot of changes during histogram shifting in whole histogram, the histogram is not continuous but the n-bit localization can be a source of reallocation, while all changes in the form of block histograms are merely minor changes. In this process the whole histogram is only modified a little bit. One of the advantages of n-bit localization is to increase the EC and to keep the embedded and original cover-image histogram continuous because the discontinuous histogram can be spotted easily and it will increase the danger of being attacked, but through n-bit localization the risk can be reduced.

3.1. Embedding with n-Bit Localization. The original image \( I \) is divided into noncoinciding size of blocks \( S \) and subsequently secret bits are embedded into each block \( B \). The n-bit plane [33] for embedding data by modifying the histogram to generate a new image is further extracted for, respectively, pixels named localized bit-plane image truncation (LBPTI), in addition to increasing the EC to split the LBPTI into non-coinciding blocks to get additional concentrated neighbors histogram of topmost points. We find the value of topmost point \( B_R \) for individually blocks \( B \) histogram while the right bordering point value of topmost point is \( B_R + 1 \) and the left bordering point value of topmost point is \( B_R - 1 \). No top-secret bits will be inserted if the topmost point does not encompass the neighboring point while the pixels except the peak points still move to 0 or 255 by \( I \); moreover, if the pixels values are organized in ascending direction while the central pixels will be designated as the topmost point in case of the blocks containing dissimilar pixels values and having several topmost points, we will select the initial as well as last topmost as topmost point and the topmost point will remain the same during the process of embedding. We find the peak point at the extraction end and utilize it to extract the secret bits and recover the embed image. The value of two points \( B_R + 2 \) and point 254 of block \( B \) increases by one, while the value 1 and point \( B_R - 2 \) are reduced by one and the embedded cover-image has been produced when all the blocks are managed.

Figure 5 highlights the histogram amid original and embedded cover-image using (LBPTI) embedding technique. At present, we fix the block size 2 and 3. The histogram is continuous approximately similar to the original histogram in proposed embedding technique, so the protection of embedded secret bits improved while attackers will not be fascinated through embedded cover-image.

3.2. Side Information. The value is equal to 0 or 255 value for border point in some cover-image. If the border point value changes, then it can be used to embed the secret bits, while if the point value is 255, in that case value will be reduced by one; moreover, the value will increase by one if the value of that point will be zero; consequently, border point has become non-border point that can be modified by secret bit. Information regarding location \( LM \) is recorded using the size of block; usually in natural images there are no border points while the \( LM \) is inadequate for data compression; thus, \( LM \) is compressed as side information besides embedded secret bits into the cover-image. 512 \( \times \) 512 size of over-image alienated into two regions \( X \) and \( Y \), the extra bits can be employed in last column and row of pixels. Efficient lossless compression method is used for extra bits compression in succeeding section.

The bitstream \( x \epsilon \{0,1\}^n \) as well as \( c \epsilon \{0,1/2\} \) is \( c \)-biased if \( 1 - c \) fraction of ones is smaller. In the efficient compression algorithm, the \( C \) is positive constant that is less than 1/2 where \( C \) is bitstream. Actually the aim of lossless algorithm is to gain more space for data embedding as well as binary arithmetic coding [29, 36]. The proposed algorithm has better compressed size and performance as compared with binary arithmetic algorithm.

Input. C-biased bitstream where \( B = (B_1, B_2, B_3, \ldots, B_n) \epsilon \{0,1\}^n \) \( f_c(X) \) compressed bitstream is got.

(1) The \( n \)-bit strings are set in ordinal numbers \( d \) and \( x \) computed with exact \( K \) ones.

(2) \((k, d)\) of binary representation output where \( \lceil \log_2 \text{ n} \rceil \) bits \( k \) are put in first \( f_c(B) \) for extraction algorithm (EA).

Input. \( n \) and \( f_c(B) \) \( \epsilon \{0,1\}^n \) obtained the original bitstream as follows:
(1) Compute \((n, k, d)\) from \(f_c(B)\) value.

(2) \((n, k, d)\) where \(B\) is reconstructed.

The \(m\)-bit binary string as \(k\) ones \(n\)-bit string encodes by using binary arithmetic coding algorithm where

\[
m = \left[\log_2 e\right] + \left[\log_2 \left(\frac{e}{k} \left(\frac{e}{e-k}\right)^{e-k}\right)\right]
\]  

(10)

and \(m\)-bit binary string as \(k\) ones \(n\)-bit string encodes by using proposed compression algorithm where

\[
m' = \left[\log_2 e\right] + \left[\log_2 \left(\frac{e}{k}\right)\right].
\]  

(11)

The secret data is extracted and recovered the cover-image without any disruption while very minor information is needed to embed the information.

### 3.3. Data Extraction Algorithm

In this portion a less distorted image has been recovered and extracted the secret information from embedded image. For the embedded cover-image \(I'\), search the peak point from histogram and the peak point will persist any variations throughout the embedding process. For extracting stego-image by LBPTI technique to extract 8-bit plane for each pixel, first get the peak point \(P\) from histogram for the reason that both image peak points remain unaffected in both original and cover-image.

\[
I_{x,y} = I'_{x,y}, \text{ if } I'_{x,y} = P
\]  

(12)

0 secret bit is extracted if secondary topmost position is equal to \(R - 1\); else \(I\) secret bit is extracted just in case of \(R - 2\) and topmost position increased by one.

\[
I_{x,y} = \begin{cases} 
I'_{x,y} + 1 & \text{and } E = 1 \text{ if } I'_{x,y} = R - 2 \text{ } 0 \leq I \leq 254 \\
I'_{x,y} & \text{and } E = 0 \text{ if } I'_{x,y} = R - 1
\end{cases}
\]  

(13)

0 secret bit is extracted if secondary topmost position is equal to \(R + 1\); otherwise \(I\) secret bit is extracted in case of \(R + 2\) while topmost position increased by one.

\[
I_{x,y} = \begin{cases} 
I'_{x,y} - 1 & \text{and } E = 1, \text{ if } I'_{x,y} = R + 2 \text{ } 0 \leq I \leq 254 \\
I'_{x,y} & \text{and } E = 0 \text{ if } I'_{x,y} = R + 1
\end{cases}
\]  

(14)

The value is placed within \(I\) and \(R-2\); in that case value of position increased by \(I\) while it decreased by \(I\) if value exists between \(R+2\) and 254.

\[
I_{x,y} = \begin{cases} 
I'_{x,y} - 1 & \text{if } R + 2 \leq I'_{x,y} \leq 254 \\
I'_{x,y} + 1 & \text{if } 1 \leq I'_{x,y} \leq R - 2
\end{cases}
\]  

(15)

This process includes both the extraction of secret bits and recovering of cover-image from embedded image; moreover, the \(I\) cover-image will be divided into noncoinciding blocks of size \(B \times B\) while the receiver side \(I'\) image is received. We find the topmost point value of \(B_R\) for, respectively, block \(B\) and the value for original cover-image of that block will be similar because topmost value will remain the same. The value will not be altered of topmost point if the value will be equal to \(B_R\) for, respectively, topmost value in block \(B\).

The block has been recuperated after the extraction; still it will not be the original form of original block. The side information that is used for recovering the cover-image shows the place of border points that can be recovered without any loss. The side information in case of border point \((BP)\) is present; then the corresponding location of \(BP\) will be \(I\). Further, if the value of the \(BP\) is 0, then the value of \(BP\) increases by 1. Alternatively, if the value of \(BP\) is 255, then the value of \(BP\) is reduced by 1 and the original block will be acquired till the end of the process of all blocks.

For illustration, 1001 is a secret bit, and whole block is scanned from top to bottom and left to right. Extract the value from blocks with \(R + 1\) having 25 and \(ZP\) having 27. In case \(R + 1\) values are less than those from \(ZP\) and \(CB\) is 1, zero will be extracted. Extracting secret bit and recovering pixels value decreasing by \(I\) in case of \(R + 1 = 26\) are shown in Figures 4(b) and 4(c).

### 3.4. Multilayer n-Bit Embedding

The multilayer n-bit embedding \([26, 34, 36, 37]\) inserts the secret bit into cover-image while upturning the \(EC\) to optimum level. The cover-image is distributed into noncoinciding block size \(B \times B\) in multiple embedding layer \(L\); afterward, secret bit is inserted into each blocks. The generated embedded image is distributed again into nonoverlapping blocks \(2B \times 2B\) before embedding the secret bit to find the \(L + 1\) embedding layer in generated embedded image. Initially, the 2 is fixed size of the block; furthermore, the block size \(B\) will be doubled. It happens on account of the range from 2 to 256 \((2, 4, 8, 16, 32, 64, 128, \text{ and } 256)\). The six greyscale images Lena, Baboon, Boat, Tiffany, and Pepper comprising the size of \(512 \times 512\) are displayed in Figure 8.

### 4. Experiments

#### 4.1. n-Bit Plane with Different Embedding Layer

The average \(PSNR\) verifies the effectiveness of LBPTI technique that the average \(PSNR\) is not lower than 50 d B while gaining high \(EC\). Through localization, the histogram remains similar to the original histogram; further, high capacity is attained with low distortion. The original and embedded image have been compared with different Embedding Layers (EL); in case \(EL\) is small, we noticed minute modifications in the histogram. The histogram changes at a larger level when the \(EL\) is increased to increase \(EC\) to optimal level besides sustaining the image distortion level in high \(EL\). Usually, the histogram remains similar to the original histogram when the \(EL\) is at lower level while resemblance only occurs when the \(EL\) becomes more than 3 levels, but this similarity cannot influence the continuity and the overall shape of histogram which remains identical with original histogram revealed in Figure 5.
Table 1: Evaluation of LBPTI with Localized n-bit-planes (Ni et al. [10], Luo et al. [2], Kim et al. [35], Lin et al. [41], Liu et al. [40]).

<table>
<thead>
<tr>
<th>M</th>
<th>Lena Cap</th>
<th>Lena PSNR</th>
<th>Boat Cap</th>
<th>Boat PSNR</th>
<th>Baboon Cap</th>
<th>Baboon PSNR</th>
<th>Jet Cap</th>
<th>Jet PSNR</th>
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<th>Pepper PSNR</th>
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<th>Tiffany PSNR</th>
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<td>49.23</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tr>
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<td>-</td>
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<td>-</td>
<td>45297</td>
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</tr>
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</table>

Table 1 highlights the EC and distortion for test images with different EL level. The EC increases with low distortion due to expansion of the EL; moreover, adjustment can be traced between PSNR and EC; if PSNR will be lower, then EC will be higher; however, the average PSNR is still not lower than 35 dB. Usually, the EL is selected on the basis of PSNR and EC. The smaller EL is chosen for the requirement of image quality, and the higher EL is selected due to the need for high EC. The pixel values change desperately from 0 or 255 with the growth of high EC and there is minute alteration in pixels values with lowest EC on lower level; besides both EC and pixel values are smooth with each other. In Baboon image histogram, there are additional pixels that are near to 0 or 255 as compared with Lena image; moreover, side
information also increases when the EC is enlarged, shown in Figures 6 and 7. The embedding process involves more pixels value (from 0 or 255); more shifting, embedding, and side information will be done on large area of image while side information is also minute when no pixel values are near to 0 or 255 similar to Lena image.
4.2. Comparison with Existing Algorithms. Hiding capacity and PSNR of stego-image are used to calculate the performance of our LBPTI method. The secret bits $E$ represent the number of secret bits that are to be embedded in cover-image. Selection of n-bit plane and size of the block division are two most important factors that can affect the performance of LBPTI technique on different block size of image. When the block size is $2 \times 2$, the number of extra bits with $EC$ is five times. It is clearly plausible that it is not possible to hide huge amount of extra bits in embedded region that decreases the size of $EC$. The results of performance comparison of LBPTI method with existing algorithms are presented in Figures 8 and 9.

In [1] the authors focus on expanding the interpolation-errors and use it for embedding the secret data. In high $EC$, Luo’s technique is useful but LBPTI method is much valuable on account of well performance not only in Boat and Airplane image but also in Baboon and Lena. The authors of [2] focus on high $EC$ with low distortion; however, his method is only useful for Lena and Baboon image. Furthermore, LBPTI method achieves high degree of performance by making comparison with other schemes like Ni et al. [10], Luo et al. [2], Kim et al. [35], Lin et al. [41], He et al. [25], Liu et al. [40] methods in terms of PSNR and $EC$ shown in Figure 9. The authors of [30] focus on histogram shifting and combination of prediction errors that also become better outcomes as compared with [31] method that used histogram shifting based high-fidelity data hiding schemes.

LBPTI method performs well on account of using histogram of cover-image to select the topmost value as reference value while embedding the secret bits through using neighboring points of topmost point as compared.
with Tain’s method that emphasizes manipulation of pixels difference histogram. Moreover, the extra bits are controlled on different blocks level to sustain high EC and on lower EL level to gain high PSNR and maximum EC as compared with Lin et al. [41], Liu et al. [40], Pan et al. [26], and Abbasi et al. [33] techniques. Our tryout assumption attests that the LBPTI method effectively achieved the objective of high EC on lowest EL, different size of block level, and sustaining the extra bit and distortion of stego-image.

4.3. Embedded Capacity versus PSNR. In Lin et al. [41], the images “Jet”, “Lena”, “Pepper”, “Baboon”, and “Boat” after 18 embedding levels have high EC but very low PSNR 30.2 dB. The main problem of Lin technique is having larger hiding capacity on higher embedded level but that leads to high distortion in the stego-images while the average PSNR of Lin technique is greater than 35 dB; however, proposed technique has gained higher EC and also preserved the balance between EC and higher PSNR with 51.33 PSNR as compared with Lin et al. method.

Liu et al. [40] scheme, 2×2 block size, has high EC growth rate with lower PSNR ratio (121663 carry bit, 698544 extra bit, and 49.16 PSNR) while maximum PSNR is 50.73 on 21×21 block division, but higher extra bit frequency makes it very challenging to accommodate the bits in embedded region. Similarly, 2- to 5-bit plane increased high EC; however, lower PSNR ratio (118299 carry bit with 37 PSNR) and 3- to 8-bit plane achieved high PSNR but low EC (56.86 PSNR, 28811 carry bit, and 9964 extra bit). Abbasi et al. [33] technique, 2×2 block size, has high EC growth rate with lower PSNR ratio (143,673 carry bit, 684,372 extra bit, and 49.18 PSNR) and, moreover, gains higher EC to 3-7-bit plane with 16×16 block division (45332 EC with 51.31 PSNR). We have gained higher EC also preserving the balance between EC and PSNR as 46921 EC with 51.33 PSNR as compared with previous technique; we can try to improve more EC on 3 to 6 embedding layers with high PSNR ratio up to 50 dB.
5. Conclusions

In this article we proposed a new concept of data hiding scheme that interconnected with efficient lossless compression based n-bit localized histogram. In order to embed secret bits, neither histogram of pixel differences nor topmost value is used in this scheme. We selected the peak point as reference point and chose to exploit the multilayer n-bit localization by means of efficient lossless compression of cover-image. For solving the security problem, the peak point is used as reference point and sporadic histogram generates various problems; however, \textit{LBPTI} technique increases the capacity of secret information with secure transmission. The outcome of experimental highlights demonstrates that the proposed technique inflates the security of embedded secret bits by attaining the high capacity with low distortion on lower block level. Compared with other algorithms, the proposed technique is more operative while the \textit{LBPTI} method is malleable and maintains a balance between the capacity and distortion of embedded images. Furthermore, in future we will try to gain more embedding capacity in higher embedding layer with n-bit plane and sustain the image quality that fails dramatically in higher embedding layer.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Figure 9: Comparison with existing methods.

References


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