An Effective Multiple-Bit Data Abstraction and Lossless Retrieval without Shifting

P. Arunkumar[1]; S. Divya[2]; E. Baskar[3]; R. Brindha Devi[4]
Student[1]; Student[2]; Student[3]; Assistant Professor[4]
Department of Computer Science and Engineering Sri Venkateswaraa College of Technology

Abstract:- Cryptography and Steganography are two major forms of enforcing data privacy, with the former being prevalent. For small payloads, Steganography is preferred, as the data remains concealed and abstracted. The process involves embedding bits onto a carrier image. However, the disadvantage of steganography is that the carrier image gets distorted, which is a major concern when it comes to pixel sensitive images, such as forensic and medical images that aremission critical. Furthermore, due to modifications in the pixel values, the images get distorted, which can be irrecoverable. Hence, the technique of Reversible Data Hiding(RDH) can be used as a solution. Usually two methods are used under RDH, namely Histogram Shifting (HS) and Difference Expansion (DE).

Histogram Shifting method shifts all pixel values between pairs of peak and zero points, which allows data to be embedded in the intermediate points. However, this method also depends on frequencies of pixel values on the image, andthe embedding capacity varies greatly on the image. In Difference Expansion Method, the difference between a pixel and its adjacent pixels is considered to embed a single bit intoone of the pixels. Here, a scheme to embed multiple bits in a pixel is proposed, which greatly enhances the embedding capacity. Initially, three horizontally adjacent pixels are taken and the difference between the rightmost and leftmost pixel iscalculated.

This difference is used to classify the centre pixel as embeddable or non-embeddable. If the pixel is embeddable, anew pixel value is calculated, which comprises of the secret bits, offset bits and flag bits, without the use of any difference expansion or histogram shifting process. The secret bits and the original pixel value can be easily recovered from the modified value using the offset and flag bits. This scheme has higher embedding capacity, and lower complexity in terms of computations, when comparedwith other RDH schemes.

Keywords:- *Information Security, Steganography, Reversible Data Hiding, Histogram Shifting, Difference Expansion,Carrier Image.*

I. INTRODUCTION

Image Steganography is a technique under the domain of information security, which works by concealing information or mission critical data within images that meet certain requirements.

This technique is also used to protect secret or sensitive datafrom malicious attacks by embedding the data into images and retrieving the same. Hiding sensitive data is easily achievable for ordinary images. However, for embedding data on sensitive images, such as medical, forensic or military images, the image tends to get distorted due to manipulation of pixel values, and this distortion becomes permanent, leading to poor quality of images. Hence, reversible data hiding schemes are preferred. There are various methods for achieving RDH.

One of the most popular Reversible Data Hiding technique is Difference Expansion (DE), which is simple in terms of implementation. As the name suggests, this RDH scheme looks for expandable differences to embed pixels into.

The existing DE techniques execute one layer embedding in a difference image and use the histogram shifting method. The evident disadvantage of this technique is that the image quality could be severely degraded as more layers are embedded. If less layers have to be incorporated, the embedding capacity is low. Moreover, computing and expanding the difference involves complex computation.

In this project, a reversible data hiding scheme that can embedmultiple bits in a pixel without shifting is discussed as a solution for the above-mentioned disadvantage.

This scheme specifies clear criteria for the embeddability of apixel and the same criteria can be used to retrieve during extraction of the data from the embeddable pixel. Flag bits, offset bits and 2 embedding bits are computed.

II. PROPOSED ARCHITECTURE

- The proposed scheme consists of two algorithms, namely:-
- Embedding algorithm RetrievalAlgorithm

A. Embedding Algorithm

The embedding algorithm makes use of correlation of three horizontally pixels at a time, to conceal multiple bits. Considering a grayscale image, *I* with width *w* and height *h* pixels, the possible values for each pixel in theimage would lie between 0 to 255. For $i \in [1, h]$ and $j \in [1, \lfloor w/2 \rfloor]$, the difference d for any pixel *p(i,2j)* isgiven by : -

For a threshold *T*, the embeddability e (i, j) is determined asper the following equation: -

If e(i, 2j) is 1, then the point is classified as an embeddable point (EP). If e(i,2j) is 0, then the point is a non-embeddable point (NEP). A NEP cannot be used to embed any secret, as there is very correlation between three adjacent pixels.

Then the *EMAX (i, 2j)* and *EMIN (i, 2j)* of *p(i,2j)*, which denotes the local maximum and minimum respectively, is given by the following equations: -

Hence, it's local offset *OS(i, 2j)* is calculated by: -

Now, a new value p' (i, 2j) consisting of secret to be embedded, offset bits and flag bits is calculated. The newvalue is constructed in binary format as shown in Figure 1.1. The EP p(i,2j) is then replaced by the calculated value. It's two flag bits, denoted by F(i,2j) can be calculated by: -

Also, T must hold the following condition: - Where n is the length of offset (in bits) in p'(i,2j).

The offset Q(i,2j) can be calculated as per the following:

Where Dec2Bin() is a procedure that converts a decimal number to its binary equivalent. Depending on the flag, local offset bits, local maximum and minimum, *p'(i, 2j)* can be calculated as per the following figure: -

Fig 1.1 Binary format of new pixel value

If F = 00, 01 or 10 then the first three bits denote the secret, the middle three bits denotethe offset Q(i,2j) which is calculated using Eq.19 , and the last two bits denote the flag bits F(i,2j), which is calculated by Eq. 17.

If the flag bits F(i,2j) = 11 and the offset Q(i,2j) is not T, then three secret bits can be embedded as three most significant bits of p'(i,2j).

The next three bits and two bits denote the offset andflag bits respectively. If the flag bits F(i, 2j) = 11 and the offset Q(i, 2j) = T, then no secret can be stored and the first three bits are occupied by another offset Q_1(i, 2j) , which is calculated as shown in the following equation.

Fig 1.2 Binary format of new pixel value whenF=11 and Offset = $2_n - 1$

Finally, the new pixel value is calculated by: -

$$p'(i,2j) = \sum_{i=0}^{7} ai \times 2i$$

B. Retrieval Algorithm

Now, for the received stego image I and for a threshold T, the reverse process of the embedding algorithm can be performedto extract the secret bits and the carrier image I′, where that p(i,2j) is a stego pixel in I and p′(i, 2j) is the corresponding pixel in retrieved image I′.

III. RELATED WORK

Reversible Data Hiding is a prevalent task in Image Steganography. There are various Image Steganography methodologies that are prevalent to achieve Reversible Data Hiding (RDH).

One of the most popular techniques for RDH is Difference Expansion (DE), which is simple to implement. In one such scheme, an image is split into multiple blocks of pixels, eachof size 2 × 2, and each block is converted into a vector by calculating the difference between the pixel values.

A set of equations, depending on the algorithm, is used to manipulate the pixel values. Another set of equations, which are an inverse of the former set, is used to retrieve the secret and old pixel value. However, in this method, the location map becomes significantly high.

A. Merits:

- One more technique that is commonly used is Histogram Shifting (HS). In this technique, two typesof pixel values, namely zero point and peak point arefound. Zero point is the pixel value which appears theminimum number of times in the image, and Peak Point is the value, which appears maximum in the image. Then, a pixel with zero-point value and a pixel with peak value is taken together to hide the secret.
- The value of pixels in between the pair is increased by 1 unit. In other words, the values of pixels between the zero and peak points in the histogram are shifted by 1 unit. However, in this method, the embedding capacity varies greatly as it depends on the number of peak and zero points,

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and hence the payload is also low

- The proposed model has a higher embedding capacityeven though the image contains evenly distributed pixel values as modified pixels in those regions can be easily noticed.
- Further the embedded text and original image can beeasily retrieved with good quality.
- The problem of underflow is completely avoided in this method because the stego pixel is directly constructed using the adjacent pixels without performing HS or DE schemes.

Multiple bits are embedded at the same time by altering the pixel values between its neighbours, which increases the embedding capability.

B. Demerits:

- After generating the stego image it was observed thatthe quality of the embedded image is notably lower with respect to the carrier image.
- After performing the image retrieval, the quality of the retrieved image was of good quality, but some of the pixels got modified.
- The algorithm did not account for the overflow of pixel values.

IV. RESULTS FOR BICYCLE.BMP

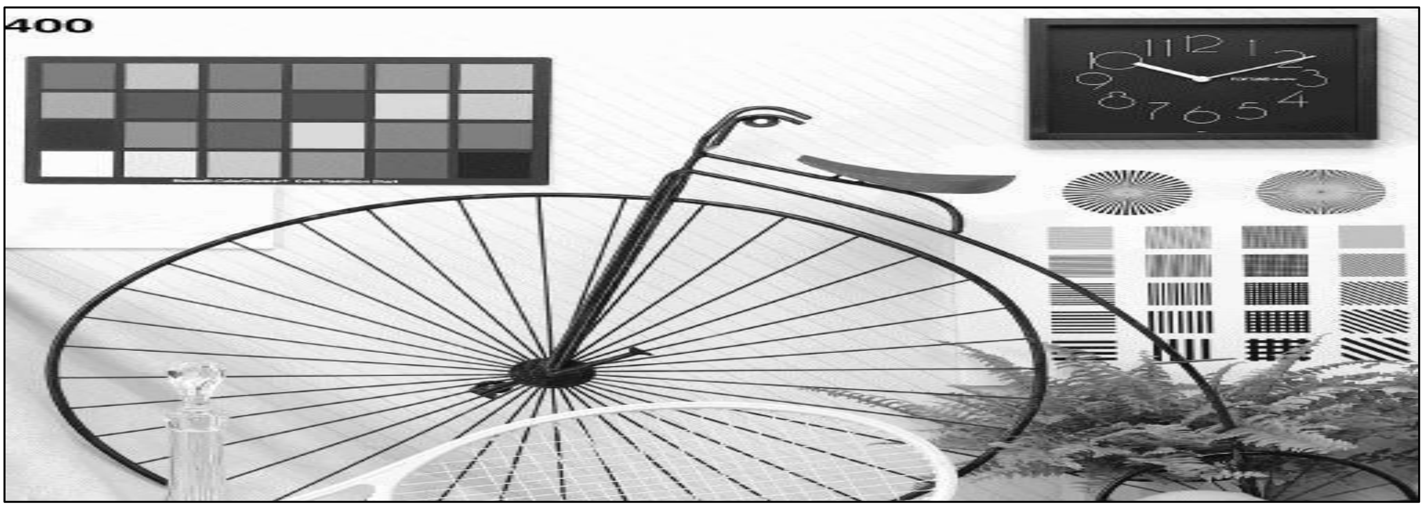

Fig 1: Original Image for Bicycle.bmp

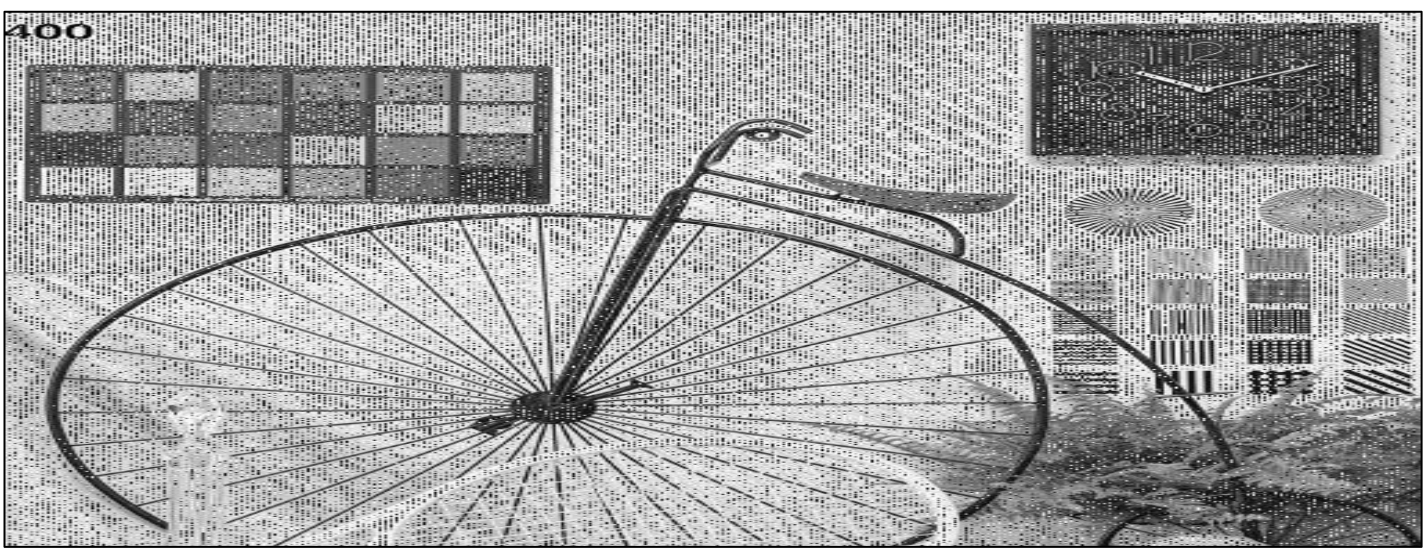

Fig 2: Embedded Image for Bicycle.bmp

Integration with third-party APIs enriches the system with real-time data and services, including travel booking.

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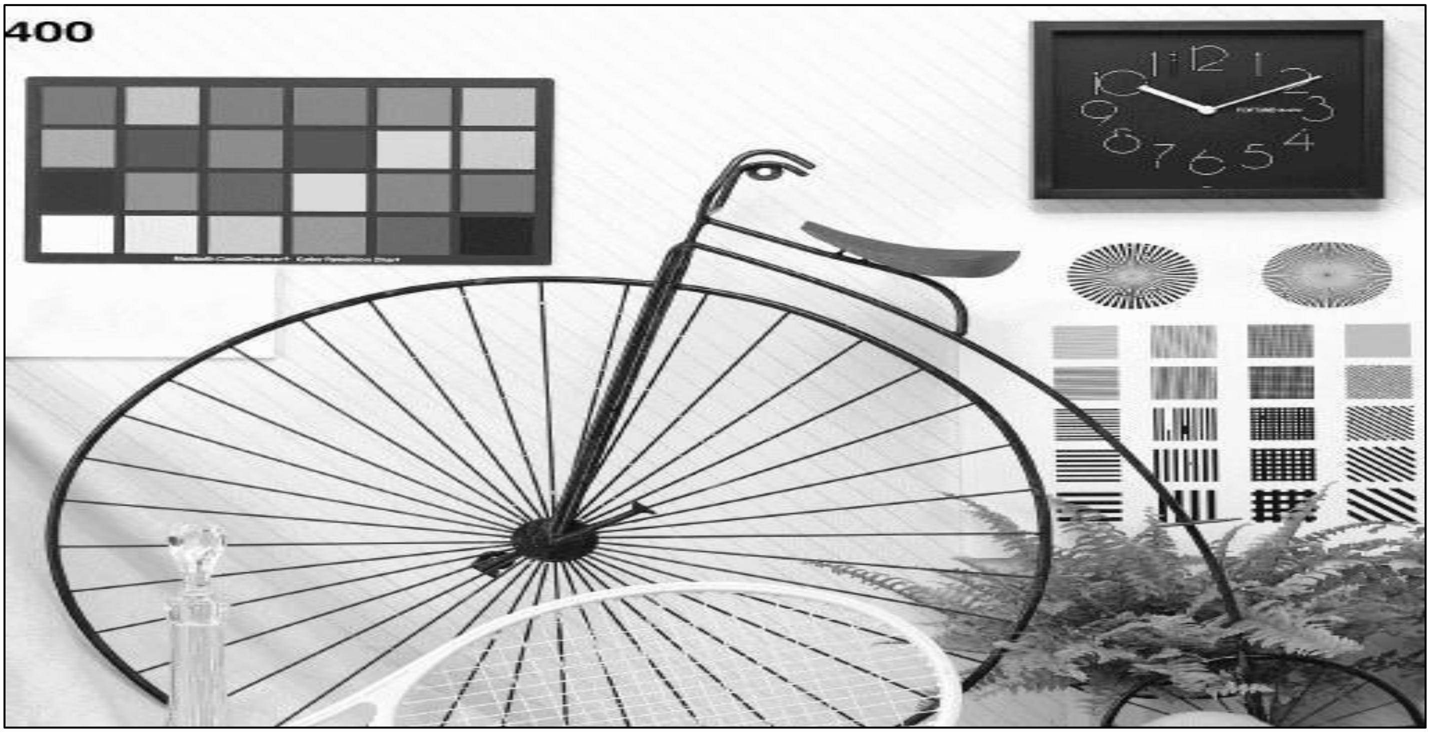

Fig 3: Retrieved Image for Bicycle.bmp

V. RESULTS FOR AEROPLANE.BMP

Fig 4: Original Image for Aeroplane.bmp

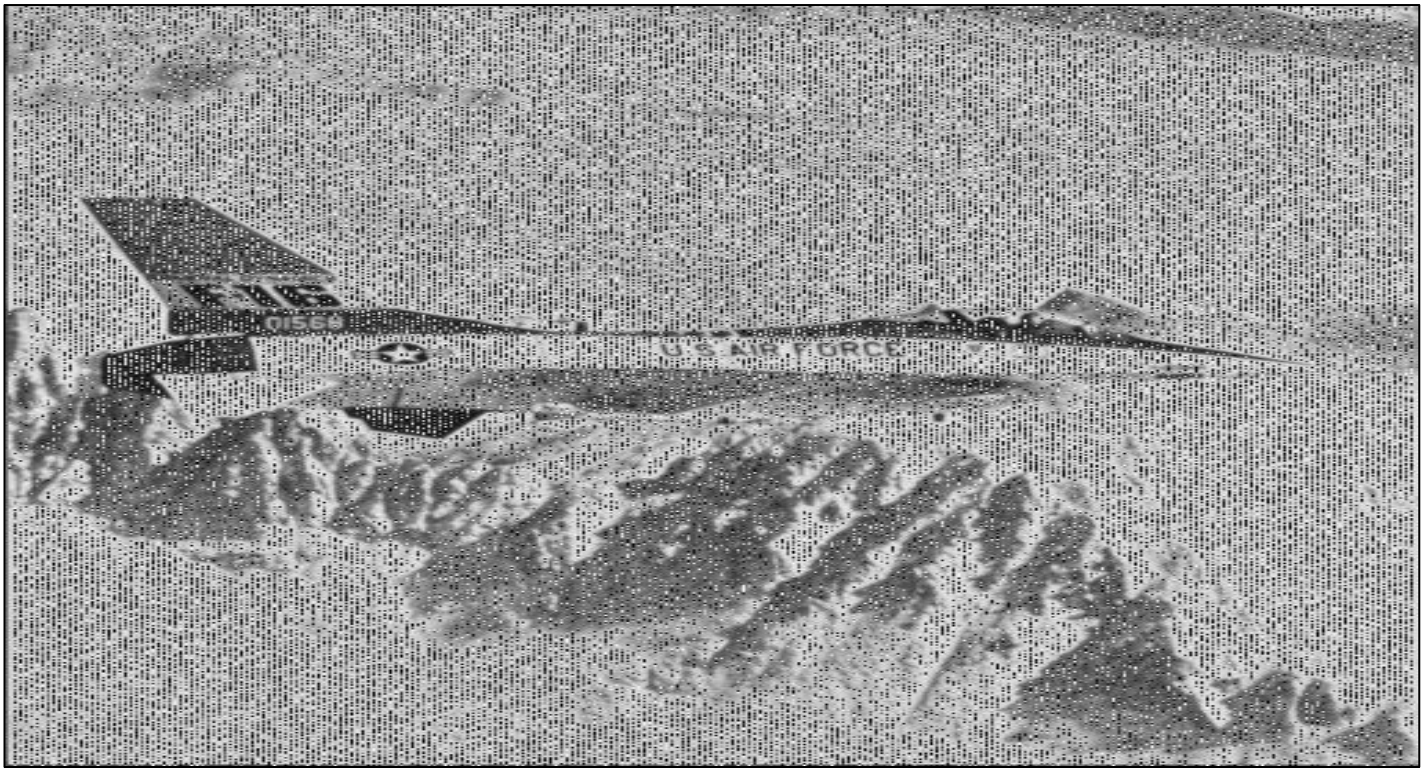

Fig 5: Embedded Image for Aeroplane.bmp

Fig 6: Retrieved Image for Aeroplane.bmp

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VI. RESULTS

The base paper has been implemented based on the architecture proposed and the results obtained have been tabulated in table 1. To analyse the effectiveness of the proposed system, three performance metrics were evaluatedviz. Embedding Capacity, Payload and PSNR.

The equation for calculating PSNR values between two images is given as follows:

$$PSNR = 10\log_{10}(\frac{(2^n - 1)^2}{MSE})$$

$$MSE = \frac{1}{H \times W}\sum_{i=1}^{H}\sum_{j=1}^{W}(p'(i,j) - p(i,j))^2$$

The following metrics were evaluated for 6 grayscale 512x512 test images as tabulated in table 1.

Table 1: Analysis of Images using EC, Payload and PSNR

S. No	Name of Image	Embedding Capacity	Payload (bpp)	PSNR (dB)
1	Airplane	281397	1.0734	53.750
2	City	213159	0.8035	43.6280
3	Houses	207879	0.7929	49.279
4	Shed	22792	0.8694	37.5353
5	Things	148395	0.5660	37.5262
6	Unicycle	200028	0.7630	36.4173

VII. CONCLUSION

In this project, an efficient method for embedding multiple bits in a pixel is proposed for reversible data hiding that doesnot employ any shifting.

By exploiting the relationship among its two horizontally adjacent neighbours, multiple bits can be directly embeddedin an EP with a strong correlation with its horizontal neighbours, without modifying any NEP.

It eliminates any need to compute the difference in histogram calculation and thus reduces computational complexity significantly. It also avoids involving multiple layers of pixelsto notably simplify the data-hiding process.

The proposed multiple bit reversible data hiding scheme without shifting works best with the threshold value of 7 yielding the highest PSNR vs. Payload ratio, as per the plot. The proposed scheme also yields good quality of the retrievedcover image and facilitates lossless retrieval of the embedded data.

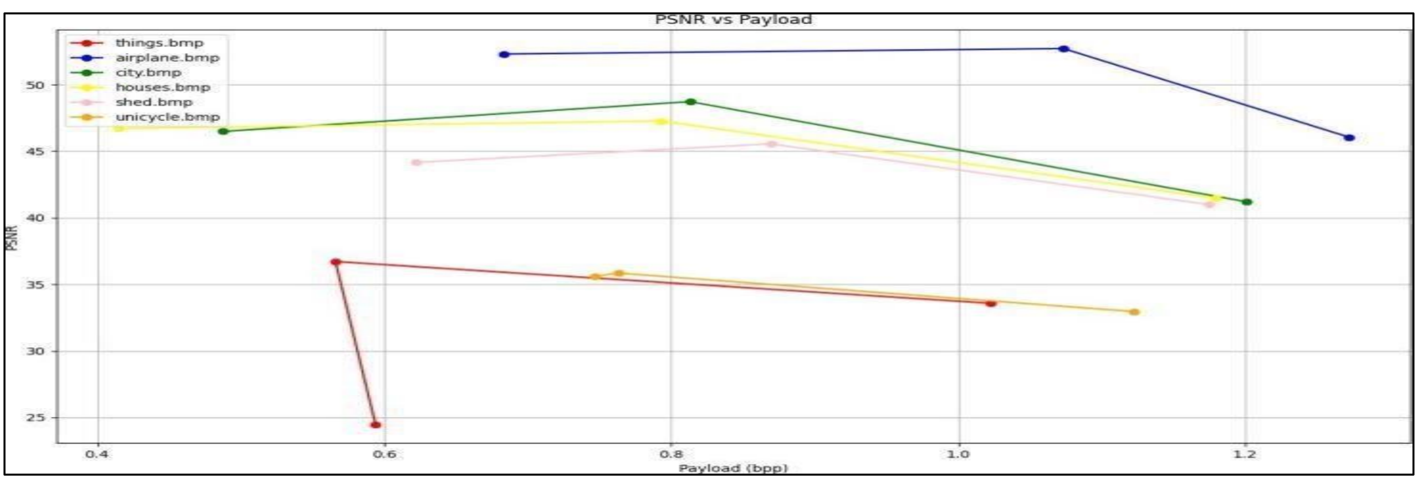

Fig 7: 1PSNRvs.Payloadplot

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Furthermore, the PSNR vs. Payload graph was plottedto analyse the trend for different threshold values to maximize the embedding capacity and the visual quality of the stego-image.

FUTURE WORKS

The proposed algorithm has further scope for improvement in terms of the quality of the embedded image and the error-free retrieval of the embedded secret. A little tweaking to the algorithm can yield better quality of the stegoimage and minimal distortion to the carrier image. The embedding capacity can be improved by adding more criteria for deciding the embeddability of a pixel apart from the offset and flag bits can be established. This also facilitates the error free embedding and retrieval of the data. We plan to improve the embedding algorithm by handling a few more cases while deciding the embeddability of a pixel and introduce a pixel map to keep track of the overflow bits during embedding. Thesecurity for the cover image can be enhanced by the using a suitable encryption algorithm. Instead of directly embedding the data into the carrier image we first encrypt the carrier image and embed data into the resulting image. During the retrieval, the user can choose to retrieve only the image, or only the secret, or both communities and cultures. Through curated recommendations and educational resources, TourTrove inspires travelers to engage in mindful and conscientious travel experiences that leave a positive imprint on the world.

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