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Analysis of Color Image Noising Process

Dr. Mohammad S. Khrisat[1]; Dr. Saleh A. Khawatreh[2]; Dr. Majed Omar Dwairi[3]; Dr. Amjad Hindi[4]; Prof. Yousif Eltous[5]; Prof. Ziad Alqadi[6]
Albalqa Applied University[1, 3, 4, 5, 6], Faculty of Engineering Technology, Jordan, Amman, Al-Ahliyya Amman University[2]

Abstract: RGB color image is one of the most papular digital data type used in data transmission, it can contain valuable and secret information, so protecting it is an important issue. In this paper research we will analyse the efeects of adding-subtracting a selected and defined noise signal to color image, this noise signal will be huge to cover any image with any size, it will be saved and used as a secret signal to encrypt-decrypt color images. The noise signal will be represented by a simple mathematical equation, we will vary the noise parameter and measure the quality parameters MSE and PSNR between the original image and the encrypted and decrypted images.
Keywords: RGB color image, YIQ image, SRNS, MSE, PSNR, encryption time, decryption time, quality requirements.

1- Introduction

RGB digital color images [1], [2], [3], [4] are considered the most important types of digital data circulating in the Internet and through most of the available social media [5], [6], [7]. The importance of the digital image lies in the following reasons:

- Possibility of the digital image being confidential
- The possibility of the image to be of a personal nature
- The possibility of the image carrying very important data

Taking these reasons into consideration [23], [24], [25] color images require preventing any third person or entity not authorized to understand the image or know the data there in, not to mention some computer systems that use digital images, and this requires providing an easy way to protect it and not to penetrate the information it carries [8], [9], [10]. RGB color images are usually represented by a three-dimensional matrix, the first dimension indicates red color; the second indicates green color, while the third dimension indicates blue color [11], [12], [13], therefore, the image can be considered as three two-dimensional matrices, one for each of the three colors, and therefore we can deal with each color separately, or it can even be reconfigured into an array and as we see fit for the treatment process [14], [15]. Figure 1 shows an RGB color image with its colors histograms [16], [17].

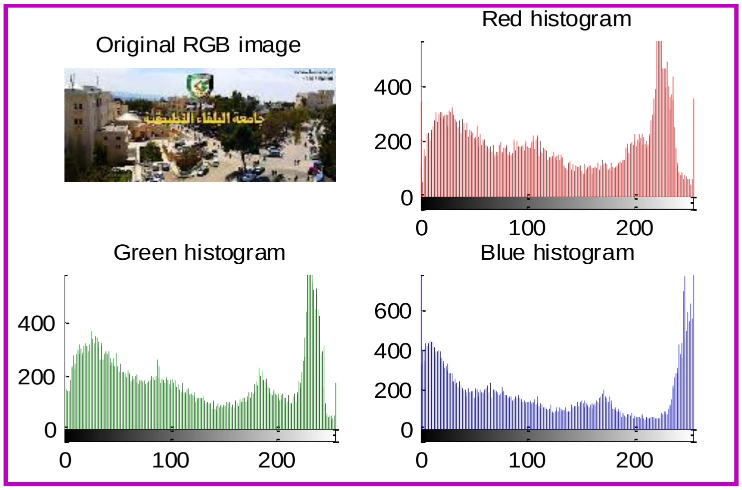

Figure 1: RGB color image and colors histogram

2- Selective Random Noise Signal

Selective random noise signal (SRNS) is a digital signal with random double values[44], [45], the values of signal are varied from 0 to 1 and they can be changed by adding a parameter k. SRNS can be generated using equation 1:

$$Noise = -k + rand(1, 9000000) \quad (1)$$

Here k parameter is used to control the values of mean square error (MSE) and peak-signal-to-\noise ratio (PSNR) [42], [43], [46] between the original and noised (encrypted) images. Figure 2 shows several SRNS using various values of the parameter k:

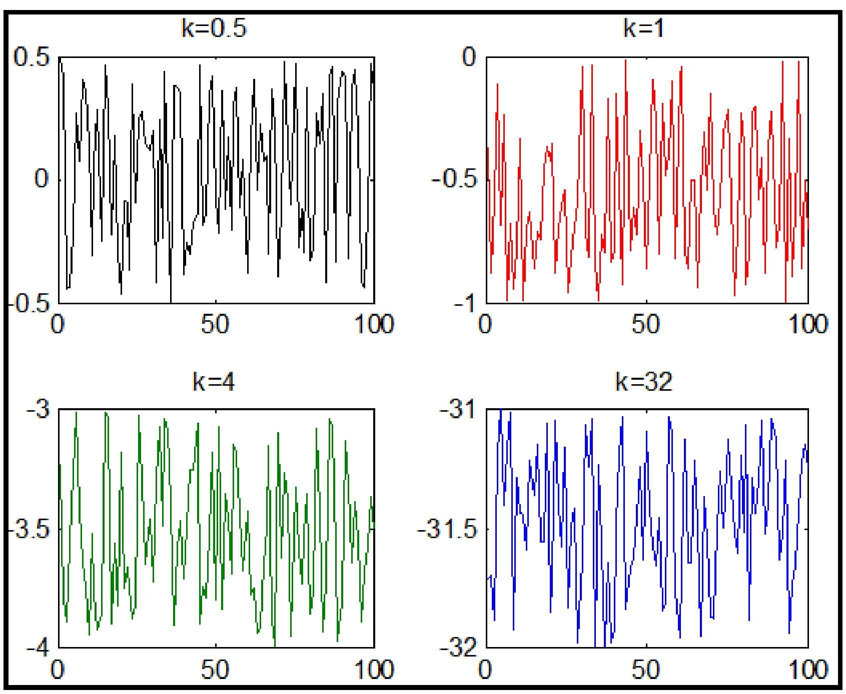

Figure 2: SRNS using various values of K

The initializing phase of color image encryption-decryption must be done applying the following steps:

1) Generate SRNS with big size to suit any color image.
2) Save SRNS.

RGB color image pixels values are within the rang 0 to 255 and they are integer values, so it is difficult to add SRNS to it, and here we have to convert the RGB image to YIQ which accepts the random noise addition or subtraction, here we can use formula 2 to get YIQ image from RGB one, and formula 3 to get back RGB image, and here we have to multiply the obtained image by 255 and take the integer part [18], [19], [20].

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \quad (3)$$

Figure 3 shows the outputs of the image conversion process, while figure 4 illustrates outputs of adding and subtracting SRNS using a sample RGB color image:

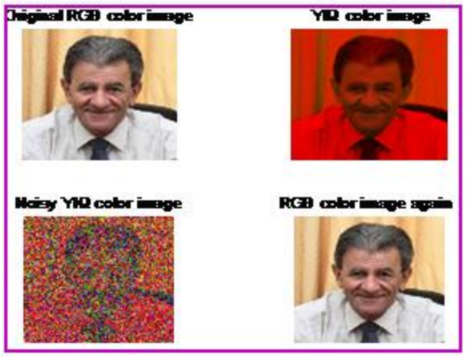

Figure 3: Conversion process

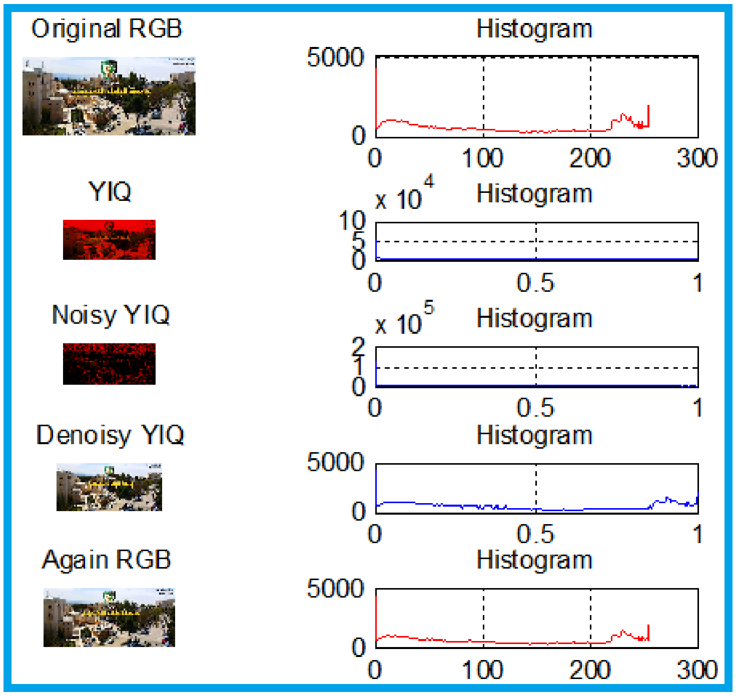

Figure 4: Adding and subtracting SRNS

3- Image Encryption-Decryption

RGB color image encryption process [21] is the process of destroying the original image so that it becomes distorted and prevents any outsider from understanding it or knowing its contents [25], [26], [27]. As for the decoding process, it means retrieving an image that is completely identical to the original image, without losing any information from it [28], [29].

The encryption and decryption process is usually carried out using one or more private keys. The encryption and decryption method should achieve the following things [22], [30], [31], [32]:

- High efficiency by maximizing the method speed and throughput or minimizing the encryption and decryption times.
- High deformation and distortion rate by decreasing peak-to-signal-ratio (PSNR) and increasing mean square error (MSE) between the original and the encrypted images [38], [39].
- High reliability rate by decreasing MSE and increasing PSNR between the original and the encrypted images.
- High level of security and protection with hard keys to hack [36].

There are now several methods available that range in how well they encode a digital image, some of these methods were based on image blocking and XORING the created blocks by a private key [31], [32], [33], [35], [41], in [34], and others were based on matrix multiplication of the original image and a special generated private key matrix [30]. In [37] the authors used matrix reordering principle, while in [39] the encryption was based on based on 3D Chaotic Cat Maps. In [40] the authors introduced a method based on Rubik's Cube principle; these methods will be implemented to make comparisons with the proposed here method.

To increase the level of image security and protection, the proposed method uses SRNS as private key and it is hard to hack. This key is to be generated once and saved by both the sender and receiver, and it contains a values range from -k to k.

The proposed encryption phase as shown in figure 5 will be implemented applying the following steps:

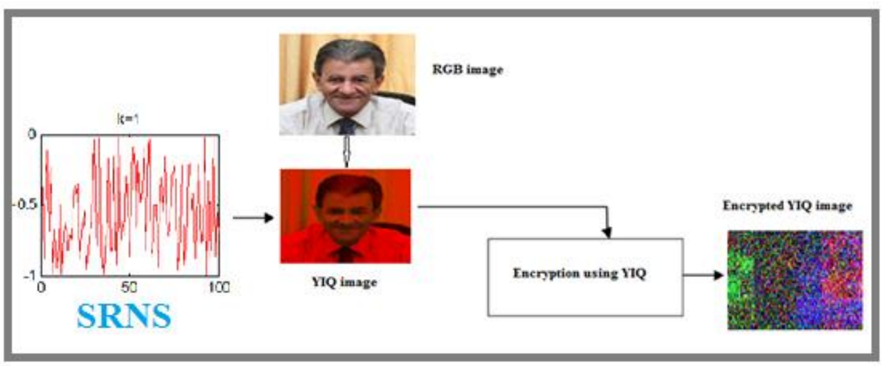

Figure 5: Encryption phase

a) Initialization:
   This phase is to be implemented once, SRNS must be generated and saved to be used as a private key, and this key can be updated from time to time.
b) Get RGB color image.
c) Convert the image to YIQ image.
d) Reshape YIQ image matrix to one raw matrix.
e) Load SRNS.
f) Adopt SRNS to suit the image size.
g) Add SRNS to the raw matrix.
h) Reshape back the raw matrix to get encrypted YIQ image.
i) Convert YIQ image to RGB image to get the encrypted RGB color image.

The decryption phase as shown in figure 6 can be implemented applying the following steps:

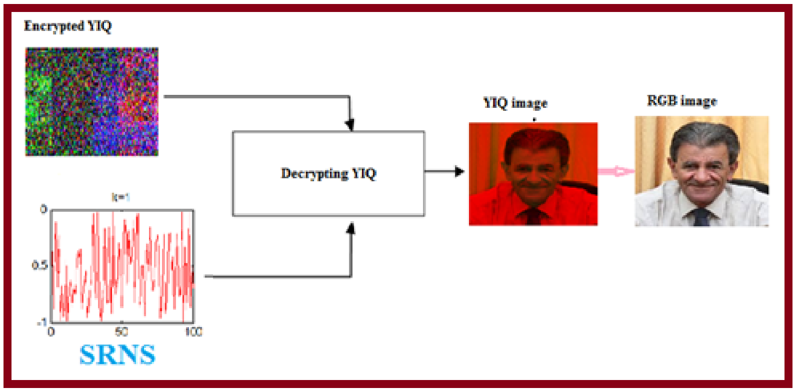

Figure 6: Decryption phase

a) Get Encrypted RGB color image.
b) Convert the image to YIQ image.
c) Reshape YIQ image matrix to one raw matrix.
d) Load SRNS.
e) Adopt SRNS to suit the image size.
f) Subtract SRNS from the raw matrix.
g) Reshape back the raw matrix to get decrypted YIQ image.
h) Convert YIQ image to RGB image to get the decrypted RGB color image.

4- Implementation and Experimental Results

Adding and subtracting SRNS to RGB color image to perform encryption-decryption process was implemented using various images, figure 7 shows the generated outputs when k=0.5, while figure 8 shows the generated outputs when k=32:

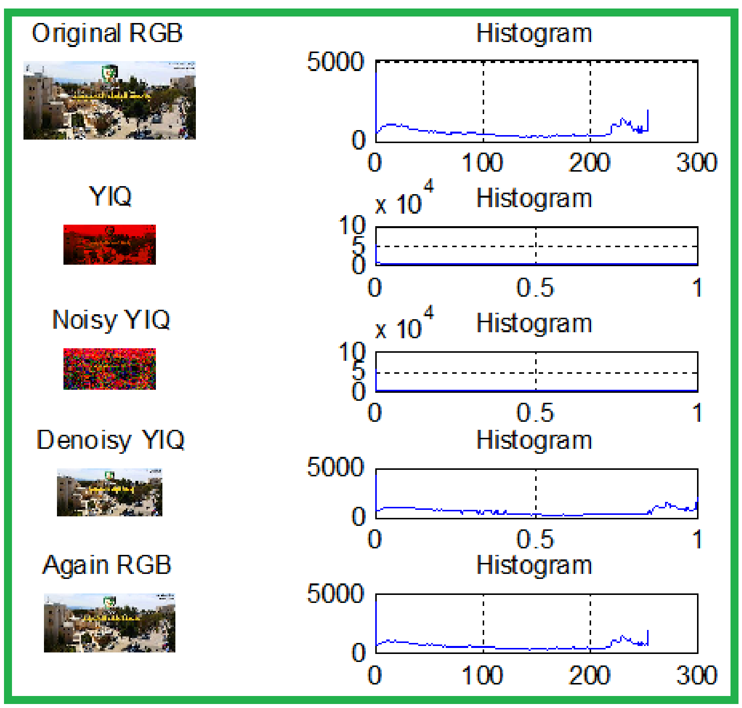

Figure 7: Generated outputs when k=0.5

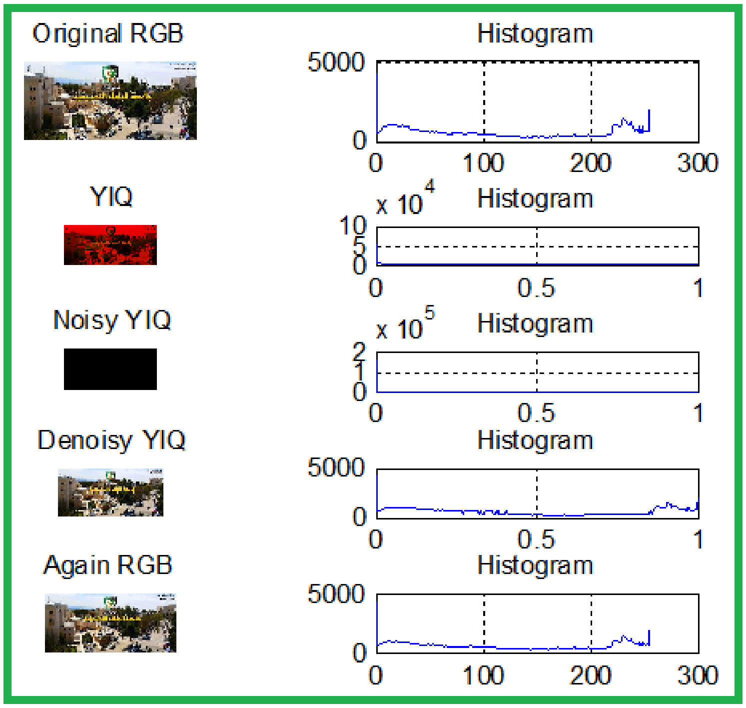

Figure 8: Generated outputs when k=32

SRNS method of encryption-decryption was implemented using RGB images shown in table 1:

Table 1: RGB color images information

Image	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Resolution(pixel)	50283	25992	172800	1713600	172800	50325	50325	50451	630000	2039752
Size (byte)	150849	77976	518400	5140800	518400	150975	150975	151353	1890000	6119256

The images listed in table 1 were used in SRNS method implementation; table 2 shows the obtained results for MSE and PSNR between the original and the encrypted images:

Table 2: Obtained MSE and PSNR

Image number	K=0.5		K=2		K=4		K=8	
	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR
1	21601	11.0203	21963	10.8542	22452	10.6339	23455	10.1970
2	47446	3.1519	48087	3.0177	48948	2.8401	50696	2.4893
3	11294	17.5047	11555	17.2762	11910	16.9736	12644	16.3755
4	13734	15.5492	13734	15.5492	13734	15.5492	13734	15.5492
5	11387	17.4230	11387	17.4230	11387	17.4230	11387	17.4230
6	21969	10.8514	21969	10.8514	21969	10.8514	21969	10.8514
7	15864	14.1072	15864	14.1072	15864	14.1072	15864	14.1072

8	12739	16.3011	12739	16.3011	12739	16.3011	12739	16.3011
9	24509	9.7572	24509	9.7572	24509	9.7572	24509	9.7572
10	20034	11.7735	20034	11.7735	20034	11.7735	20034	11.7735

From table 2 we can see the following facts:

- ✓ SRNS method provides a high quality of encryption, by providing a high value of MSE and low value of PSNR between the original and the encrypted images.
- ✓ For Small size images it is recommended to increase the parameter K in order to increase MSE value and to decrease PSNR value.
- ✓ Changing K parameter value does not affect the values of MSE and PSNR for big size images.
- ✓ The same SRNS can be used to encrypt-decrypt different color images.
- ✓ SRNS method provides a high quality of decryption, by providing a zero MSE and infinite PSNR between the original and the decrypted images.

Conclusion

A method of generating selective random noise signal was proposed, it was shown that this signal can be efficiently used in RGB color image encryption-decryption. For small size images it was shown that using high value of noise parameter will increase the quality of encryption, for big size images the value of k parameter does not affect both MSE and PSNR.

Using SRNS in encryption completely destroyed the original image by generating an encrypted image which cannot be understood by any third party or by unauthorized person.

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