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Colour image steganography through channel transformation approach

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ABSTRACT

The interest in information security strategies is expanding due the quick expansion in the use of media content and transmission over the web employments. Accordingly, there is a need of special embedding procedure for steganography. The creator presents an original reversible data hiding (RDH) algorithm for colour pictures that further develops the inserting execution by applying a channel transformation function and a versatile expectation blunder extension prediction error expansion structure. The proposed calculation will bring the first colour picture with no information misfortune from the inserted picture (which is unique in addition to target picture). The evaluation is done here at the zero for the given base place for the histogram that marginally changes the pixel esteems for inserting the information. It can insert more information when contrasted with the majority of the current data hiding calculations. A hypothetical confirmation and various examinations state that the embedding capability of the proposed model which consistently is further noteworthy in comparison with other reversible data hiding techniques. The calculation has been applied to a wide scope of various colour pictures effectively. Some exploratory outcomes are introduced to show the legitimacy of the calculation.

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1. INTRODUCTION

As the technology is advancing each day, the key goal of guarding digital data is of high demand. The main aim here is toto guarantee the safety of digital data is by means of steganography for better embedding. Reversible data hiding in encoded colour pictures (RDHEI) is an efficient method for the purpose of data security. This is predominantly related for a variety of multimedia data, including pictures, audio files, and video files. Steganography with suitable embedding is a well-established and expanding scientific discipline that can be used to conceal information. A powerful safekeeping tool known as steganography that offers a high level of security, predominantly when it is shared with encryption. The Stego picture transmission should be private, where just the approved individual should have the option to peruse the message, while others ought not to speculate it. Picture steganography is the specialty of concealing the information behind the picture in such a way that the changes caused in a picture are not really perceptible to natural eye. The picture behind which the information is to be put away is called cover picture and the picture created in the wake of concealing the information is called stego picture. Hiding the information can be divided in 3 sub-sections.

– Capacity-volume is to assess the quantity of data hidden in shield medium.

– Strength-this assessment will contribute the amount of adjustment that is capable of processing on a process on the basis of stego images prior to any opponent terminate the secret data.
– The secret data should be authenticated so that the hackers cannot steal it for construction of an image.

A few colourpicture reversible data hiding (RDH) approaches are given to concentrate on the correlations between each channel. A combined reversible data hiding system, according to Yang *et al.* [1] can reduce prediction errors for the colour filter array used in mosaic pictures clustering-based histogram mechanism and a modification method that is proposed by Tseng *et al*. [2] This integrates a covert message that covers a colour image in reversible format. The channel-dependent payload partition performance strategy and adaptive embedding have been improved by the enhanced colour mechanism for image RDH algorithm [3]. The current system anticipates techniques that do not adequately use inter-channel communication.

One major issue associated with RDH scheme is concerned with identifying the upper bound payload value for the aspect of host sequence for a particular distortion parameter. An individual and identical scattered host sequence, the key issue that has not been solved by Kalker and Willems [4] which has been formulated for the purpose of special rate-distortion function is used. The upper limit on the built-in given distortion parameter,

$$\beta_{rev}(\Delta) = [\mathfrak{M}\{H(Y)\} - H(Y)], \tag{1}$$

$$\sum_{x,y} P_X(x) P_{y|x}(y|x) d(x,y) \leq \Delta \tag{2}$$

where X and Y depict the variables allotted to the host sequence as well as the marked sequence, and $\mathfrak{M}$ stands for maximization function. The entropy value reaches maximum transition probabilities $P_{\_Y|X}(y|x)$ for the purpose of justifying the distortion parameter. The probability distribution of X is P X (x), and the expected price for modification from X is d(x,y). For spatial colour images, a novel steganography method [5] that takes into account a colour pixel vector is proposed; in this method, colour pixel vectors are made up of embedded units and colour components that are similar to the spatial position. A clustering technique for immediate strategy adjustment is designed to enhance performance. Incorporating data coding to modify data embedding for picture encryption is a revolutionary RDHEI approach for digital imaging communications in medicine images. Further [6], presents a novel RDHEI method for digital imaging and communications in medicine (DICOM) images. The concept of introducing data coding to enable data embedding for encrypted images. The work in [7] an efficient RDH technique for colour image via double-layer embedding. Due to its great embedding capacity and usage of double layers in data embedding, this technique inherits from histogram shifting its reversibility characteristic. Yang *et al.* [8] proposed double-layer least square prediction to satisfy the sorting requirement and maintain prediction accuracy, and then the blue-red-green embedded principle is proposed to enhance the visual quality of the marked colour images for diverse visual perceptions.

2. RELATED WORK

In this section, we will introduce the current common RDH algorithm and some studies on the Internationale Commission on Illumination (CIE) colour space. Numerous RDH methods can be classified into two subclasses, namely the RDH methods based on grey images and the RDH methods based on colour images. The former generally used the co-relation between neighbouring pixels to predict and yield a sharp histogram of prediction errors and then embedded messages by modifying the histogram, while in the latter, the image can be split into three interconnected grey images, and in each grey image in the embedding, the correlation between the red green and blue (RGB) channels can be used in addition to the RDH algorithm of the grey image. In the development process of the colour space, CIE1931RGB, CIE1960UCS and CIE1976 L ∗a ∗ b ∗, CIEDE2000 have been developed. In the following, we describe some classical RDH methods from these two subclasses, and some applications of the CIE colour space and the development history of CIE colour space. The additional data is placed in the image using various techniques [9] histogram shifting [10], [11], difference expansion [12]–[15] or pixel value ordering, [16], [17].

Tang *et al.* [7] proposes a RDH algorithm which is a two-stage scheme, including the stages of the first-layer embedding and the second-layer embedding. In the stage of the first-layer embedding, colour image is firstly down-sampled and then the RGB channels are resized to the original size of the cover image by image interpolation. The RDH method of colour image adds the research on the correlation between the three channels of the colour image on the basis of the grey image RDH method. To date, some of the existing colour image RDH methods only used grey image RDH methods in the RGB channels directly rather than considering the correlation of the three channels. Subsequently, Li *et al*. [18] proposed the use of edge information from the reference channels and inter-channel correlation to improve the efficiency of the prediction error expansion and the prediction accuracy. Then, Ou *et al*. [3] utilized the inter-channel correlation for payload partition and adaptive embedding to achieve minimal distortion. Hou *et al*. [19] proposed a RDH scheme that maintained the same grayscale of the marked image as the cover image after embedding. However, most existing colour image RDH methods do not consider the different subjective visual perception in each R, G, and B colon channels, and they all use the peak signal to noise ratio (PSNR) as the criteria for the assessment of the marked images' quality. However, the PSNR metric is inconsistent with the subjective feeling of human eyes in image quality assessment research area.

RDH methods based on visual optimization [20]: this study proposed the RDH scheme based on minimizing the visual distortion. Using a visual quality score, the correlation between all the original overlapped blocks with the marked blocks is measured. The optimal flippable pixels can be selected based on the highest visual quality scores. And data extraction and image recovering can be achieved by calculating the same visual quality score. RDH methods based on Halfton methods [21], [22].

3. PROPOSED METHOD

Most popular RDHEI techniques have not yet produced desirable payloads. We suggest a novel RDHEI approach that uses hierarchical embedding to solve this issue. We both contribute in different ways. In (1) for the purpose of bit-planes of a plaintext image, a brand-new method of classified label map generation is suggested. Utilizing a prediction technique, the hierarchical label map is computed, compacted, and inserted through the encrypted image. In (2) High embedding payload is the goal of hierarchical embedding. Prediction mistakes are divided into three categories using this embedding technique: small, medium, and big, each of which is identified by a different label. In contrast to conventional methods, the hierarchical embedding technique uses both pixels through small-magnitude as well as large-magnitude prediction errors to incorporate hidden bits, which results in a high embedding payload.

The propose method is aimed at decreasing this average distortion which provides an embedded rate R in a colour picture with the help for channel transformation function. Unlike the ongoing methods such as RDH approaches which take PSNR as the measures which analyses the quality of a marked image, but it has been demonstrated that PSNR cannot be employed consistently in the case of a specific human vision sense. We present a new B-R-G embedding principle in our model, which is applied in various visual perception in each and every R, G, and B colour channel. First, a two-layer last successor (LS) prediction approach is offered in order to analyse and predict the original image. Then, after sorting and eliminating peak-energy pixels using the energy threshold, we proceed to choosing the embedded pixels.

In order to embed the data into the selected pixels, the B-R-G embedded concept is utilized. Then the sender changes X=(x 1...,x). Thus the host sequence Y=(y 1...,y N) has a length of N, and the rate of embedding R=L/N. The cost of transforming x to y is defined as d(x,y), where Y stands for the random variables and d(x,y) could either the square error distortion metric (d s (x,y)=x-y2) or the L 1-Norm distortion metric (d 1 (x,y)=|x-y|). The suggested technique reduces average distortion to this approach a specified embedding rate R in a colour image using a channel transformation function.

In this study, we use diverse visual perception to each and every R, G, and B colour channel to propose a ground-breaking B-R-G embedding principle. Contrast this with contemporary methods like RDH methods, which evaluate the worth of the marked picture using PSNR as a criterion. A two-layer LS prediction method is suggested, and analysis using it is used to first forecast the original image. The selection of the embedded pixels comes next. A distortion-limited sender is the target of the optimization problem in (1). In practice, we typically take into account a sender with a payload restriction, as illustrated in (3) that reduces the average distortion for a specified embedding rate R. Given that X and Y are combined finite alphabet groups and that x X=0, 1, m-1 and y Y=0, 1..., n-1, the distortion metric d (x, y) is best characterized by a distortion matrix shown as in (4),

$$\mathfrak{M} \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} P_x(x) P_{Y|X}\,(y|x) d(x,y) \tag{3}$$

$$subject\ to\ H(Y) = R + H(X)$$

$$D = \begin{matrix} d(0,0) & \cdots & d(0,n-1) \\ \vdots & \ddots & \\ d(m-1,0) & \ldots & d(m-1,n-1) \end{matrix} \tag{4}$$

where $d(x,y)$in (4) has this similar function for variables like$x = 0, m-1\ and y = 0, n-1$.

In order to accomplish peak signal-to-noise ratio that is high PSNR. The current colour RDH approaches [18], [23] for this color-marked image focus mostly on the relationships between the three colour channels. This implies that the three colour channels can be changed and the image quality will not be affected. The colour will affect how sensitive the human eye is to colour, though. The weights in (5) represent how brightly normal trichromatic people perceive light that is precisely additive primary colour and it is often used to transform a colour image to grayscale.

$$f = 299/1000_r + 587/1000_g + 114/1000_b \tag{5}$$

Where f is the generated grayscale level and R, G, and B are the levels of the R, G, and B channels, respectively. The human eye is more sensitive to green and less sensitive to blue, as shown by (5). A reasonable class assessment of a colour tagged image, as shown by Cummilative-PSNR, is determined by (5) and is equal to given. And $MSE_R, MSE_G andMSE_B$ are the mean square errors from the R, G and B channels, correspondingly. The quality assessment, is a practical multi-distortion metric for three host sub sequences for the R, G and B channels is well-defined as mentioned in (8).

$$C - PSNR = 10log_{10}(255^2/ MSE_C) \tag{6}$$

Where,

$$MSE_C = 0.299MSE_R + 0.587MSE_G + 0.114MSE_B \tag{7}$$

$$\begin{aligned} &ForRedChannel, d_R(x, y) = 299/1000(x - y)^2 \\ &ForGreenChannel, d_G(x, y) = 587/1000(x - y)^2 \\ &ForBlueChannel, d_B(x, y) = 114/1000(x - y)^2 \end{aligned} \tag{8}$$

3.1. Multi-distortion metric for sub-sequences

Based on the previous discussions, when a payload is provided (R), the problem of reasonably distributing the total payload R among K sub sequences to minimize the average embedding distortion can be formulated as mentioned in (9). In (9) gives the rate-distortion bound of RDH for a multi-distortion metric, matching (3) if K=1. In (9) gives the rate-distortion bound of RDH for a multi-distortion metric, matching (3) if K=1. The produced compound distortion metric can also be described by a single distortion matrix, Dc. Actually, (9)'s optimization problem I am changed into (9)'s optimization problem II (10). Problem I,

$$\begin{aligned} &minimize \frac{\sum_{i=1}^{K} N_i \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} P_{X_i}(x) P_{Y_i|X_i}(y|x) d_i(x,y)}{N} \\ &subject\ to \frac{\sum_{i=1}^{K} N_i.H(Y_i)}{N} = R + \frac{\sum_{i=1}^{K} N_i.H(X_i)}{N} \end{aligned} \tag{9}$$

$$\begin{aligned} &\sum_{x=0}^{Km-1} \sum_{y=0}^{Kn-1} P_{X_c}(x)\, P_{Y_c|X_c}(y|x) d_c(x, y) \\ &subject\ to\ H(Y_c) = R + H(X_c) \end{aligned} \tag{10}$$

3.2. Channel transformation function ($\mathcal{C}_T$)

In this paper, we propose an obvious picture filter termed as the channel transformation function. The filtering outcome is a local linear change for the directed image. On the one hand, the channel transformation function takes good edge-preserving smoothing characteristics similar to the bilateral filter while not having gradient reversal artefacts.

Yao *et al.*[24], Yin *et al.* [25] scheme, each colour channel's pixels are split into two groups, dark and white, to simulate a chess board. R, G, and B channels are split into 6 sets as a result, signifying by R_w, G_d, G_w, B_d, B_w, G_w where C_d and C_w denote the sets of scales in channel C that come from the white and dark regions, with channel C standing for either the R, G, or B channel. Prior to embedding, the payload is irrespectively distributed among the six divided sets to minimize embedded distortion. Then, one by one, messages are fixed into the six sets. A specific set is chosen for alteration; the channel transformation function creates a crisp PE histogram using the other 5 sets as references.

$$\begin{aligned} &DPER_d^0 = \mathcal{C}_T\ (R_d(R_w, G_d, G_w, B_{d\,,} B_w)) \\ &DPEG_d^0 = \mathcal{C}_T\ (G_d(R_d, G_w, G_w, B_{d\,,} B_w)) \\ &DPEB_d^0 = \mathcal{C}_T\ (B_d(R_d, R_w, G_d, G_{d\,,} B_w)) \end{aligned} \tag{11}$$

In order to attain a high PSNR through this colour marked image, the existing colour RDH methods largely explore the correlations among the three colour channels, suggesting that for these approaches, changes to the three colour channels which show the same effect on image quality. Nonetheless, the human eye's colour sensitivity differs depending on the colour. We start by defining a general linear translation-variant filtering function, which consists of an input picture for guidance I, an output image q, and an input image p for filtering. According to the application, I and p are both provided previously and may be the same. Using a weighted average, the filtering result at pixel i is expressed,

$$q_i = \sum_j W_{ij}(I)p_j \tag{12}$$

where i and j are pixel indexes that, using a function of the guidance picture i and p's self-determining, filter the kernel W_{ij}. This filter has a linear relationnship with p. where pixel indexes i and j are used. The guidance picture I determines the filter kernel W_{ij}, which is independent of p.

4. RESULTS AND DISCUSSION

The experiments and findings of the suggested technique are presented in this section. The experiments are run with MATLAB 2016 on Windows 10 with an Intel Core i7 2.60 GHz processor and 8.0 GB of RAM. Figure 1 displays six standard cover images, including one standard 512×512 colour images from the USC-Signal and Image Processing Institute database.

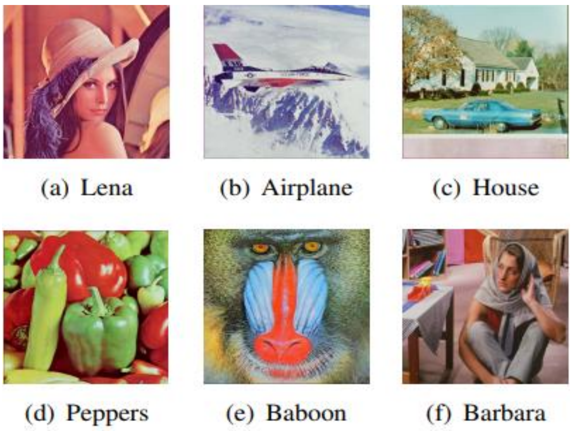

Figure 1. Six test cover images

Barbara is listed in the live database. The proposed method's performance was compared to the methods developed which are the most sophisticated colour image RDH methods currently on the market, as well as to the method developed by [10], which is the most effective RDH method based on the grey image. This contrast enabled a more impartial assessment of the suggested approach. Performance comparison of ΔE values between the proposed method and four other RDH methods for six standard images shown in Table 1. Performance comparison of ΔE values between the proposed method and four other RDH methods for six standard images when embedding capacity is 50,000 bits, respectively. Figure 2 displays the comparison of ΔE at 50,000 bits.

Table 1. Performance comparison of ΔE values between the proposed method and four other RDH methods for six standard images when embedding capacity is 50,000 bits, respectively

Image	Ou *et al.*	Yao *et al.*	Hou *et al.*	Hu *et al.*	Proposed
Lena	0.067	0.056	0.116	0.087	0.029
Baboon	0.241	0.225	0.505	0.331	0.0265
Airplane	0.052	0.045	0.149	0.091	0.0096
Barbara	0.104	0.068	0.237	0.173	0.0147
House	0.025	0.026	0.108	0.184	0.0102
Peppers	0.190	0.113	0.382	0.155	0.130
Average	0.113	0.089	0.250	0.170	0.037

In Figure 2 the performance comparison of ΔE values 50,000 bits**.** between the proposed method and four other RDH methods for the standard images are shown in Figure 2. X-axis represents the existing and proposed methods and Y-axis represents the ΔE value. Comparison of ΔE values between the proposed methods and ordinary equal partition scheme are shown in Table 2. Figures 3 to 5 shows the performance comparison of ΔE values between the proposed method and four others RDH methods for the standard images when embedding capacity is 50,000 and 100,000 bits, respectively.

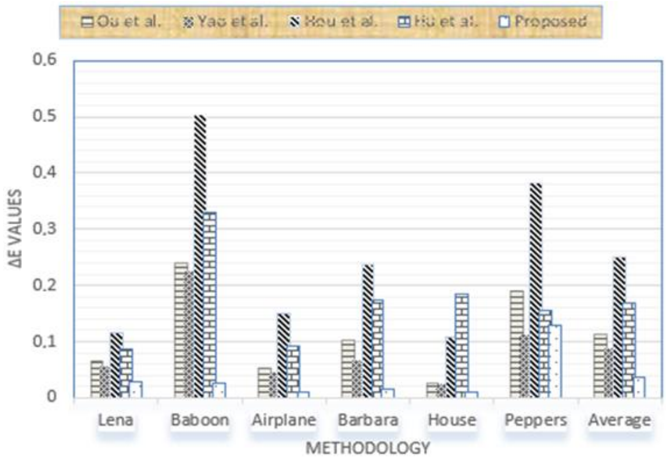

Figure 2. Comparison of ΔE at 50,000 bits

Table 2. Comparison of ΔE values between the proposed methods and ordinary equal partition scheme on six standard images

Image capacity (bits)	Equal partition scheme	Proposed scheme
At 30,000		
Lena	0.044	0.0163
Baboon	0.157	0.0127
Airplane	0.028	0.0058
Barbara	0.047	0.0106
House	0.020	0.0066
Peppers	0.115	0.0885
At 60,000		
Lena	0.091	0.0356
Baboon	0.360	0.0358
Airplane	0.057	0.0117
Barbara	0.098	0.0179
House	0.035	0.0125
Peppers	0.237	0.1429
Average	0.107	0.01326

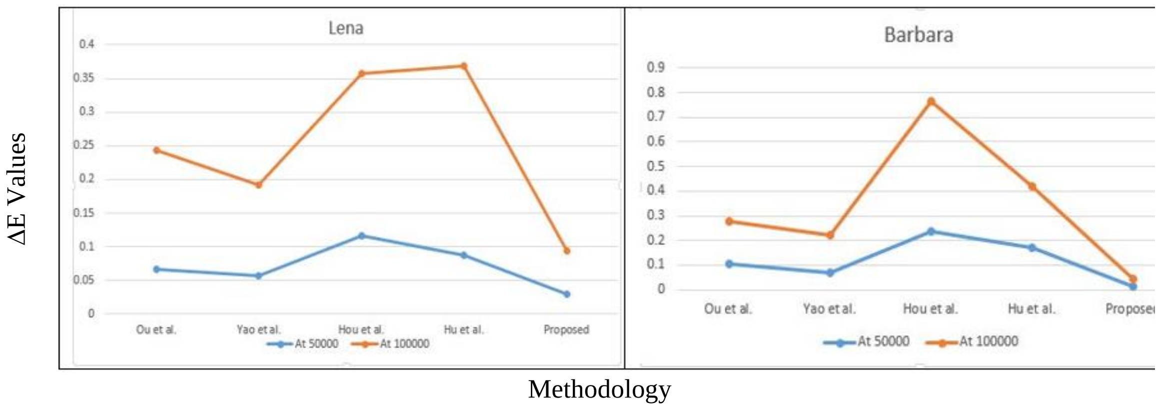

Figure 3. Performance comparison of ΔE values between the proposed method and four others RDH methods for two images lena and barbara

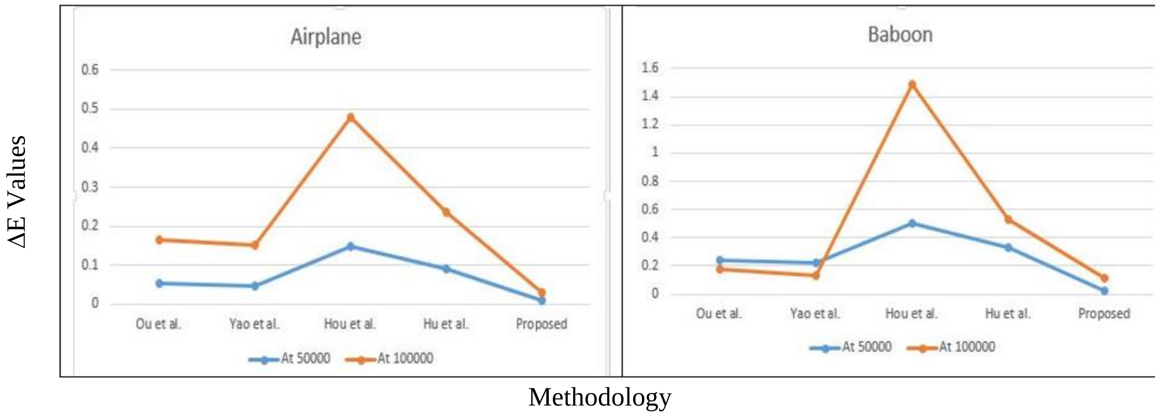

Figure 4. Performance comparison of ΔE values between the proposed method and two others RDH methods for two images airplane and baboon

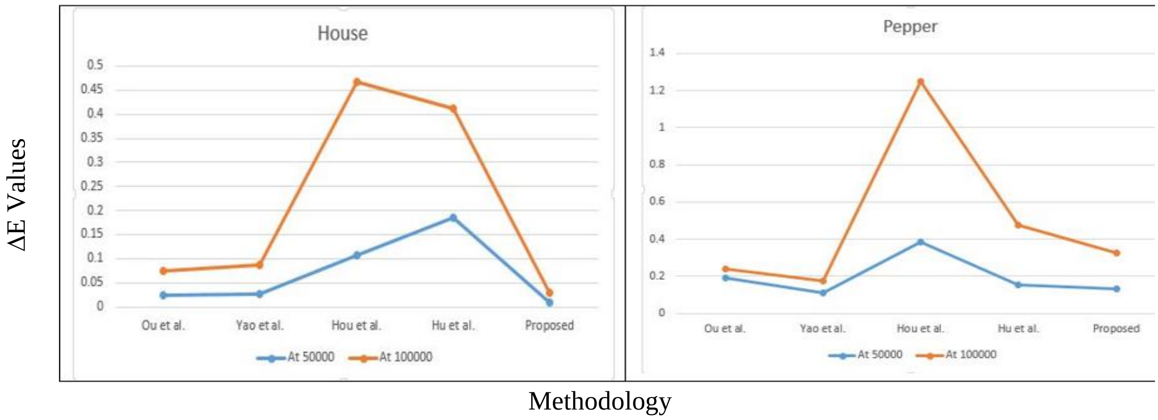

Figure 5. Performance comparison of ΔE values between the proposed method and two others RDH methods for two images house and pepper

5. CONCLUSION

The suggested technique, which uses a channel transformation function as its foundation, outperforms all earlier methods. The outcomes show that our technique expands the code building and has a better ability to include a color image. Additionally, with the help of our suggested channel transformation function, we are able to increase the detection rate. The channel transformation method's increased embedding capacity improves security performance as well. All the functions are simulated using various payloads. Our approach will outperform the currently used techniques in terms of the security and ability to conceal a color image. The experimental results confirmed the assertion that the suggested procedure produced photographs of higher quality than those obtained using cutting-edge techniques.

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