Securing of Coloured Images Using Visual Cryptography and Digital Enveloping

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Abstract— Visual Cryptography is a Cryptography scheme which is used to secure images. In this scheme the image to be sent to receiver via sender is divided into number of shares and then they are sent to the receiver. In Decryption processes, these shares of images are combined or stacked together to get an original image. The initial model developed was only for the binary images. Later the black and white images or 0-1 image was further studied for the Coloured Images that means for Red, Green, and Blue. For the RGB images various methods have been developed but in all these techniques the received image has degraded quality. In this paper we propose a new algorithm with implementation for coloured visual cryptography and making it more secured by applying Digital Enveloping technique on the shares of the image. Digital Enveloping is a technique in which shares, of the image to be sent, are distributed over various sample images to create what is known Enveloped images. At the receiver end, shares are retrieved from the enveloped images and combined to form original image without degrading the quality of image. The important feature of the Visual Cryptography is decryption process is done by human eyes not the computer less computational power is required.

Keywords: Visual Cryptography, Digital Enveloping, Shares, Rubik's Cube, Image Security, Alpha Component, Encryption, Decryption

I. INTRODUCTION

Visual cryptography was given by Moni Naor and Adi Shamir in 1994. They demonstrated the original visual secret sharing scheme, where an image was divided up into n shares so that only someone with all n shares could see the original image, while with any n-1 shares he/ she gets no information about the original image. Each share was printed on a different degree of transparency, and decryption was performed by stacking the shares. When all n shares were stacked, the original image would be seen [3][4][7].

Visual cryptography is a cryptographic technique where visual information like Image, data in form of text, etc. gets encrypted in such a way that the decryption can be performed by the human eye without the use of computers[5][6][11].

In this technique we deal with pixels of the image. Pixel is the smallest unit that denotes an image. We here deal with 32 bit pixels and these 32 bit pixels are divided into four parts: - Alpha, Red, Green and Blue.

Red, Green and Blue each having 8 bit pixels and are better known as RGB components. Alpha also has 8 bit pixels and is the degree of transparency. A 32 bit sample pixel is denoted in Fig-1.

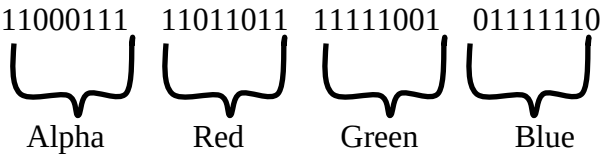

Fig. 1: Structure of a 32 bit pixel

Here, we have devised a new algorithm.

In Encryption Process we firstly applied shuffling on the original image using Rubik's Cube[1][2] method, that is the pixels of the image is shuffled in some manner firstly row wise and then column wise.

Next in Encryption process for secret sharing, we divide the resultant of the above image into 4 shares namely: - Alpha, Red, Green and Blue. And then we applied Digital Enveloping Technique on these shares by putting each share into an image known as "*Innocent Cover*". So we put these shares in the innocent covers in such a way that we are unable to see the shares in this enveloped image as they are completely hidden and one cannot retrieve the original image if he/she does not have all the 4 enveloped images, hence supporting secret sharing and image security. That is, the image if hacked or interpreted by any other user than intended will open up in any other image but not displaying the data if data is sent in image or shares. This protects the data from being visible as it shows only the encrypted image and hence data is secure during transmission.

In Decryption process, exactly opposite process occurs to that in encryption process. That is, first of all, from all the 4 enveloped images the shares are extracted. And secondly, these shares are stacked or combined together after applying reverse algorithm for de shuffling to get the original image without any loss or degradation in the quality of the image.

II. RELATED WORK

A brief survey is given in this section about the related works that had been done till now on Visual Cryptography.

The visual cryptography concept was initially known as secret sharing. This was pioneered by Adi Shamir in 1979. He in his paper stated that the secret image, data etc is divided in *n* no. of pieces and can easily be reconstructed from any of these *k* pieces. He also claimed that the data is surely protected after the encryption technique but the key used for the same is not necessarily to be protected. He thus suggested this secret sharing algorithm to protect the keys that are used for the encryption process.

According to Naor and Shamir, the algorithm is *k*-*n* secret sharing algorithm [3].The simplest structure given by them was the 2 by 2 scheme where the source image would be encrypted into 2 shares and both the shares are needed for a successful decryption [3][4][15]. In 2 by 2 scheme the black and white image was taken and each pixel of it was divided

in 2 sub-pixels, and an example of 2-2 scheme is shown below in Fig-2.

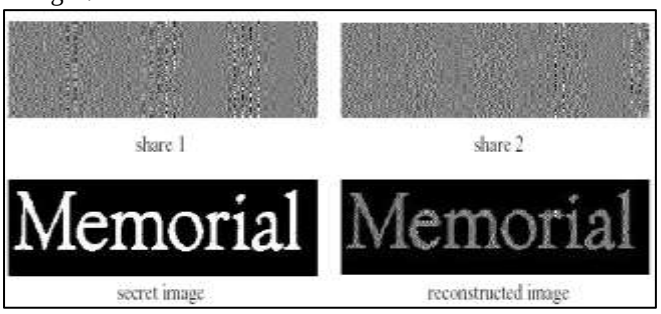

Fig. 2: Implementation of 2-2 VCA

The major drawback of this scheme was that it can be applied to only black and white images not the colored ones. Che Lee used this scheme for authentication that is based on the 0-1 images with the limitation that the binary image should be in png format. In binary images, only two possibilities of pixels are there viz. black and white. So one can use 0 to represent black and 1 to represent white [8].

So, based on this ideal algorithm the researchers enhanced and performed their survey on visual cryptography. In these surveys of Visual Cryptography schemes they found out that the this technique not only works for black and white images but also colored images.[12][14]

Various cryptography schemes like Algorithm for General Access Structure, Half toning scheme, For Grey images, Multiple secret sharing, Extended VC, Progressive VC, Region VC, Segmented VC etc. were made for secure transfer[5].

After some years of these great works on visual cryptography, works on Digital Enveloping was done[7][13]. With Digital enveloping came the Digital Watermarking and its various techniques [6][16][9]. Initially, the coding of these algorithms were done on MATLAB but for greater security since past few years JAVA language is preferred [10][11]. Watermarking Techniques like Single Watermark Embedding and Multiple Watermark Embedding which is extension to Single Watermarking techniques were made [16]. Also a technique called LSB replacement [6] was made which we have used here along with our new algorithm.

Recently, the work to build a physical visual cryptographic system is going on that is based on optical interferometry [17]. But, all of these earlier results of the works while decrypting the image generates an image of reduced quality.

III. Overall Process

1) Step I: The sample/source image's pixels are shuffled using Rubik's Cube method.
2) Step II: The image generated from Step I is then divided into 4 shares using our previous algorithm called ARGB Algorithm such that all these 4 shares when combined gives us the original image.
3) Step III: Each of the 4 shares generated in Step II is embedded into 4 different envelope images or innocent covers using LSB replacement.
4) Step IV: 4 enveloped images generated in Step III are taken and reverse LSB process is applied to generate the shares of the encrypted image
5) Step V: These shares are combined to get the shuffled image at the receiver end.
6) Step VI: Finally the de shuffling algorithm is applied on the shuffled image generated in Step V to retrieve the original image.

IV. Ru-ARGB Algorithm for Visual Cryptography

A. Scheme:

The source image is taken as the input. We already know the number of shares that are 4 and method for shuffling that is Rubik's cube. Now, the following algorithm is applied to shuffle the pixels of original image.

Step I: Take an image IMG as input and calculate its width and height. Apply Rubik's cube method on the Original image.

Assume all the constants , i.e. , values of b1, b2, a where,

b1:- modulo operator for row

b2:- modulo operator for column

a:- number of iterations

Step II: Now Rubik's Cube algorithm works as:

(a)Sum=Sum of pixel values in row 1

(b)M = Sum%b1

(c)S = M%2

(d)if S=0 then circular right shift

(e)if S=1 circular left shift

```
img   = read(file);          // where file is the input image IMG

for(y = 0 to height-1)
{
  for(x=0 to width-1)
  {
     p =getRGB(x,y)       //extracting overall pixels of image
in
                           //RGB format
     sumr[y]=sumr[y]+p; // find the row sum of pixels
   }
 }

for(y = 0 to height-1)
{
   m1= sumr[y]%b1;
   s= m1%2;   // check for remainder
    if(s==0)    // if even
    {
     for(x=0 to width-1)
      {
          int p1=img.getRGB(x+1,y);
          p=p1;
           img.setRGB(x,y,p);    // circular right shift
        }
      }
    }
    else      // if odd
    {
       for(x=0 to width-1)
       {
            int p1=img5.getRGB(x-1,y);
             p=p1;
             img5.setRGB(x,y,p);   // circular left shift
```



```
    }
  }
```

Step III: Similarly repeat for column
(a)Sum=Sum of pixel values in column 1
(b)M = Sum%b2
(c)S = M%2
(d)if S=0 then circular up shift
(e)if S=1 circular down shift

Step IV: Repeat it for 'a' no. of times

Step V: Now extract the Alpha, Red, Green and Blue components from this image by extracting first 8 bit for alpha, next 8 bit for red and so on using following process.

```
for(y = 0 to height-1)
{
  for( x = 0 to width-1)
   {
     p =getRGB(x,y)       //extracting overall pixels of image
in
                          //RGB format
     a = (p>>24)&0xff     // extracting alpha component
     r = (p>>16)&0xff     // extracting red component
     g = (p>>8)&0xff      // extracting green component
     b = p&0xff           // extracting blue component
   }
}
```

Step VI: Now save these ARGB components in the copied files by setting the extracted components in copied images using the following process.

```
for( y = 0 to height-1)
{
  for( x = 0 to width-1)
   {
    p=r<<24
    img1.setRGB(x, y, p)      /* setting images with ARGB
    p=r<<16                components extracted in StepV*/
    img2.setRGB(x, y, p)
    p=g<<8                    /*Both Step V and Step VI
    img3.setRGB(x, y, p)        works simultaneously/*
    p=b
    img4.setRGB(x, y, p)
   }
 }
```

This Encryption process is shown in Fig-3.

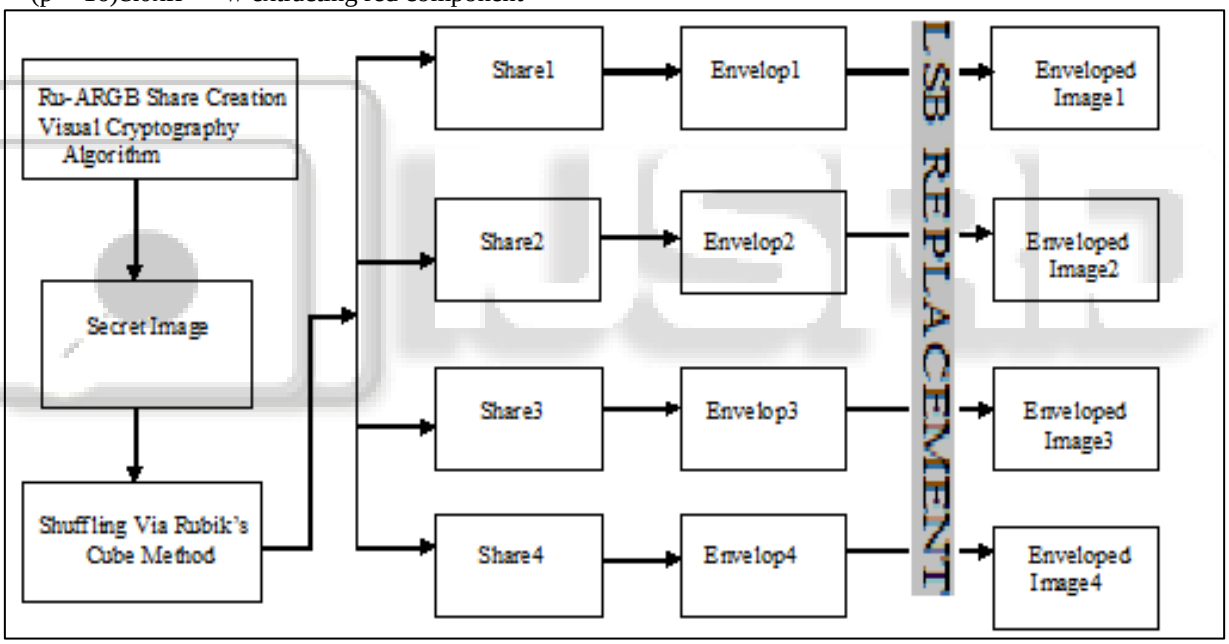

Fig. 3: Secret Sharing With Digital Enveloping (ENCRYPTION)

V. DIGITAL ENVELOPING

Using this step the shares that of the original image that were divided are enveloped within other image. Least Significant Bit (LSB) replacement digital enveloping technique is used for this enveloping process. It is already discussed that a 32 bit image pixel is divided into four parts namely alpha, red, green and blue; each with 8 bits. This algorithm shows that if the last two bits of each of these shares are changed; the changed colour effect is not detected by human eyes. This process is called invisible digital watermarking [4][10][14].

For using up all the 32 bits of a pixel of shares, that are divided, 4 pixels of the innocent cover are required. It means to envelope a share with dimensions sw X sh (share width and share height); we need a cover image with sw X sh X 4 pixels. Here we have taken each /cover envelope of size 4 X sw X sh. The following fig-3 describes the LSB replacement procedure. For replacement of 8 bit alpha share, one pixel of the envelope is required. In the same way red, green and blue (RGB) shares are enveloped using three other pixels of the cover image.

The enveloping is done using the following algorithm: -

Step I: Take the 4 shares that were created using ARGB as input and for each share = 0 to 3 repeat Step II to Step IV.

Step II: Take all the 4 shares, let that be Share1 to Share4 and the name of the covers be, ENV1 to ENV4 as input. Let the width and height of the shares be sw and sh and the width of the covers must be 4 times of the width of Shares. But height must be same as that of Share

Step III: Create an array ORG_SH of size sw*sh*32 to store the pixel values of the SHARE using the following loop


```
for(y = 0 to sh-1)
{
  for(x = 0 to sw-1)
  {
    p = img.getRGB(x,y)
    for( j=0 to 31)
      ORG_SH[y*sw*32+x*32+j]=s.charAt(j)
  }

 }
```

Create the array of ENV of size 4*sw*sh*32 that would store the pixel values of the ENV1 to ENV4.
Step IV: Use the marker value as M= −1. Using the following given procedure the SHAREs are embedded within ENV.

```
for(j = 0 to 4*sw*sh-1)
{
    ENV [j*32+ 6] = ORG_SH [++M]
    ENV [j*32+ 7] = ORG_SH [++M]
    ENV [j*32+14] = ORG_SH [++M]
    ENV [j*32+15] = ORG_SH [++M]
    ENV [j*32+22] = ORG_SH [++M]
    ENV [j*32+23] = ORG_SH [++M]
    ENV [j*32+30] = ORG_SH [++M]
    ENV [j*32+31] = ORG_SH [++M]
}
```

Now the Alpha, Red, Green and Blue shares are embedded or enveloped in the 4 innocent covers to generate and enveloped image and hence the image or data is encrypted in form of another image which cannot be seen by any other person other than the receiver who will get all the 4 enveloped image. The Decryption process at the receiver is explained in the following paragraph.

VI. DECRYPTION PROCESS

In this step, 4 enveloped images are taken as input. From these enveloped images (taken one at a time), for each pixel, the shares alpha, red, green and blue are extracted and the OR operation is performed and finally de shuffling is done to retrieve the original source image. It is already known that human eye acts as an OR function [6][16].
The decryption process is performed by the following algorithm.
Step I: Input the 4 enveloped images that were generated in encryption process; eheight (h) and ewidth (w) of each image.
Step II: Now extract the RGB components from the enveloped images and using following process

```
for(y = 0 to eheight-1)
{
  for(x = 0 to ewidth-1)
  {
          p = .getRGB(x,y)
          s= Integer.toBinaryString(p)
          for(j=0 to 32)
          ENV[y*ewidth*32+x*32+j]=s.charAt(j)
   }
}
```

Step III: Now saving these extracted components into different shares which are 1/4th of these envelope images using following algorithms.

```
for(int j = 0 to 32*ewidth*eheight-1)
{
        ORG [++M]=ENV [j+ 6];
        ORG [++M]=ENV [j+ 7];
        ORG [++M]=ENV [j+ 14];
        ORG [++M]=ENV [j+ 15];
        ORG [++M]=ENV [j+ 22];
        ORG [++M]=ENV [j+ 23];


        ORG [++M]=ENV [j+ 30];
        ORG [++M]=ENV [j+ 31];
  }
```

Now by shifting of ARGB pixels to its appropriate places while combining the shares (just in the opposite way as we did in Step V of Encryption process) gives us the shuffled image IMG.

Step IV: Now we perform de shuffling in exact opposite way we performed the shuffling.

Take all the constants, i.e., values of b1, b2, a same as in encryption where

b1:- modulo operator for row
b2:- modulo operator for column
a:- number of iterations
Step V: Now decryption of Rubik's Cube algorithm works as:
(a)Sum=Sum of pixel values in column 1
(b)M = Sum%b2
(c)S = M%2
(d)if S=0 then circular down shift
(e)if S=1 circular up shift

```
 img   = read(file);            // where file is the shuffled image IMG obtained in step III
for(y = 0 to height-1)
 {
   for(x=0 to width-1)
   {
      p = img.getRGB(y,x);  // extracting RGB pixels from image
      sumc[y]=sumc[y]+p;   // calculating column sum
    }
   }

  for(y = 0 to width-1)
   {
     n1= sumc[y]%b2;
     s= (n1%2);   // checking the remainder
     if(s==0)   // if even
     {
       for(x-0 to height-1)
       {
            p1=img5.getRGB(y,x-1);
             p=p1;
             img5.setRGB(y,x,p);     // circular down shift
       }
```



```
 }
else
 {

    for(x=0 to height-1)
    {
        p1=img.getRGB(y,x+1);
        p=p1;
        img.setRGB(y,x,p);  // circular up shift
     }
 }
```

```
 }
```

Step VI: Similarly repeat for row
(a)Sum=Sum of pixel values in row 1
(b)M = Sum%b1
(c)S = M%2
(d)if S=0 then circular left shift
(e)if S=1 circular right shift
Step VII: Repeat it for 'a' no. of times
Finally we get the original image after de shuffling.
This Decryption Process is shown in Fig-4.

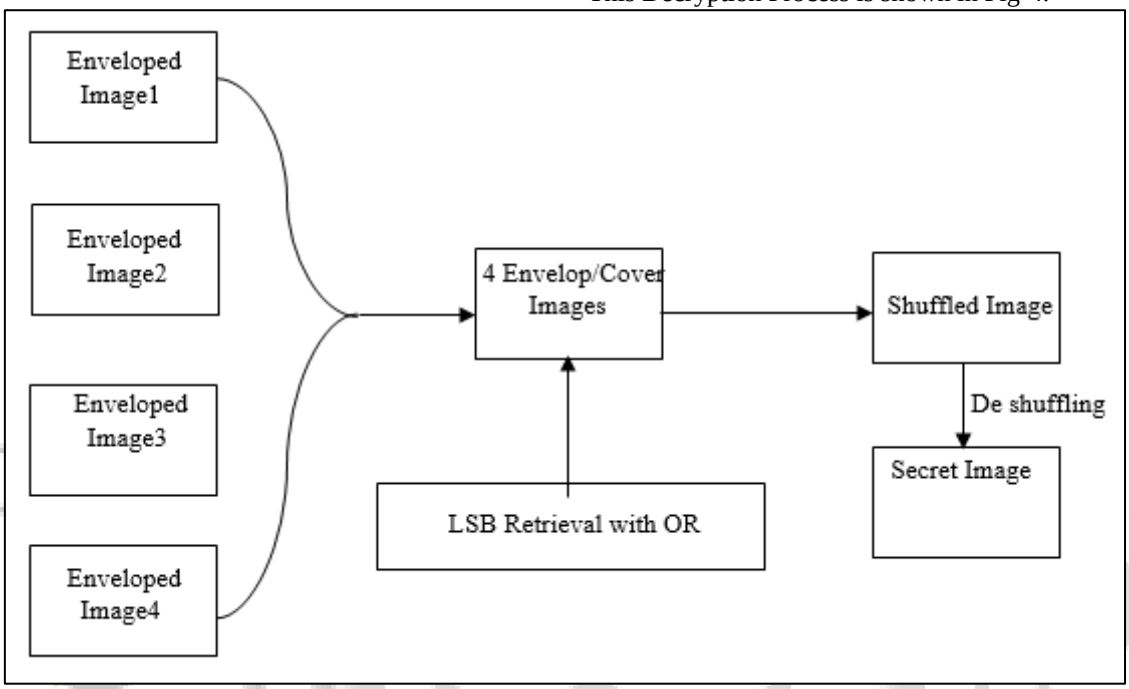

Fig. 4: Decryption Process

VII. EXPERIMENTAL RESULTS

A. Dividing into shares using Visual Cryptography:

Secret Image: Sample_1.jpg
Secret image to be sent by sender to the receiver on a network is:

Fig. 5: Secret Image to be sent

Number of Shares: 4
Image shares produced after applying shuffling and ARGB Algorithm are:
Alpha (Degree of Transparency) generated by extracting first 8 pixels of the Shuffled image.

Share 1: Alpha (Degree of transparency)

Red Component is generated by extracting next pixels of the Shuffled image.

Fig. 6.b
Share 2: Red Component

Green Component is generated by extracting next pixels of the Shuffled image.

Fig. 6.c
Share 3: Green Component

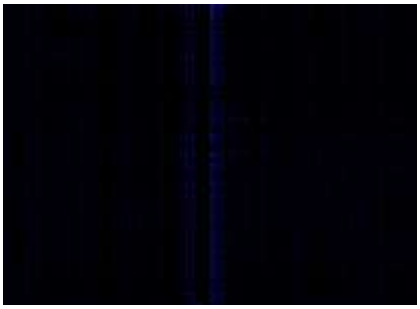

Fig. 6.d
Share 4: Blue Component

Blue Component is generated by extracting next pixels of the Shuffled image.

B. Digital Enveloping

Fig. 7.a Enveloping of (Share1.jpg OR Envelope_1.jpg)

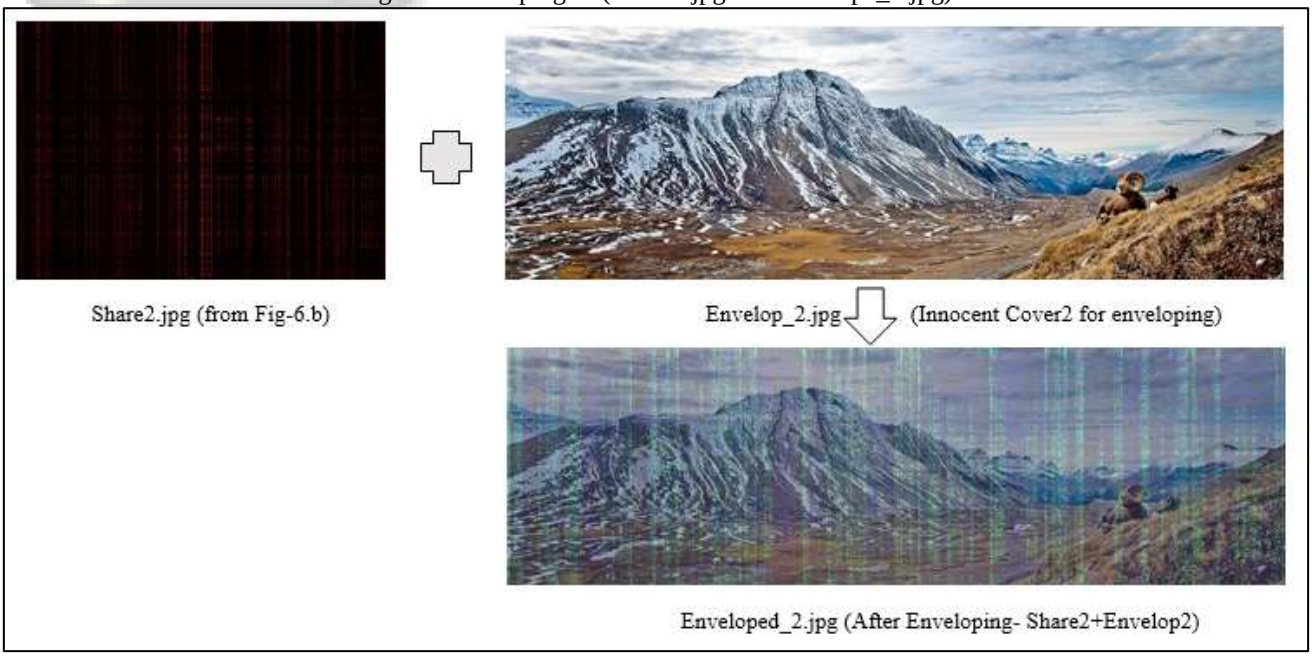

Fig. 7.b Enveloping of (Share2.jpg OR Envelope_2.jpg)

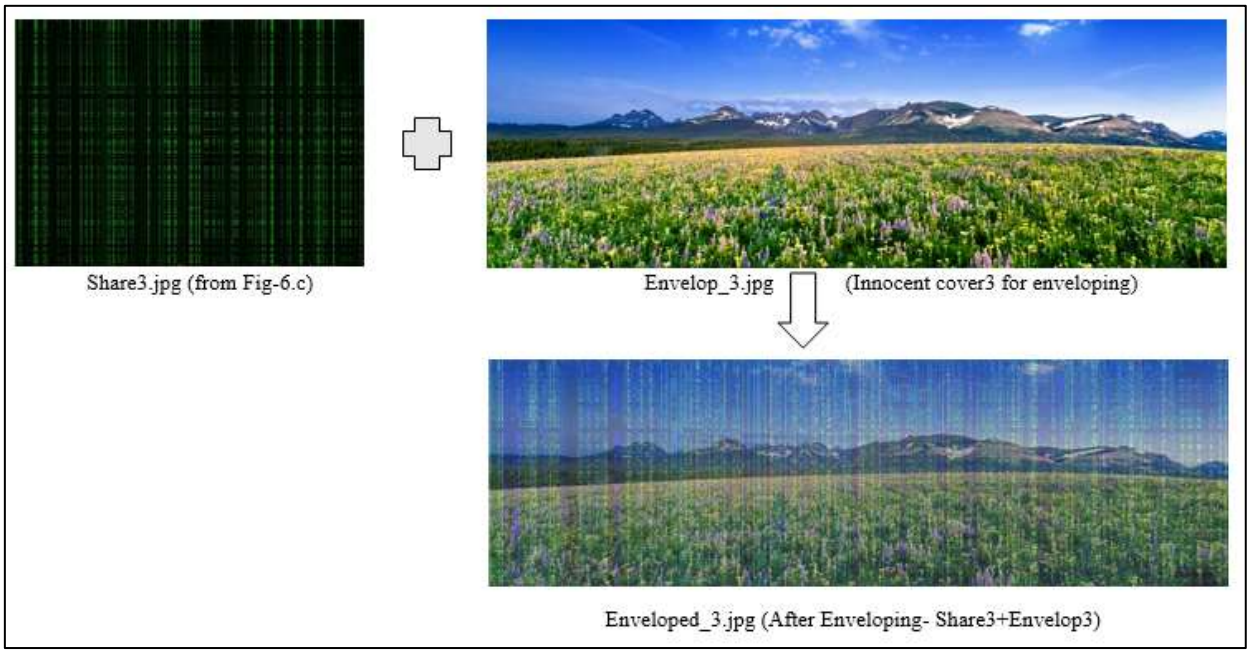

Fig. 7.c Enveloping of (Share3.jpg OR Envelope_3.jpg)

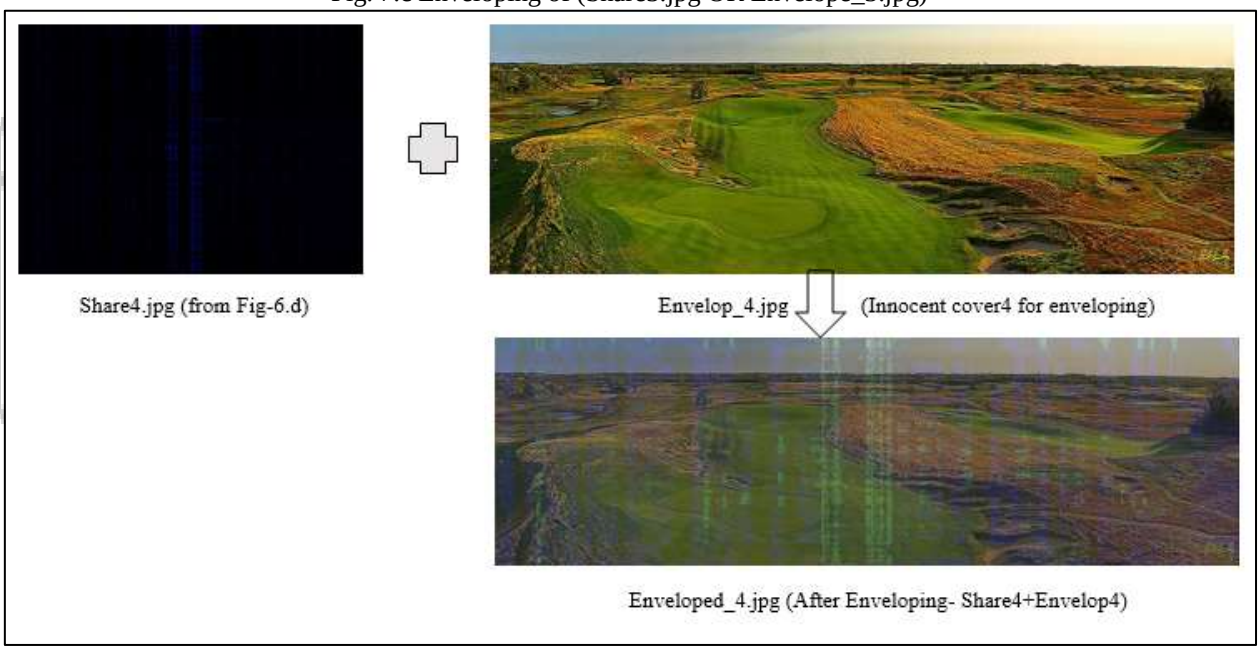

Fig. 7.d Enveloping of (Share4.jpg OR Envelope_4.jpg)

Fig-7 Enveloping Ru-ARGB shares using Digital Watermarking (Encryption technique) at Sender

C. Decryption Process:

Number of Enveloped images: 4
Name of the images: Enveloped_1.jpg, Enveloped_2.jpg, Enveloped_3.jpg, Enveloped_4.jpg
Enveloped_3.jpg (Taken from Fig-7.c)

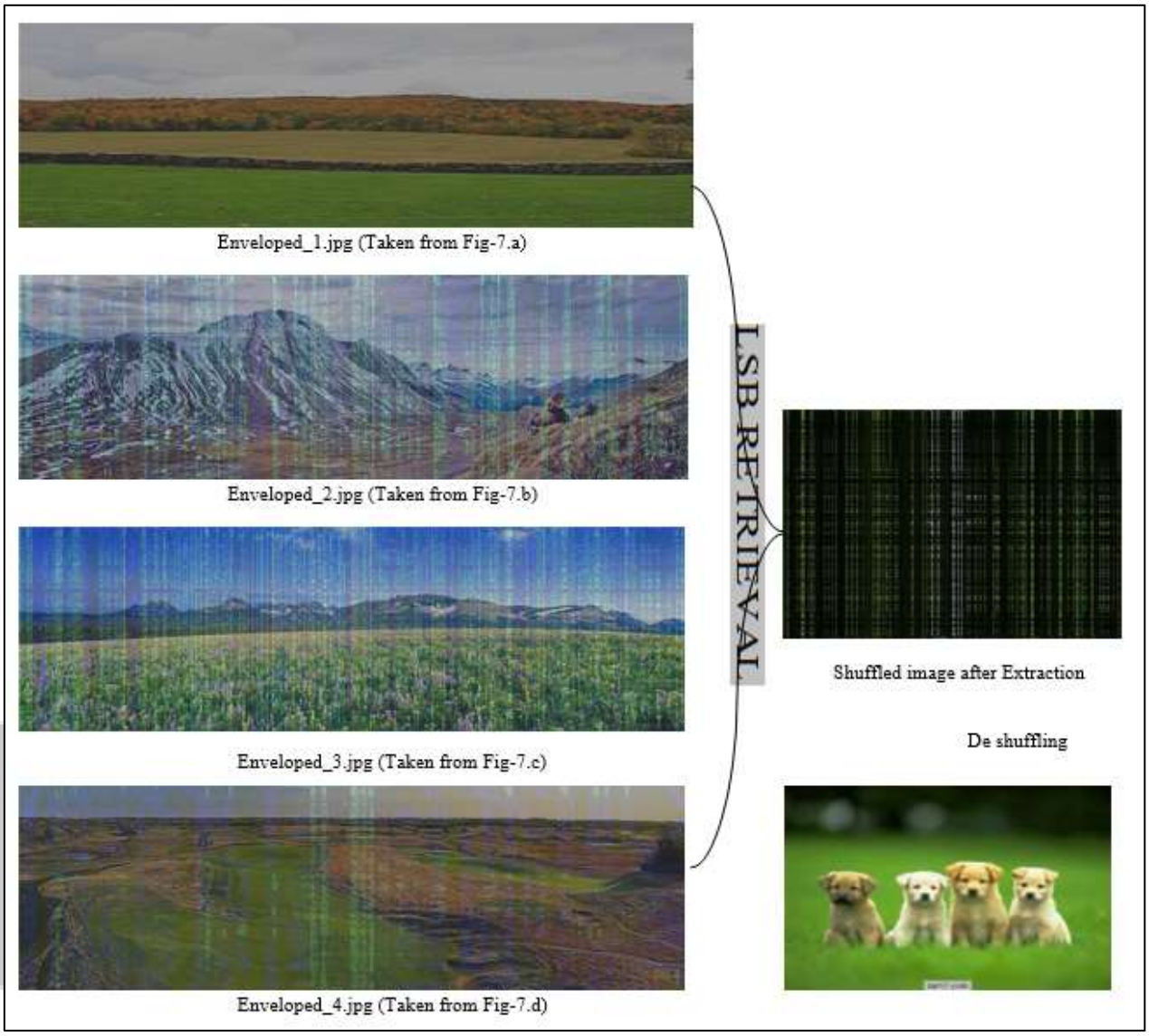

Fig. 8: Decryption Technique (Image retrieval) at Receiver

VIII. CONCLUSION

Decryption technique of visual cryptography algorithm is based on OR operation that is 0+1=1, 1+0=1, 1+1=1 and 0+0=0, so if any person gets all the shares; then he would be able to decrypt the image easily. In our current work, with new Ru-ARGB Algorithm for secret sharing of colored images along with enveloping technique that was earlier proposed where the image is firstly shuffled using Rubik's cube method (previously developed) then ARGB shares are extracted and then enveloped inside innocent covers of images or pictures using LSB replacement. Hence, this technique increases the security to visual cryptography technique from attack by the hacker as he is not able to retrieve the images without having all the 4 enveloped images and without knowing the random numbers used by sender during Rubik's cube shuffling. That is we here have tripled the security, first, by shuffling the original image and secondly, by creating the shares and thirdly, by enveloping them into other innocent images. The division of a shuffled image into 4 shares is done by simple extraction of ARGB components, which is a new technique devised. This technique needs no to very less mathematical calculation as compared to other existing algorithms for visual cryptography.

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