Secure Transmission of Data Using Mosaic Images With 3D Steganography

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Abstract- *The field of digital image processing plays an important role in education, security, health domain etc. Many researches have been carried out in order to hide data in some digital content but secure image transmission is still taken as one of concerned area. Steganography term is used nowadays which is the art and science to hide secret message by one side user as encryption also called hiding data in video and decrypting the secret message at other side user. Steganography means concealing the secret information in a file. In this paper a technique used is mosaicing which is used for secure data transmission over the network. We take video as input and divide it into frames and apply mosaicing technique. This paper takes 3D data as input. Also, terms such as Peak Signal to Noise Ratio (PSNR) and the Mean Square Error (MSE) is used with aim to keep MSE value low and PSNR high.*

Keywords- Secret message, data hiding, PNSR, RMSE, Video Steganography

I. INTRODUCTION

Steganography is the term which is obtained from Greek word: “Steganos” means “covered” and “graphia” means “writing” respectively. Today Internet and digital media are very popular, so to prevent secret information from unwanted people, there is requirement to transmit a data more securely. The aim of steganography is to encrypt messages inside other non-harmful messages in such a way that does not allow any third party to detect that there is a second sensitive secret message present. Steganography is a kind of art and science of hiding a secret message inside the other digital files as here we are using video file which are in avi format. The video steganography takes any frame of video file to encrypt the secret message. This steganography information hiding is done in such a way that it feels as if no information is hidden. Steganography provide security by obscurity. Video Steganography technique hide data along with presence of data. The data is hidden even from receiver but receiver can decode data as they know the key also called password that is used to encrypt the data. The video file can hide large quantity of information because it carries large number of frames and its storage capacity is also more.

Video file size is higher as compared with audio files and image files that can hide more data. The video steganography consists of two steps. The first step has encrypting secret data in the video file. The second step involves extraction of secret message from video file. This video steganography has more hiding capacity which is always an important consideration while working with steganography.

Another main advantage of encrypting data into video file is more security against third party attack or unintended receiver due to some complexity video structure as compared to other files like image and audio. After hiding information in multiple frames of a video file, these frames are combined together to make a stego video and this video look like a normal video. Authorized receiver performs the reverse process to decode the hidden message or data. Stego video will be broken into frames and retrieve the data.

A new secure image transmission technique is used in this paper, which automatically a secret image into a mosaic image which is of the same size. This mosaic image looks similar to any selected target image, this can be used as a cover of the secret image. It is extracted by dividing the secret image into fragments and converting their color characteristics that of corresponding blocks of the target image. Useful techniques are created to do the color transformation process so that the secret image may be recovered without any loss. The information required for recovering the secret image is embedded into the created mosaic image by a data hiding scheme using a key. Good experimental results exhibit the feasibility of the proposed method.

The paper is organized in following order. Section 1 gives introduction about what is steganography, what is video steganography and importance of it. Section 2 gives various literature survey done and the inference out of it. Section 3 gives the methodology which gives architecture of the proposed system and explanation of each module. Section 4 explains various results obtained from different experiments conducted. Section 5 gives conclusion of the paper.

II. LITERATURE SURVEY

In conventional methods secret text can be hidden into image which is called as Steganography. In this method only, text can be encrypted but not an image. Secret images can be hidden using watermarking principles. Watermarking is very simple process and it is weak that anyone can decrypt easily. Mosaic image technique is one of the streamlined techniques to hide the secret images. Along with a secret image, this methodology also needs another image which is said to be cover image. Many methods have been presented to create different types of mosaic images. Ancient mosaic, crystallization mosaic, puzzle image mosaic and photo-mosaic are four types of mosaic images. An image is fragmented into small tiles. Then these tiles are randomly embedded onto a cover image. For encryption embedding process should be performed in a particular order. A secret key is used for embedding the small tiles of secret image onto the cover image. LSB (least significant bit) replacement scheme is a technique mostly used for embedding process. LSB technique reduces the blur effect of encrypted mosaic image.

Authors [1] discussed about analysis of security in image transfer using network. Secret fragment visible mosaic image technique is proposed by the authors for making together the small tiles in the secret image to generate a target in the form of mosaic. They applied searching of tile images in a secret image for similar ones in order to fit the target blocks of a selected particular image.

Authors [2] used mosaic images which is composed of small fragments of an input secret image. They split the source image into number of small piece of images called as tiles. All the fragments of the secret image which can be seen clearly, they are tiny in size and are random in position that people cannot figure out what the source secret image looks like. Authors were maintaining the quality of the image as well.

Authors [3] main focus was to hide text data inside a video file and maintaining mean square error as low as possible and with maximum PSNR i.e. peak signal to noise ratio.

Authors [4] used video as the input and used mosaicing of the image frames. This provided secure image transmission over the network.

Authors [5] used different kinds of databases and gave results of RMSE and PSNR for proposed and conventional method for tile size of 8by8, 16by16 and 32by32 sizes.

Authors [6] took image quality with very little distortion in the image as the main factor. Authors used AES algorithm, and the LSB embedding with RGB color transformation steganography technique for mosaic image steganography.

Authors [7] introduced secure image transmission technique through video by using mosaic image creation method. Without any need of database, they took target image and using pixel color transformations visible mosaic image was created without any loss in the data.

Authors [8] proposed a solution for image-based data hiding technique to improve the capacity of hidden data. As there is limitation on how much information can be hidden into an image. To overcome the capacity problem, the data hiding is required and to provide high security, a separate key should be used for encryption and decryption was proposed by the author.

Authors [9] proposed that messages are encrypted with RSA and encrypted messages are compressed using Huffman code algorithm. The compressed encrypted messages are concealed using Least Significant Bit (LSB) algorithms. This research brings to light the concept of effectively combining steganography, asymmetric cryptographic algorithm and compression.

Authors [10] proposed secure picture transmission by using mosaic picture utilizing HSV shading algorithm by changing target picture, LSB techniques and reversible information concealing technique. To expand security, mosaic picture alongside scrambled data that is required to regain unique picture are covered up inside target picture by utilizing a reversible information concealing strategy.

Authors [11] proposed an efficient data hiding method for digital color images. Steganography technique is used in this system, in this process of hiding secret information into cover image is carried out.

Authors [12] proposed a secret image hiding scheme with new security features. A meaning mosaic image is created from the secret image and the selected target image. The fitting is done appropriately for generating the mosaic image. By using the proper color transformation to each pixel of secret image, we can achieve high visual resemblance to the selected target image. These similarities are checked using the quality metric i.e. RMSE value.

It was observed from the literature survey in above papers that only embedding a secret text message inside a video or image is not enough for video or image steganography. By using various steganography techniques such as RSA algorithm, AES, DES, Huffman Coding algorithm security data hiding can be achieved. By using mosaicing of the images is equally helpful in data encryption without loss of actual data. With in-depth study of the research papers it was found that there is need of mosaicing in not on image but in audio and video as the data in real day to day life is through audio, video and through chat messages is more. So, in order to maintain everybody's privacy this security technique is also important in every electronic device.

III. METHODOLOGY

The flow diagram of the proposed method is given in Fig. 1.

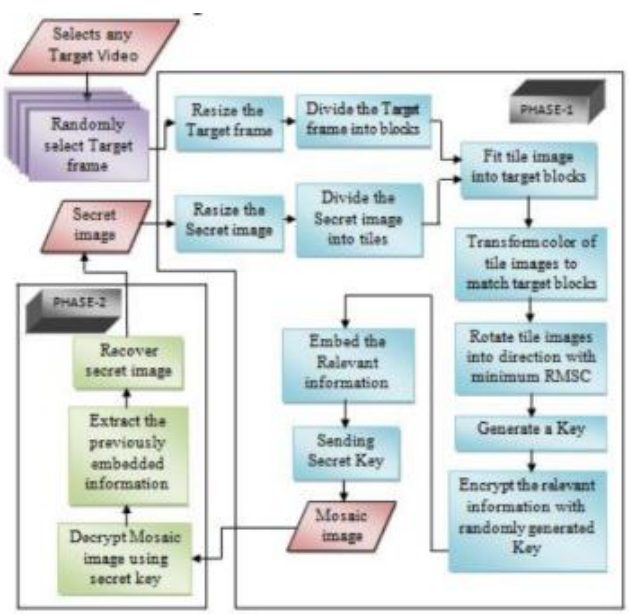


Fig 1. Proposed Architecture

Figure 1 Description: The proposed method is based on mosaic frame which includes two phases as shown in the following diagram: 1) Mosaic frames creation and 2) secret images recovery. The two phases of this method are: (A) In the first phase, a mosaic frame is obtained, consisting of fragments of an input secret image with color corrections according to a similarity criterion based on color variations. This phase includes six stages: 1) Resize target frame and secret image to pre-defined image size and divide it into blocks and tiles. 2) Fit tile images of the secret image into the target blocks of a preselected target frame. 3) Transformation of the color characteristic of each tile image in the secret image to that of the corresponding target block in the target frame. 4) Rotation of each tile image into a direction with the minimum RMSE value with respect to its corresponding target block. 5) Generate a random key and encrypt the relevant information with the key. 6) Embed relevant information into the mosaic frame for future recovery of the secret image. (B) In the second phase, the secret image and embedded information is extracted in nearly lossless manner from the generated mosaic frame. This phase of recovering secret image includes four stages: 1) Decrypt mosaic frame using the secret key. 2) Extraction of the embedded information for recovery of secret image from the mosaic frame. 3) Recovery of the secret image from the mosaic frame using the extracted information. 4) Measurement of performance of the recovered original secret image.

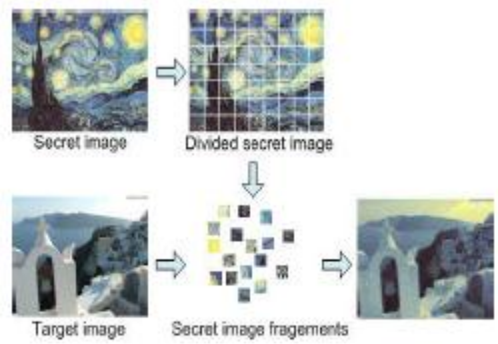


Fig. 2 Flow diagram for creation of secret fragment visible mosaic image

A. Image similarity and target image selection

The first step of the project is picking up the most similar image for the source image. Selecting of target image is an important process, for generating the mosaic for source image. In this, an efficient image similarity algorithm is used for comparison. Input for application of image similarity is the images and output of this is a percentage value for both secret and the target image. The value return from the algorithm determines how the similarity is. The input image is given by the user only. The second step is to split source image.

Split the source image into number of small pieces of image called as tiles. The split images or tiles are placed with the target image for mosaic creation. Source splitting is directly proportional to the output quality. Source splitting size is high then output quality is very low, and if split size is low then the quality of output is high. For example, split source image into 8x8 matrices, finding the apt or correct position for placing the image in target is difficult. So that the quality is totally dropped and the target image will get disappeared in this case. If the image is split into 20x20 matrixes, quality is high. Splitting of text image is same as that of the colored image. But the output quality is totally different from the quality of colored image. The image is split and ready for the further process of creating the mosaic.

The purpose of going to this fixed square block is that, the above methods are perfectly suitable for generating the mosaic but not efficient retrieving process. The simplest range partition consists of the fixed number of square blocks. Fixed block partitions, completely neglect the image content. As a consequence, it leads to severe blocking artifacts and a deteriorating image quality. The coding concepts try to abandon fixed block partition in favor of a content related picture representation. The usual solution is to introduce an adaptive partition with large blocks in low detail regions and small blocks where there are significant details.

Let Z_t be the size of each fragment, N number of tiles can be obtained, W_s be the width of secret image and H_s be the height of secret image.

B. Mosaic Generation

Before the generation of mosaic image, split target image into very small size. Here we use separate splitting algorithm for splitting of the target image and the size of the target image and tile is different, when the target image size is large and it can't find the perfect match for tile. If it is small in size it is able to find the perfect match for each tile. The splitting of target image is used for finding the best fit for the tiles in the target image. The main problem behind this is there some replication of each image of tile and size of output image is too large compare to input image. Comparison of tile with all the split target images is done to get position of perfect match. After the finding of the best fit process, a blank image is created.

The output image is formed based on the position. Find the position of target image and place the tile into the blank black image. Concatenated output image will look same as like that of target image. Here the placing will not overlap another image. Output image size is based on how the placing of the tile image occurs. According to this the tile images will not overlap with each other. The output image is having little quality drop. If the tile image size is too small then the computation time is high. The place of fitting a tile image is represented by a vertex of the graph, and the action of fitting the tile image into a target block is represented by an edge of the graph with its weight taken as similarity value between the pixels' colors of the tile image and those of the target block. The above process is for the text, and here the target image is fully filled with tile images and background image is disappeared fully. The process of fitting a tile image is represented by a vertex of the graph, and the method of fitting the tile image into a target block is represented by edge of the graph with its weight taken to be the similarity value between the pixel colors of the tile image and those of the target block. File sequence is the information file that consists of data of where the tile is placed in target image. While in creation of mosaic process best fit of particular tile is taken and stored in text file for future use. Hence the mosaic image doesn't contain any information of stored image in it and it has only the image of tile. For construction of the final output are need a position file to make the output as input. For this purpose, we use the merging information file. This contains where were the tile images will be stored and name of the image is stored on particular position which is available in the file. Embedding file consist of merging information. This file would be combined with output image and will be sent to sender without any loss. Security transaction will be held between the sender and the receiver. Without a decryption algorithm, the others can't read the file or they can't separate the file. A highly secure method is used for embedding both files. Repetitively select a block in random which is not selected till yet by using the random number generator with the secret key as the seed, and embed bits of into all the pixels of by the lossless LSB replacement scheme proposed until all the bits in it are exhausted. A different technology is used for hiding the sequence file into mosaic image. The created mosaic image is converted to string for hiding the sequence information file. After having the sequence file, it separates the string by order for information hiding. Here each and every line in the file is added to the converted string image file. The order is after every 25 characters of the line of the fitting sequence file added. This will continue till the entire line is added in the fitting sequence file.

C. Reconstruction of secret image

This is the final step of the project; here the output which is obtained is similar as the input in sender side. Before going to reconstructing first extraction of the image file and the text file is done. After that we do the creation process in reverse manner. There are two steps which we follow. The retrieval process is based on width and height of tile image in mosaic creation process. The mosaic image is split with duplicates which belong to size of tile and is named as position in the file.

In text file the position is not in the same order (i.e.) here the position file has the name corresponding to the image. Keep on selecting random unselected block other than the first block by using the random number generator with the secret key as the seed, extract bits from all the pixels of using a reverse version of the lossless LSB replacement scheme and concatenate them sequentially, until all the bits of are extracted. Transform every bit of into an integer which specifies the index of a tile image in the original secret image (to be composed), resulting in the secret recovery sequence.

After getting the tile images from position file there is no replication of images because the image is repeated then the name would be same and it will overwrite the previous image.

IV. ALGORITHMS OF THE PROPOSED

The detailed algorithms for creation of mosaic frames of selected frames of a target video and secret images recovery are explained in Algorithms 1 and 2.

4.1 Algorithm 1: Take 3D video, divide into frames, create mosaic images

Input: a secret images S, a target video V, & secret key K

Output: Video with few mosaic frames F.

Steps:

Step 1: Selection of few random frames from target video V.

1. Depending upon the number of secret images we want to transmit to the receiver, based on its frames are selected from the target video, randomly. Then processing is done on one frame from targetvideo and secret image want to transmit.

Step 2: Fitting blocks of secret image into target frame Blocks

1. Change the size of target frame Tand secret image S.
2. Make them identical. (We are resizing both to 768*1024).
3. Theinput secret image is divided into fragments called tile images.
4. Aframe from target is selected arbitrarily, and this too divided into rectangular fragments called target blocks. (We are taking each block/tile of size 8*8)
5. Compute the means and the standard deviations (SD) of each tile images and target block, in each of the three color channels R, G, and B by the following formulas:

$$\mu_c = \frac{1}{n}\sum_{i=1}^{n} c \text{ , } \mu'_c = \frac{1}{n}\sum_{i=1}^{n} c' \quad (1)$$

$$\sigma_c = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(c-\mu c)^2} \text{ ,}$$

$$\sigma'_c = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(c'-\mu c')^2} \quad (2)$$

Note: Type this equation
6. In which ci and ci denote the C-channel values of pixels pi and pi', respectively, with c= r, g, or band C= R, G, or B.
7. Compute the average standard deviation.
8. The tile images and target blocks are arranged in ascending order of computed average standard deviation value.
9. Obtained secret tile images are then fit into similar blocks of the target frame, called target blocks, according to the similarity criterion based on color variations.
10. Mosaic frame is created.

Step 3: Transforming color characteristics of tiles of secret image to the similar blocks of target frame

10. Mean and standard deviation is calculated for each mapping.
11. Next, the color characteristic of each tile of secret image is transformed to be that of the corresponding target block in the target frame.

Compute new color values (ri", gi", bi") for each pi in Z (tile image) by,

$$c''_i = q_c(c_i - \mu_c) + \mu'_c \quad (3)$$

In which qc= σc /σc is the standard deviation quotient and c= r, g, or b.
12. If ci’’ > 255 or if ci" < 0, then change to be 255 or 0.

Step 4: Rotating secret image tiles

For further improvement on the color similarity,

13. Compute the RMSE values
14. Rotate tile images into one of the four directions, 0-degree, 90-degree, 180 degree or 270 degree, with the minimum RMSE value with respect to target blocks.
Here, verifies the new color mean and variance of the resulting tile image Z' are equal to those of B (target block), respectively. If it is equal then mosaic frame is looks similar to that of target frame.

Step 5: Generate a bit stream

15. For each tile image in F, a bit stream M is constructed for recovering Z
i. Rotation angle θ°
ii. Means and
iii. Standard deviation quotients of all three color channels.
A three-component bit stream of the form,
M = r1r2m1m2...m48q1q2...q21 (4)
16. Generate a total bit stream Mt by concatenating the bit streams M of all Z in raster-scan order.

Step 6: Generate a random key and embed the secret image using the key K.

17. Encryption of the generated a bit stream Mt , with randomly generated Key K called Mt'.

Step 7: Embed information for recovery purpose.

18. Embed the information Mt' into obtained mosaic frame F. (Using DWT technique)
19. The result is called a Mosaic frame which looks like the target frame.

4.2 Algorithm 2: Recovery of Secret images

Input: Video with few mosaic frames F, secret key

Output: the secret images S.

Steps: The second phase involves, the Secret Image Recovery, The embedded information we have to extract to recover nearly lossless secret images from the generated video.
Now inverse procedure is done in mosaic frames creation.

Step 1: Extracting the embedded information

1. Extraction of bit steam Mt by using Inverse discrete cosine transform (Inverse DWT).
2. Decrypt the bit stream Mt' by K into Mt.
3. Decompose Mt into n bit streams i,e, M1 through Mn.
4. M is decoded for each tile image to obtain the data items. (Rotation angle is θ°, Mean and SD quotients of all three color channels)

Step 2: Recovery of secret image

5. Tile is rotated in the reverse direction and fit the resulting block content into T to form an initial tile image.
6. Use the extraction means and related standard deviation quotients.
7. Compute the original color values (ri, gi, bi) of pi from the new ones (ri'', gi'', bi''), by using the formula which is inverse form of previous one,

$$c_i = 1/q_c\,(c_i'' - \mu_c') + \mu_c \quad (5)$$

8. All the final tile images are combined to form the desired secret image S.

Step 3: Recovery of secret images

9. The same process of recovery is used for all selected frame numbers of a video to get respective original secret images from it.

Dataset and formats

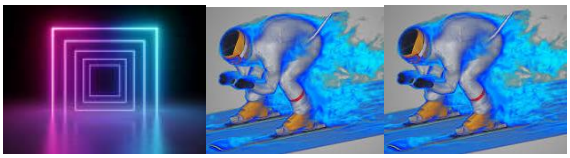
Table 1 Image and Video- quality, format, size of video

Quality	3D Video	144p, 240p, 360p, 480p, 720p HD
	3D Image	4:3 aspect ratio resolutions: 640×480, 800×600, 960×720, 1024×768, 1280×960, 1400×1050, 1440×1080, 1600×1200, 1856×1392, 1920×1440, and 2048×1536. 16:10 aspect ratio resolutions: 1280×800, 1440×900, 1680×1050, 1920×1200 and 2560×1600. 16:9aspect ratio resolutions: 1024×576, 1152×648, 1280×720 (HD), 1366×768, 1600×900, 1920×1080 (FHD), 2560×1440, 3840×2160 (4K), and 7680 x 4320 (8K).
Format *	3D Video	For Windows 7 or higher MPEG-4, including H.264 encoded video (.mp4, .m4v) Apple QuickTime Movie (.mov)
	3D Image	BMP, GIF, HDF, JPEG, PCX, PNG, TIFF, XWD
Size	3D Video	1Kb-5Mb
	3D Image	1Kb-5Mb

*Supported by MATLAB 2018a

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

5.1 Experimental results on 3D images



(a) (b) (c)

Fig. 3. Result yielded by the proposed method. (a) Secret image. (b) Target image. (c) Mosaic image created from (a) and (b) by the proposed method.

(a) (b)

(c) (d)

(e) (f)

(g) (h)

(i) (j)

Fig. 4: (a) Target Image (800*600) (b) Secret Image (400*260) (c), (d), (e), (f) are Patch 1, Patch 2, Patch 3, Patch 4 of secret image. (g) Encrypted Mosaic image which is occurred using randomly generated secret key. (h) Recovered secret image using a correct key with RMSE = 2.1839 with respect to secret image.

(b), (e), (f) Mosaic images created with different tile image sizes: 16 × 16, 32 × 32. (i), (j) Recovered secret image using a correct key with tile image sizes 16 × 16, 32 × 32 with respect to secret image (b)

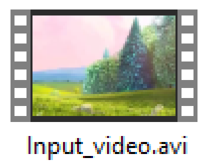
(a) (b) (c)

(d) (e) (f)

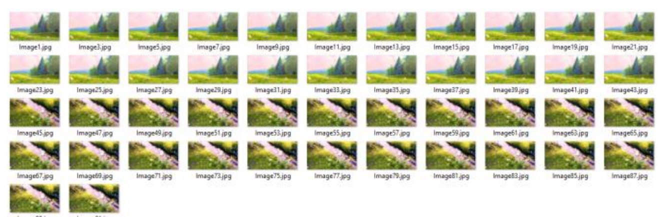
(g) (h)

Fig. 5 Two other experimental results of mosaic image creation and secret image recovery: (a) and (d) Target images (400*600, 274*406). (b) and (e) Secret images (385*528, 240*320). (c) and (f) Mosaic images created from (a) and (b)and (d) and (e)respectively, with tile size 8 × 8. (g) and (h) Recovered secret images formed from (c) and (f), respectively.

5.2 Dividing 3D video into frames

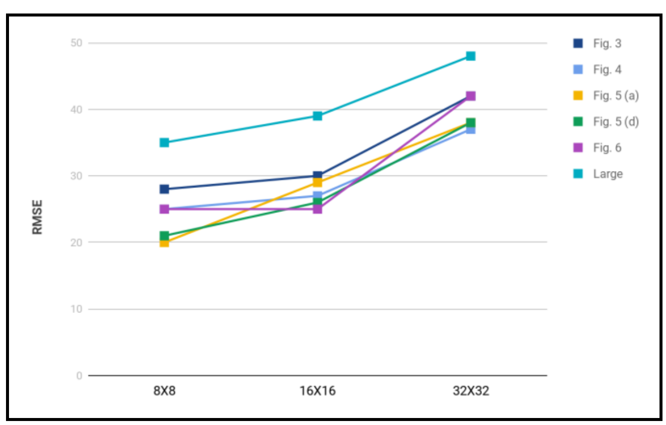


(a) Input

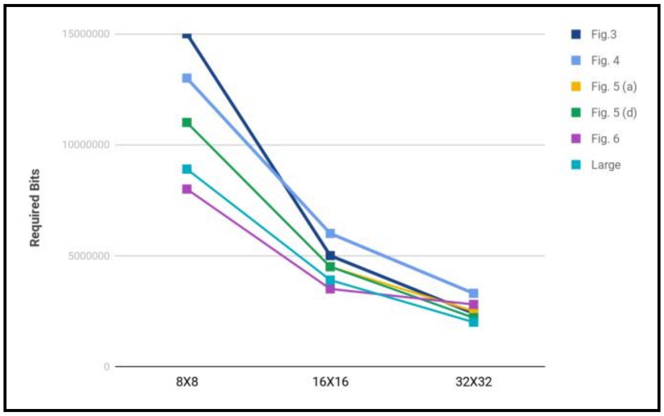


(b) Frames from video

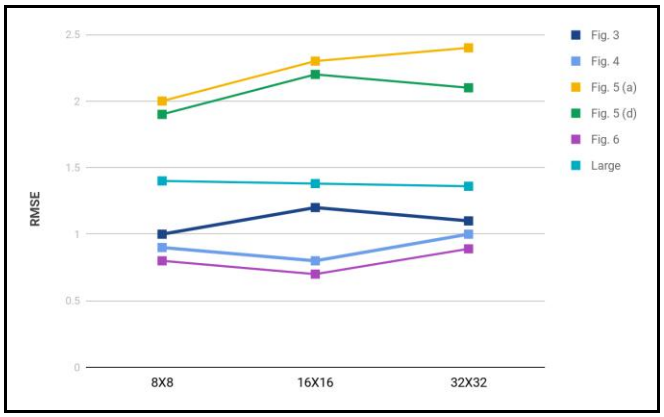
Fig. 6. Input video and frames from the video



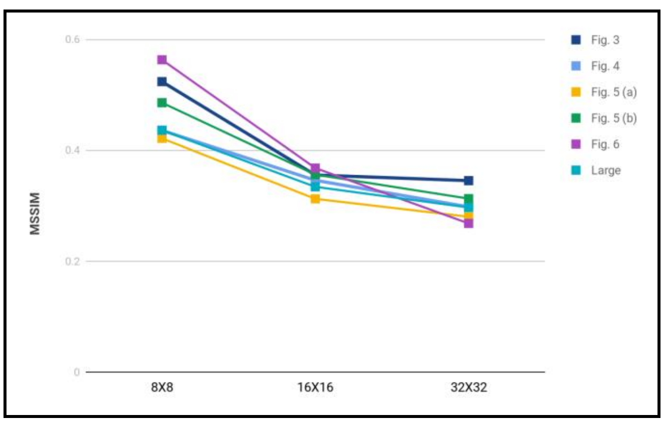
(a)



(b)



(c)



(d)

Fig. 7. Plots of trend of various parameters versus different tile image sizes (8 × 8, 16 × 16, 32 × 32) with input secret images shown previously and coming from a large dataset. (a) RMSE values of created mosaic images with respect to target images. (b) Numbers of required bits embedded for recovering secret images. (c) RMSE values of recovered secret images with respect to original ones. (d) MSSIM values of created mosaic images with respect to target images.

We have plotted the graphs depicting RMSE (Root mean square error) and MSSIM (Metric of mean structural similarity index) with respect to the 8X8, 16X16, 32X32 tile size. Figure 7(a) it is observed that the rmse values are increasing as the tile size changes. The best results are shown for 8X8 tile size whose error rate is low as compared with 32X32 tile size. As compared [13] we obtained less error by using 3D images not only for 8X8 but also for 16X16, 32X32 tile size. But error still persist for which more processing is required. In figure 7 (b) it is observed that the required bits gets reduced when tile size increases. In figure 7(c), it is observed that 3D images taken are providing more better results when mosaic image is created and when recovered secret image is extracted. In figure 7 (d), it is observed that the mean structural similarity index gets reduced as the tile sizes increase this is because the data becomes more granular and the pixel value differs by some range.

VI. CONCLUSION

The new method used for covert communication of secret images. The mosaic image is composed of small fragments of an input secret image and through all the fragments of the secret image can be seen clearly, they are so tiny in size and so random in position that people cannot figure out what the secret image looks like. A new algorithm is also proposed for searching the tile images in a secret image for finding the most similar ones to fit the target blocks of a selected target image more efficiently. In future, where instead of one secret image we can hide multiple secret images in digital video and the resulted video will look like selected target video.

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