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PIXEL INTEGRATION TECHNIQUE FOR MULTI-IMAGE AND VIDEO COMPRESSION FOR DATA SECURITY

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Abstract:

This paper approaches security application for digital image and video processing. The techniques involve JPEG image and H.264 video compression, Simon cryptography algorithm using Verilog HDL followed by Image Interleaving, and last by Pixel Integration to generate integrated multi-image and video. The user can choose any of the image/ videos among the several integrated inputs displayed with a unique security. With the secure key assigned for each input, the original image or video is displayed by decrypting it from multiple image and videos.

Key Words: Simon Cryptography, Encryption;, Image Processing; Pixel Integration; Compression; Image Interleaving

1. Introduction:

With the recent trends in digital processing and multimedia applications, security is an important issue in image storage and communication. Encryption algorithms play a major role for security. An image can be encrypted to convert the original image to other image format which changes the property of the image and makes difficult to identify as the original image. The main purpose for encrypting the image is to keep confidential among users, in other words, it is essential to secure in order to avoid the piracy or terrorism misleading the contents of the image. In addition, benefit, the encryption algorithm finds applications in secure storage, transmission and reliability of digital images which is necessary in the area of military, communications, medical imaging systems and confidential video conferencing, etc. [1].

In communication network [2]- [4], data exchange presents certain risks factor, which requires the existence of appropriate security measures. For example, the images are transmitted and can be copied or saved during their transmission without loss of image quality. During an exchange, images can be hacked in time of digital information storage and reproduce illegally. It is, therefore, necessary to develop software for effective protection of transferred data against arbitrary interference. Data encryption with image merging is very often the only effective way to meet these requirements.

Image information loss and its recovery is still one of the biggest concern in digital communication networks. Interleaving schemes are important mechanism for reducing the effect of network error on image transmission. Interleaving schemes spatially de-correlate neighboring image blocks by putting them into packets that are far distant apart from each other in the transmission sequence. Most of the existing schemes do not offer the same performance in the case of bursty packet losses as it does on random packet losses.

Advanced digital technologies and growth of computer networks, a huge amount of digital data is being transferred to various types of networks. A large part digital data of this information is either private or confidential. Most of the security algorithms specifically designed to encrypt digital data are proposed in the mid-1990s. Encrypt and decrypt of images can be done by different encryption algorithms. There are two groups of cryptography] image encryption algorithms: (a) Non-chaos selective methods and (b) Chaos-based [5], [6] selective or non-selective methods. It can be admitted, no particular encryption algorithm which satisfies all image type requirements [6]. A good encryption algorithm should be strong against all types of attacks. Different security algorithms [7] have been used to provide the required protection and many encryption algorithms have been proposed to enhance the image security.

The process of image encryption is to convert an image to another format that is hard to understand. The reverse process is on another hand that retrieves original image is by decryption. The transformation of information in a secure manner is based on encryption.

In this paper we presented, image integration method to enhance security, which is considered as complex process the information is two-dimensional, due to its size and redundant in nature. In our proposed method, nine input images with an image size of m*m pixels are taken for integration with a block size of 4*4 is applied to test the performance. The first compression is applied then interleaving with pixel-based integration and the Simon encryption algorithm is used on the number of images to generate encrypted image decryption process is done by selection of the key. The entropy, compression ratio and correlation of the encrypted images are calculated and evaluated.

To increase the image entropy value and to decrease the high correlation among pixels, and thus an improved security level of the encrypted images, we propose a process based on interleaving the columns and rows of the image using the pixel-based technique for image merging. The interleaving process will be used to split (divide) the original image into several blocks that are then shifted through the columns and the rows within the image before the encryption process starts. The image which generated is then processed into the Simon image encryption algorithm.

2. Related Work:

Ahmed Bashir Abugharsa et al. [8] proposed an encryption algorithm based on the rotation of the faces of a Magic Cube. This process involves dividing the original image into six sub-images and further these sub-images are divided into small blocks and attached to the faces of magic cubes.

Mitra A et al. [9] have proposed image encryption using a combination of different permutation techniques.

Sinha A et al. [10] proposed a new technique for image encryption and decryption in which the image is broken up into bit planes. A new method to jigsaw the image has been proposed in which every block is trans-located to a different location of the three-dimensional cube. This increases the robustness of the encryption system by several orders of magnitude.

Zhi-Hong Guan et al. [11] proposed encryption scheme based on position shuffling and changing the image pixel grey values are combined to confuse the relationship between the plain-image and the cipher-image.

Rogelio Hasimoto Beltran et al. [12] proposed interleaving scheme where the de-correlation process is applied to co-efficient or pixel level in the compressed domain.

Frank Dellaert et al. [13] proposed image-based tracking algorithm, which relies on the selective integration of a small subset of pixels that contain a lot of information about the state variables to be estimated.

3. Proposed Work:

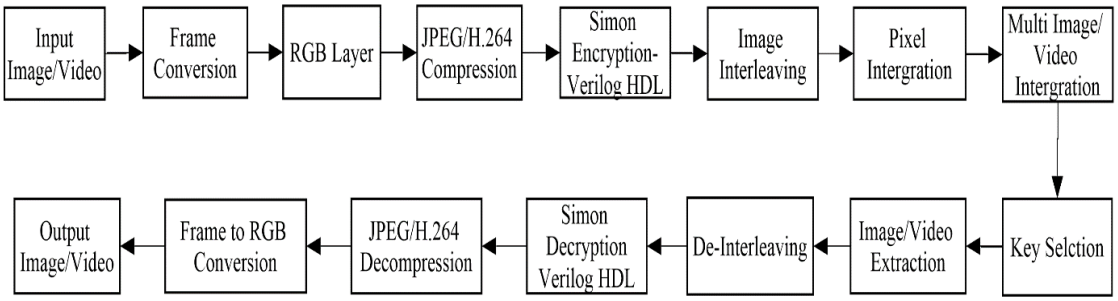


Figure 3: Block Diagram of Proposed System

H.264 Compression:H.264 [14] defines a method of coding video that can give better performance than any of the preceding standards. It compresses video into a smaller space, which means that a compressed video clip takes up less storage space compared to older codecs and less transmission bandwidth. Generally, standard definition is available in the DVD-video format, capable of supporting only a single movie whereas High definition videos with H.264 compression, to record hours of video on a memory card and to deliver video streaming over in online. First, the given input videos are converted into frames in RGB format.JPEG compression is applied to all image layers individually for better performance. H.264 video compression technique consists of 4 functional stages.

- ✓ Converting the video into frames.
- ✓ RGB image format.
- ✓ Using discrete cosine transform(DCT) transformation of a blocked representation of RGB data to frequency domain representation
- ✓ Quantization of the blocked frequency domain data per a user-defined quality factor

JPEG Compression:JPEG [15] image frame consists of three 2-D patterns of pixels, one for luminance and two for chrominance. Because high-frequency color information is less sensitive to the human eye, JPEG calls for the coding of chrominance (color) information at a reduced resolution compared to the luminance (brightness) information.The input images are layered as RGB.JPEG compression is applied to all image layers individually for better performance. The JPEG image compression technique consists of 5 functional stages.

- ✓ RGB image is converted to YCC color space,
- ✓ A spatial subsampling of the chrominance channels in YCC space,
- ✓ Using discrete cosine transform (DCT) transformation of a blocked representation of the YCC spatial image data to a frequency domain representation.
- ✓ Quantization of the blocked frequency domain data per a user-defined quality factor, and finally,
- ✓ Huffman coding for storage of frequency domain

Simon Algorithm:SIMON [16] algorithm that is flexible enough to provide excellent performance and highly-optimized block ciphers, in both hardware and software environments. In addition, each SIMON has been optimized for performance in both hardware software devices and this algorithm has a range of block and key sizes. The Simon block cipher with an n-bit word (and hence a 2n-bit block) is denoted SIMON2n, where n is required to be 16, 24, 32, 48, or 64. SIMON2n with an m-word (mn-bit) key will be referred to as SIMON2n/mnTable.1 lists the different block and key sizes, in bits, for SIMON Algorithm.

Table 1: SIMON Block and Key Size

Block Size	Key Sizes
32	64
48	72,96
64	96,128
96	96,144
128	128,192,256

Simon Algorithm Defnition:

n = word size (16, 24, 32, 48, or 64)
m = number of key words (must be 4 if n = 16,
3 or 4 if n = 24 or 32,
2 or 3 if n = 48,
2, 3, or 4 if n = 64)
z= [11111010001001010110000111001101111101000100101011000011100110,
10001110111110010011000010110101000111011111001001100001011010,
10101111011100000011010010011000101000010001111110010110110011,
11011011101011000110010111100000010010001010011100110100001111,
11010001111001101011011000100000010111000011001010010011101111]
(T, j) = (32,0) if n = 16
= (36,0) or (36,1) if n = 24, m = 3 or 4
= (42,2) or (44,3) if n = 32, m = 3 or 4
= (52,2) or (54,3) if n = 48, m = 2 or 3
= (68,2), (69,3), or (72,4) if n = 64, m = 2, 3, or 4
x,y = plaintext words
k[m-1] …k[0] = key words
---------- key expansion ----------
for i = m.. T-1
tmp ← S−3 k[i-1]
if (m = 4) tmp ← tmp⊕ k[i-3]
tmp ← tmp⊕ S−1tmp
k[i] ← ~k[i-m]⊕ tmp ⊕ z[j][(i-m) mod 62]⊕3
end for
---------- encryption ----------
for i = 0..T-1
tmp ← x
x ← y ⊕ (Sx & S8x) ⊕ S2x ⊕ k[i]

Co-Simulation Simion Algorithm: Figure 4 shows the system architecture being developed for Simon encryption algorithm. MATLAB is used as the software platform and ALTERA-ModelSim 6.3g is used as the hardware platform. QUARTUS II (8.1 web edition) design flow is used to simulate and verify the functionality of HDL code. Xilinx ISE 14.3 is used to understand the device and logic utilization, memory design, and test control of the architecture developed

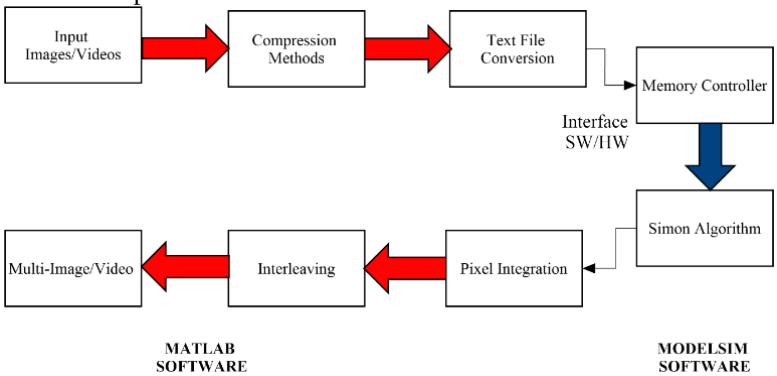


Figure 4: System Architecture-Hardware/ Software co-simulation platform

The input videos which produces image frames of RGB pixels are applied with compression algorithm first. The images for the database are captured using a Canon camera. The temporal resolution requirements of the application must be considered. The size of the image frame is 640 × 480 pixels. To maintain the resolution and decrease redundancy, the frames are resized to 64 × 64 pixels. Once the input images are obtained, they are converted to grayscale values within a range of 0–255. The database obtained is read on the computer using MATLAB. The software converts the entire database image frames into text files. These files are stored in the memory of the ALTERA-ModelSim using the command "$readmemh." The ALTERA-ModelSim is being called from the MATLAB using HDLDAEMON as shown in Figure 5 HDLDAEMON controls the server that supports interactions with HDL simulators.

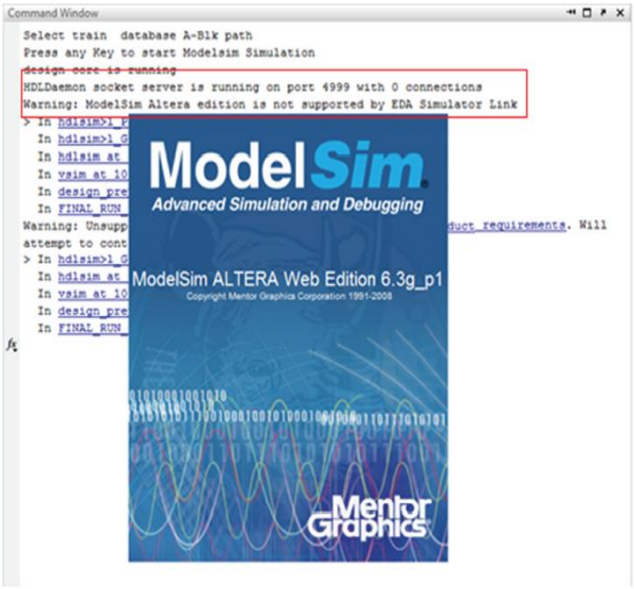


Figure 5: HDLDAEMON as the interface between MATLAB and ALTERA-Model Sim

Text File Conversion: The images are converted into text files which contain the hexadecimal value of the pixels. Each image is configured and stored with the appropriate configuration ID. The text file of each image contains 4096 values to be read and stored in the memory of the ALTERA-ModelSim. The figure displays the pixel values.

```
0001 0001 0001 0001 0001 0001 0002 0001 0000 0001
0002 0002 0002 0001 0001 0001 0001 0002 0002 0001
0002 0002 0001 0002 0002 0002 0002 0002 0002 0002
0002 0002 0001 0002 0002 0001 0002 0002 0001 0001
0001 0002 0002 0001 0002 0002 0002 0002 0002 0003
0002 0002 0003 0004 0003 0002 0002 0002 0003 0003
0002 0003 0003 0002 0003 0003 0005 0004 0002 0001
00CF 00D3 00DF 00E3 00E2 00E0 00D7 00CB 00DC 00DE
00B3 00C4 00C5 00C4 00C8 00CE 00D6 00DA 00DB 00DE
00D9 00D7 00D1 00C7 00C0 00C2 00C1 00BA 00BC 00B9
0004 0003 0004 0003 0067 00C8 00CE 00B0 00A8 00B0
00C6 00D1 00CB 00C2 00B5 009D 00A8 00B3 00AD 0095
00A4 008A 00A5 00A5 00A6 00B8 00CF 00D8 00DD 00DA
00AE 00AD 00A6 009C 0098 008E 0088 0081 007A 0069
0002 0002 0002 0002 0002 0001 0001 0002 0002 0001
0003 0003 0003 0003 0003 0004 0004 0004 0005 0004
0005 0006 0006 0005 0006 0006 0007 0007 0004 0005
0008 0008 0009 0007 0006 0005 0004 0004 0005 0004
0004 0002 0003 0004 0002 0002 0002 0003 0002 0002
0003 0003 0004 0003 0003 0003 0003 0002 0003 0005
```

Figure 6: Pixel Values in Memory Location

Image Interleaving: Encrypted RGB frames are divided small blocks [17] [18] as 4*4, for better security the block size should be small. These sub-block images are interleaved column-wise. The number of sub-block pixel values in each block is fixed for a given interleaver. The interleaver operation on a set of image pixel values is independent of its operation on all other sets of symbols Applying block based interleaving by selecting the initial location randomly.

A1	A2	B1	B2
A3	A4	B3	B4
C1	C2	D1	D2
C3	C4	D3	D4

(a)

A1	C1	A2	C2
D1	B1	D2	B2
A3	C3	A4	C4
D3	B3	D4	B4

(b)

Figure 7: (a)Block interleaving (b) Proposed method block interleaved sequence

In 2D type of interleaves, the idea of extending from 1D prime interleaved into two dimensional is utilized. The concept of proposed 2D prime block based interleaved is followed: Consider the two-dimensional interleaving of n_r by n_c matrix. Firstly, we divide the interleaving scheme into column-wise interleaving and row-wise interleaving. Secondly, we assign the value of seed as column-wise seed and row-wise seed to column-wise interleaver and row-wise respectively. Therefore, the location of bits after interleaving will be as follows.

Row-wise	**Column-wise**
1-1	1-1
$2-(1+p_{row}) \bmod n_r$	$2-(1+p_{col}) \bmod n_c$
$3-(1+2p_{row}) \bmod n_r$	$3-(1+2p_{col}) \bmod n_c$
$n_r-(1+(n_r-1)\ p_{row})$	$nc-(1+(n_c-1)\ p_{col})$

Where p_{row} and p_{col} are row-wise and column-wise seeds. After we get the new location of bits after interleaving on both row-wise and column-wise, the new locations are mapped back into 2D interleaver to get the resulted interleaved bits in 2D.

Color Format:*16-bit Color: Each pixel is represented [1] using 2 bytes or 16 bits. The bits are divided as red, blue and green each having values i.e. 5-bits for red, 6-bits for green, and 5-bits for blue.*

Figure 8: 16-bit color format

Pixel Integration Technique: Consider image input RGB frame of size m*m,

Step:1 The input videos are converted into the frame, RGB is represented as pixel values ranging from 0-255.In case of the image, it is converted into pixel values directly.

Step:2 Create a pixel integration table column and row-wise, forming pixel values in the columns with values 1-266 and the input images are taken along the rows.Step:3 The image is converted into frames as shown in fig.9 and choosing the sub-blocks as 4x4 as shown in figure.10(a)

Step:4 Considering an RGB frame size of 64x64 and dividing into 4x4 blocks will produce 16 blocks i.e Sub-Block A, B, C and D,fig10(b).

Step:5 Considering the first sub-block A(i,j),where i represent pixel value and j represent index(location). The pixel integration table is created as shown in fig.11 by assigning the pixel index to the corresponding pixel value for the first block of RGB frame of every image, later the second block of every image, and so on till the last block.

Step:6 In case of multiple indices with the same pixel value in a block, the value is calculated by representing them in the 16-bit color RGB palette as shown in figure.12 and finding their corresponding value as shown in fig.10.

Step:7 This process is carried on for all the blocks of the image and the results are noted.

Step:8 Image Integration is finally done by summing up the pixel indices value for each pixel value for all the images taken together

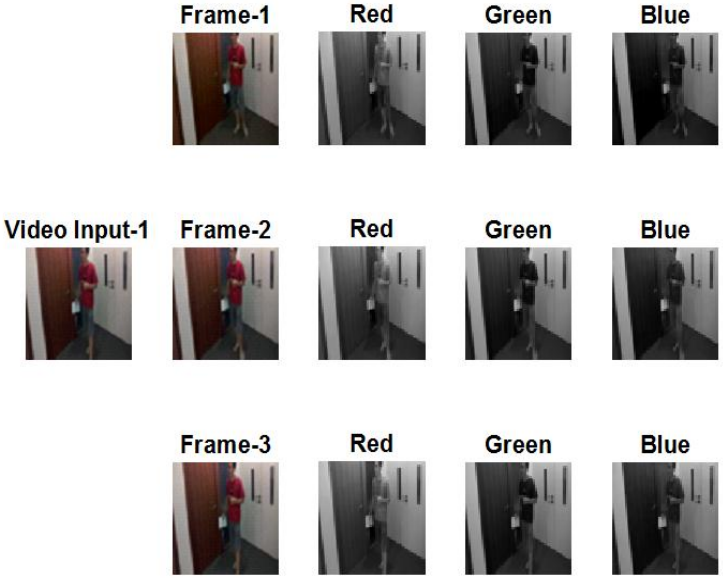


Figure 9: Input Video to Frame Process

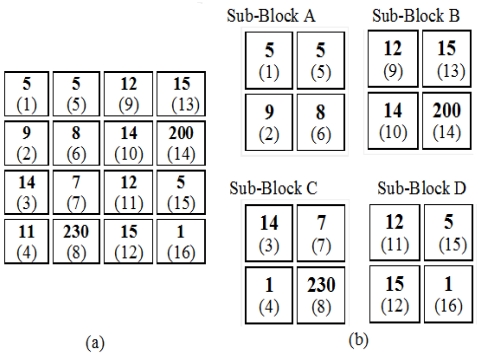


Figure 10: (a) Input Frame Pixel value for 4*4 Size (b) Sub-blocks value for (a)

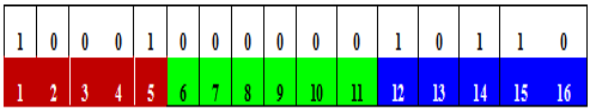


Figure 11: Multiple values location in RGB format

Image/Pixel	1	2	3..	10
1	4,16			
2	9			
3				
4				
5	1,5,15			
6				
7	7			
8	6			
9	2			
10				
11				
12	9,11			
13				
14	10,3			
15	13,12			
.				
.				
200	14			
230	8			
256				

Figure 12: Pixel Integration values

4. Experimental Details and Results:

The proposed method has been implemented in MatLab 8.6 in windows environment with a system configuration of I7 Intel Pentium VI Generation processor with 16 GB RAM. The proposed algorithm has been tested with various images. A good quality encryption algorithm should be strong against all types of attack. Another important factor that evaluates the efficiency of algorithms is measuring the amount of time required for the overall process. Some experiments are given in this section to demonstrate the efficiency of the proposed technique.

Correlation Co-Efficient: The correlation [19] is analyzed between the input image and encrypted image, which is called the correlation coefficient, ranges from -1 to +1. If the encrypted image correlation value is equal to zero or very near to zero, then the encrypted image and original image are totally different, i.e., the original image has no features and is highly independent of the encrypted image. The encrypted image is a negative of the original image if the correlation is equal to -1. Correlation coefficients were calculated by using the following equation (1), (2) and (3),

$$r_{xy} = \frac{Cov(x,y)}{\sqrt{D(x)}\sqrt{D(y)}} \quad (1)$$

$$E(x) = \frac{1}{n}\sum_{i=1}^{n} x_i \,,\; D(x) = \frac{1}{n}\sum_{i=1}^{n}(x_i - E(x))^2 \qquad (2)$$

Where x, y is input image and encrypted image values of two adjacent pixels in the image. In numerical computation, the following formulas were used.

$$Cov(x,y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - E(x))(y_i - D(x)) \qquad (3)$$

The obtained correlation coefficient for encrypted counterpart is shown in Table II, III and IV.

Information Entropy: Information entropy [20] is defined to express the degree of uncertainties in the system. A secure encryption should provide a situation which the encrypted image is not provided any information about the original image. On the other hand, higher entropy images such as an image of heavily cratered on the moon have a great deal of contrast from one pixel to the next and consequently, pixel cannot be compressed as much as low entropy images. Entropy indicated that each symbol has an equal probability. The information entropy for encrypted is calculated using equation no (4),

$$H = -\sum_{i=1}^{n} P_i \, x log_2 P_i \qquad (4)$$

Compression Ratio: Compression ratio is the process of reducing the size of a data file. In the transmission of data, it is called source coding in opposition to channel coding. Compression is useful because it reduces resources required to transmit and store the data. Compression ratio is called with the below formula,

$$Compressionratio = \frac{uncompressedsize}{-compressedsize}$$

Result Analysis: High compression ratio with high information entropy valuesachieves good encryption along with low correlation values. The simulation time period using H.264 compression algorithm for video input, encryption and decryption with the specific key is 197.1251 sec.

Results for the compression ratio for each frame image for RGB layer, correlation co-efficient value and the entropy values are shown in Tables II ,III and IV. The correlation values are very low and negative values which produce high encryption standard corresponds to high entropy value and compression ratio.

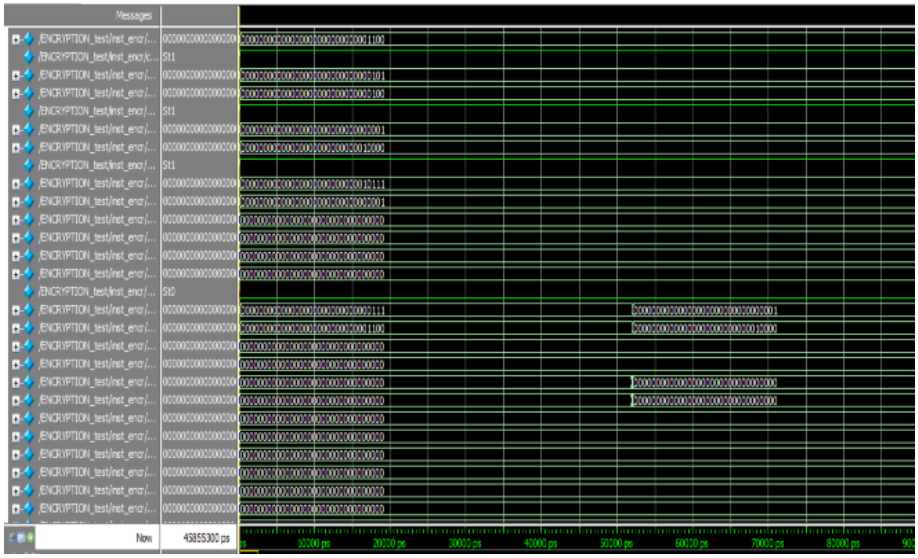


Figure 13: Simon Encryption Algorithm Model sim Waveform

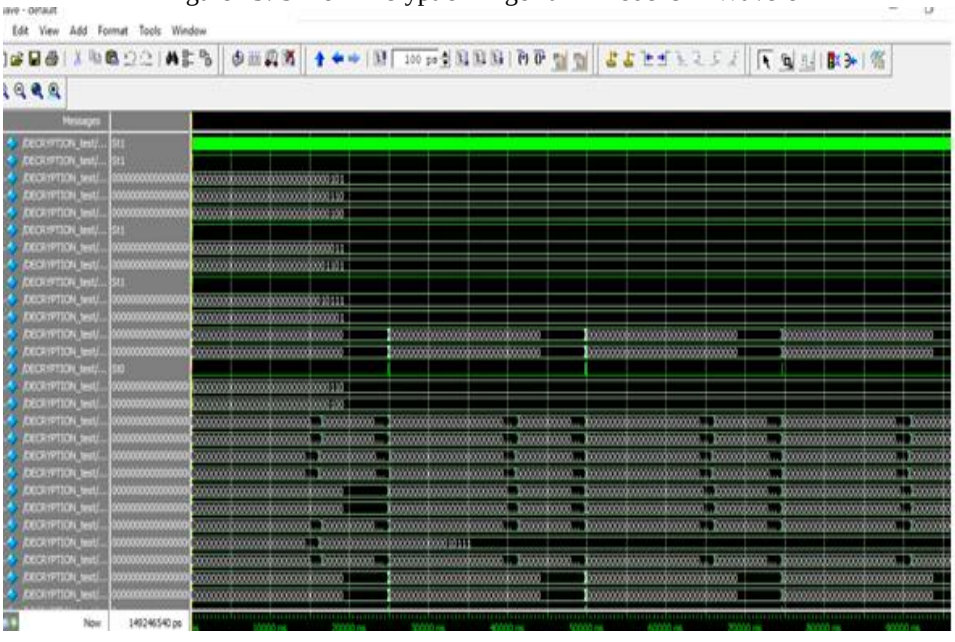


Figure 14: Simo Decryption Algorithm Mode lsim Waveform

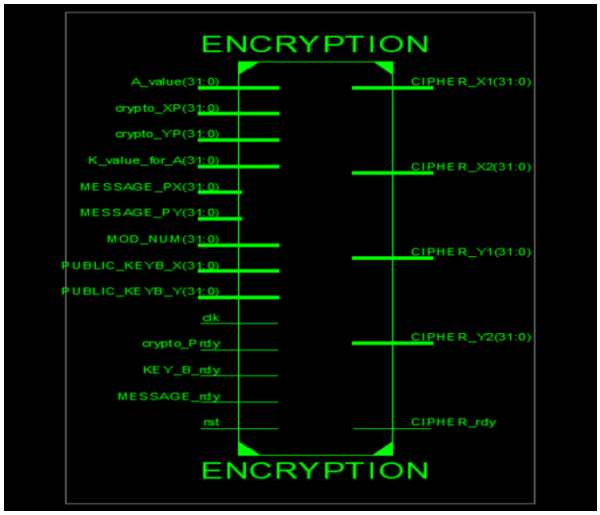
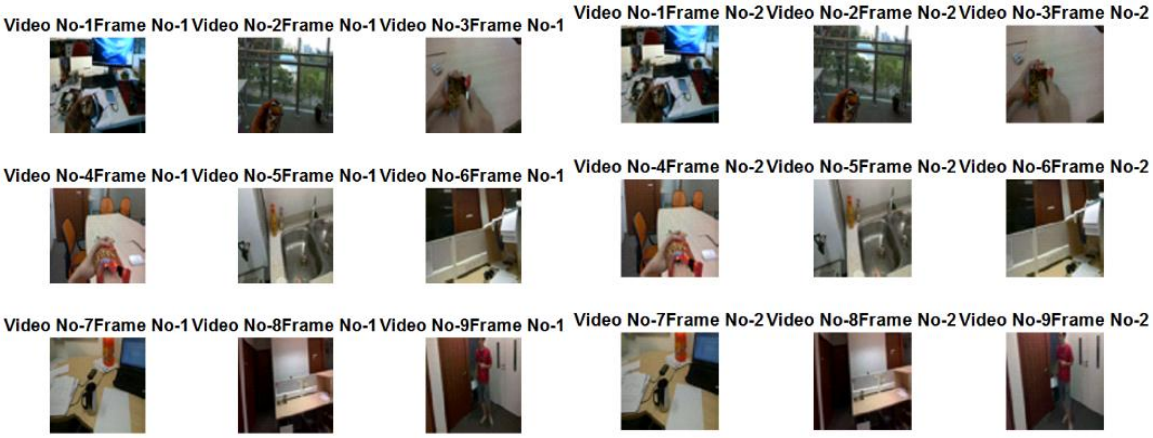


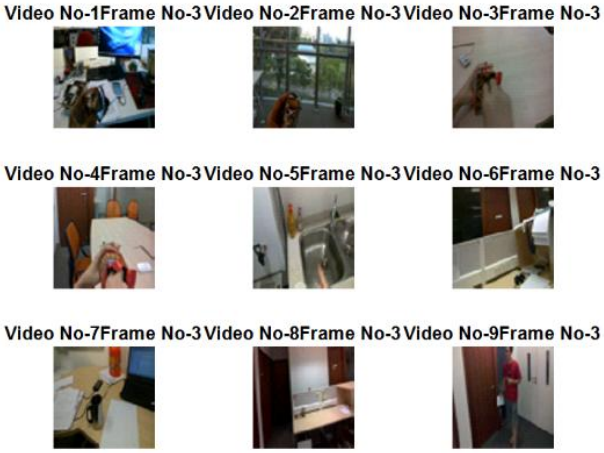
Figure 15: Simon Algorithm RTL View-Xilinx ISE

Logic Utilization	Used
Number of Slices	10401
Number of Slice Flip Flops	3506
Number of 4 input LUTs	19342
Number of bonded IOBs	358
Number of MULT18X18SIOs	4
Number of GCLKs	24

Figure 16: Simon Algorithm Device Utilization Factor-Xilinx ISE



(a) (b)



(c)

Figure 17: Input video to frame-1,2, 3

Table 3: Compression Ratio, Entropy and Correlation Value for Input Video-Frame-1

Image No	Compression Ratio			Entropy Value	Correlation Value
	R	G	B		
1	0.5469	0.5625	0.5625	0.0537	-0.0130
2	0.6875	0.6719	0.7188	0.0009	-0.0065
3	0.3906	0.4063	0.3906	0.0001	0.0061
4	0.4844	0.5625	0.5313	0.0005	-0.0014
5	0.5781	0.5469	0.5469	0.0000	0.0346
6	0.5313	0.5313	0.5313	0.0253	-0.0240
7	0.3906	0.4844	0.5000	0.1739	-0.0050
8	0.5469	0.5781	0.5938	0.3185	-0.0071
9	0.5000	0.5625	0.5469	0.0158	0.0320

Table 4: Compression Ratio,Entropy and Correlation Value for Input Video-Frame-2

Image No	Compression Ratio			Entropy Value	Correlation Value
	R	G	B		
1	0.5469	0.5625	0.5625	0.5459	-0.0129
2	0.6875	0.6719	0.7188	0.6875	-0.0065
3	0.3750	0.3750	0.3750	0.0001	0.0060
4	0.5000	0.5938	0.5313	0.0005	-0.0015
5	0.5781	0.5469	0.5469	0.0000	0.0343
6	0.5313	0.5313	0.5313	0.0252	-0.0238
7	0.3594	0.4688	0.5000	0.1739	-0.0050
8	0.5469	0.5781	0.5781	0.3186	-0.0071
9	0.4844	0.5469	0.5156	0.0158	0.0317

Table 5: Compression Ratio,Entropy and Correlation Value for Input Video-Frame-3

Image No	Compression Ratio			Entropy Value	Correlation Value
	R	G	B		
1	0.5469	0.5625	0.5625	0.0537	-0.0128
2	0.6875	0.6563	0.7031	0.0010	-0.0065
3	0.3594	0.375o	0.3594	0.0001	0.0060
4	0.5156	0.5938	0.5313	0.0005	-0.0015
5	0.5625	0.5469	0.5625	0.0000	0.0341
6	0.5313	0.5313	0.5313	0.0252	-0.0237
7	0.3281	0.4844	0.5000	0.1739	-0.0049
8	0.5469	0.5781	0.5781	0.3186	-0.0071
9	0.4688	0.5625	0.5625	0.0158	0.0315

5. Conclusion:

Digital image security has become highly important since the communication by transmitting of digital products over the network occur very frequently. The encryption algorithm is proposed, based on pixels interleaving with image integration in this paper. First applying compression method with interleaving the image pixels, then through the method of pixel integration increasing the difficulty of decoded. At last, a camouflaged image for all the input, getting the final multi encryption image-video. Experimental result shows good performance with low correlation, high compression ratio and high entropy which shows that the pixel-based algorithm is highly secure. With this approach, it is also able to encrypt large volume of data more securely and simultaneously. Our new approach is expected to be useful for transmission applications and real-time system. Future work includes the incorporation of other types of the encryption algorithm.

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