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Нагиева Абабил Фахраддин, *докторант кафедры Компьютерная Инженерия и Телекоммуникация, Азербайджанский Технологический Университет*
Вердиев Сакит Гамбай, *научный руководитель, д.т.н., проф., зав. кафедрой Компьютерная Инженерия и Телекоммуникация, Азербайджанский Технологический Университет*

РЕВЕРСИВНЫЙ МЕТОД СОКРЫТИЯ ИНФОРМАЦИИ ОСНОВАННЫЙ НА ИСПОЛЬЗОВАНИИ КВОРУМ ФУНКЦИИ

Аннотация: Стеганография это наука о сокрытии секретных сообщений в любой форме медиа без оставления в ней заметных следов.Передача секретного сообщения осуществляется электронным носителем информации не вызывая подозрений у третей стороны насчёт существования спрятанной шнформации. В настоящей статье предлагается реверсивный метод внедрения секретной информации в цифровых изображениях обеспечивающих надёжность передачи информации в необходимом количестве сохраняя при этом качество стего изображения.При использовании предлагаемого метода данные внедряются и извлекаются путём комбинирования операции сжатия и и вычисления минимального значения пикселей,а для внедрения данныхиспользуется кворум функция.Были проведены эксперименты для сравнения эффективности предлагаемого алгоритма с наиболее успешными алгоритмами последних 5 лет.Результаты показали преимущества предлагаемого метода над сравниваемыми.

Ключевые слова: Стеганография изображений, сокрытие данных, кворум функция, оценка показателей, визуальное качество.

Abstract: Steganography is a science of concealing secret message in any form of media without leaving any remarkable trace on the host medium .It is

providing transmitting a secret message in an electronic carrier of information without causing suspicion concerning the presence of hidden information of a third party. This article proposes a reversible method of embedding secret information in digital images, which provides reliable transmission of a secret message under conditions of embedding of a considerable amount of information while maintaining the visual quality of the stego-image. The data is embedded and extracted using the proposed method in which information compression operation is combined with the minimum pixel value computing and the quorum function is used to embed the data. Experiments have been conducted to test the efficiency of the algorithm against successful algorithms of recent years. The results demonstrate the advantage of the proposed method in terms of PSNR and Hiding Capacity values.

Key words: Image steganography, data hiding, quorum function, performances estimation, visual quality.

Introduction

The increase in the volume of digital communications, including the Internet, requires that particular attention be paid to the security of the information and data being transmitted to prevent unauthorized access to the information being transmitted [1; 2] . In this regard, the development of new methods of concealment is very relevant.

Steganography is a new, rapidly developing scientific direction in the field of information technology. When using steganography, the date hides in multimedia media -image, video, audio files that are used as a container to conceal and transmit secret information through open communication channels. The main purpose is to keep the transmission of information secret. The most popular method is to hide a secret message in a digital image [3; 4; 5; 6] called the cover image. Along with the various types of multimedia, the digital image is usually used as a host image for the transmission of secondary data in it. Combination of methods and tools used to create a covert channel for transmitting information are called a steganography system (stego-system). In opposite of the cryptography the main purpose of the

steganography process is not to encrypt data, but to ensure that embedded data transmits unnoticed, intact and recoverable. In a stegosystem, a secret message is embedded in the container in such a way that no one except the sender and receiver of the message should be aware of its existence. By the type of problem to be solved, methods of concealment of information are divided into reversible and non-reversible [7]. In the first case, once a secret message has been successfully transmitted, it is extracted from the Stego image and recovered on the receiver's side. In the second case, it's not possible. In this paper, we focused on reversible data hiding image steganography methods in spatial domain. At present, the reversive concealment of information and data is one of the main areas of information security. To date, many techniques have been developed to conceal the data, including those based on interpolation of images. This is due to the fact that such data concealment schemes [8; 9] are easy to use, have a big of embedding capacity and numerically efficient. Interpolation algorithms are used in image steganography for improving image resolution which is utilized as a cover for secret message transmission.

Related works

Ki-Hyun et al. [10] in 2009 year first propose a novel data hiding algorithm using image interpolation which has low time complexity and accordingly the high speed of computing. According to proposed method input image down scaled 4 time, which after this act called original image. The interpolated image is transformed into a cover image with the size w x h. After the embedding of the secret message, the cover image transforms into a stego image. The receiver extracts a secret message from the stego image and recovers the original image from the cover image. By the proposed algorithm, called neighbor mean interpolation NMI. Neighbor pixel values are used for mean number calculation, and after that inserted these calculated values into to be embedded pixels. Generally, it is possible to get pixels with more high resolution by the implementation of such calculating technics. That is the advantage of the proposed NMI algorithm. A number of researchers have tried to improve the results of the Jung's method, but despite the superior embedding capacity, the image quality is mediocore. Lee [11] introduced a reversible method of data hiding called

Interpolation by Neighboring Pixel (INP). The proposed method had better results than Jung and Yoo scheme but this method is modification of Jung's method. Another looking as interesting work on the field of reversible data hiding of Ahmad A. M., et al [12]. In contrast to Ki-Nyun Jung et al.[-10], they are have proposed a novel algorithm that has been providing for embedding less secret message bits. According to the author's idea of the proposed algorithm provides high embedding payload and limited image distortion. All operations are divided into two phases. On the first step scaling down/up operation is made and on the second step data hiding algorithm is performed. The distinguishing feature of this algorithm is to trade-off between data hiding payload and quality of the image is regulated by the implemented algorithm in an adaptive manner.

In [5] by combining Interpolation and Difference Expansion methods has increased the data hiding capacity and the quality of the image but computational complexity was high. Sabeen Goving in his last work [13] proposes a very serious novel approach to developing reversible data hiding algorithm using İnterpolation technique, quorum function and optimal bit change operation. The use of this approach makes it possible to significantly increase the data hiding capacity, while at the same time improving the visual quality of the stego image, and being computationally much more simple. Another effective method of backward date embedding is the Nistogram Schifting [14], which is based on the use of peak and zero points. This moves the histogram left or right. Although the embedding capacity is limited to the peak points of the histogram, the quality of the stego images is good, and therefore this method is still used for different purposes. SA Parah et al. [8] proposed a reversible embedding scheme using the pixel to block method (RTV). The data became more secure due to the use of non-linear dynamics and the ability to detect and localization hacks. The vectorized encrypted recording of patient data and the logo are embedded into the medical image using the method of bit permutation.

The following sections will present the proposed method using a quorum function, numerical example, methodology and results of the experiments, the main conclusions.

Proposed method

To The research on reversible data embedding (RDE) is devoted many works that differ from each other in terms of PSNR and Hiding Capacity. The method we propose produces good results for the above-mentioned indicators (PSNR and HC) in comparison with existing similar methods. Sender performs secret data compression operation. Cover image and secret message are used in embedding algorithms based on Quorum function. The result is a stego image that receiver gets on the output of stego system. He extracts the stego message using the algorithm ,which is opposite form of embedding algorithm. An operation of extraction is performed to recover the original image. The proposed method provides reversibility by using an algorithm for embedding secret data without affecting the visual quality of the original image.

Realization of the proposed method

Step 1. Using Hoffman's algorithm by applying a lossless compression operation reduces the capacity of a secret message as below

$$B=b_1b_2b_3.....b_n$$

Step 2. Cover image is divided to 2x2 blocks

a_{11}	a_{12}
a_{21}	a_{22}

Cover image

Step 3. The pixel with the lowest value is subtracted from the other three

$$c_{12}=a_{12}-min$$

$$c_{21}=a_{21}-min$$

$$c_{22}=a_{22}-min$$

In this article, we propose the use of a quorum function for embedding and extraction of secret data. Quorum function(QF), are widely used in Boolean algebra, summators, substrators, hash function, etc. and are given as follows

$$QF(x_1, x_2, ...x_n) = \begin{cases} 1, if \sum_{i=1}^{n} x_i \geq \frac{n}{2} \\ 0, \quad otherwise \end{cases} \quad (1)$$

For More detailed information refer to [13]

After the creation the Cover image, quorum function utilized for embedding secret data in the last 3 least significant bits of this image. So using logic AND (**v**) and EX-OR(+) it possible define a quorum function (3QF) with three inputs according to equality (2

$$3QF(x_1, x_2, x_3) = (x_1 \wedge x_2) \oplus (x_1 \wedge x_3) \oplus (x_2 \wedge x_3) \quad (2)$$

x_i means input of the quorum function and this input can be 0 or 1. If the input is 1, then the output of the quorum function is also 1. Similarly, if the input is 0, the output of the quorum function will also be 0. In this article, embedding and extraction secret data is based on the use of a quorum function. Embedding data using a three-input quorum function (3QF). The embedding procedure is detailed below:

Numerical example.

Suppose Secret Data=101111001110, Secret Data[1] =1 and the last 3 bits of the first pixel Cover Image (125=(1111101)) are defined by the quorum function 3FC and can be 1 and 0. If the output of 3KF (101)=1 coincides with the input of the last 3 bits of the Cover image, then the value of this Cover image pixel can also be used as the value of the stegopixel. Otherwise, i.e. if there is an output inequality of 3QF and secret bits, then the acceptable output value of 3QF corresponding to the input of the secret bits is determined by equation (2).

After embedding in the first block, the algorithm selects the next block and after completion of the above-mentioned procedure and the corresponding bit exchange operation, the minimum bits (bit or pixel) are added back to the pixels of the blocks, thus forming the stego pixel.

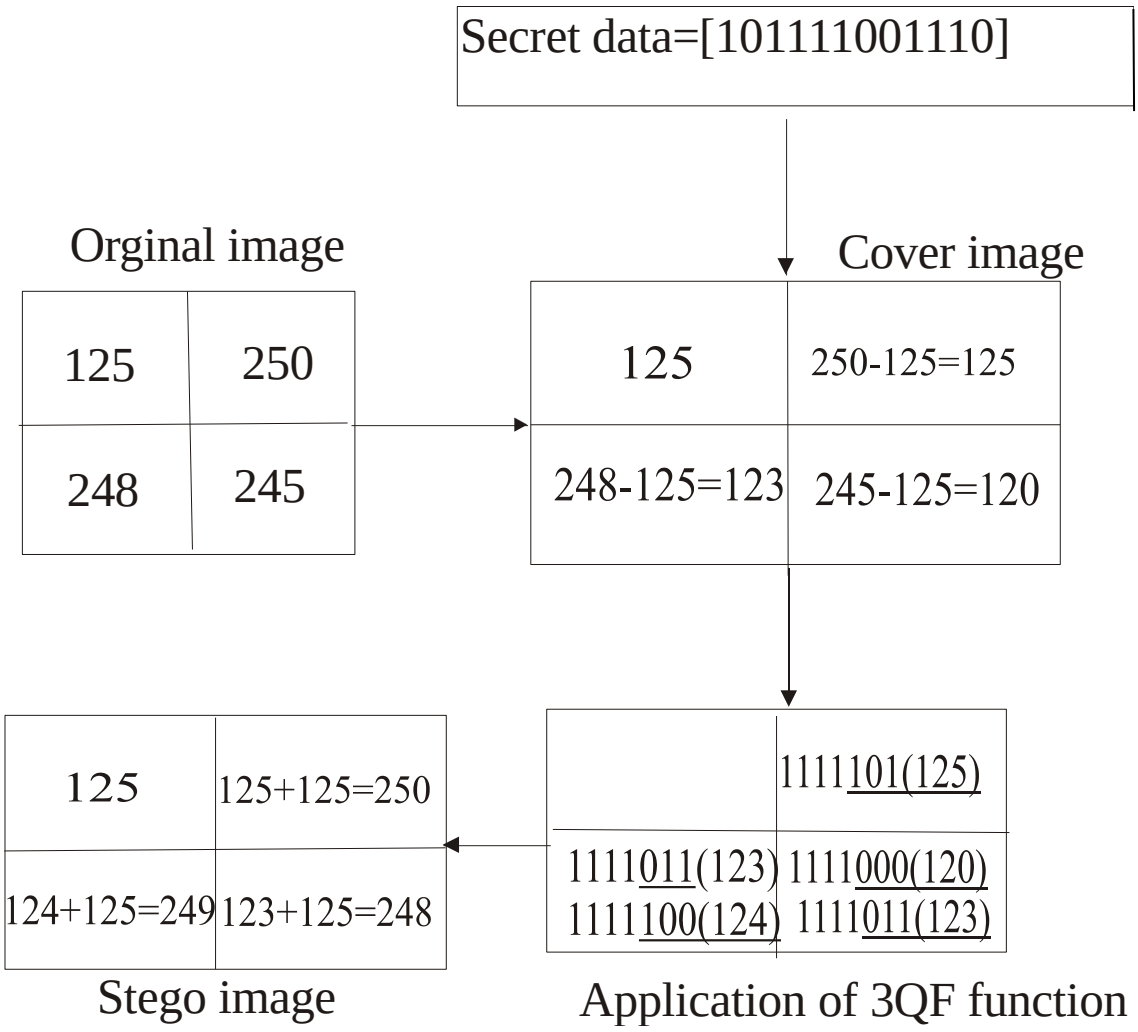


Figure 1 Figure 2

The entire image is divided into 2x2 blocks. In each block, the first pixel is estimated as original and contains no secret information. The objects for extraction are the other 3 loaded pixels. Therefore, the minimum pixels are subtracted from these three pixels. These pixels are then converted to a binary system and their last 3 bits are transmitted to 3QF. Finally it becomes possible to extract all the bits of the secret message.

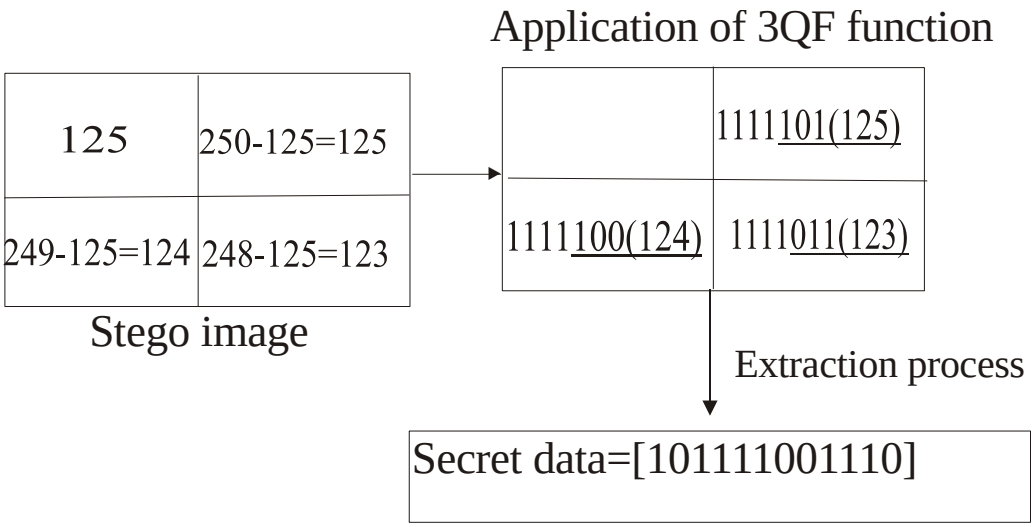


Figure 3. Shame of Extraction process

Experimental results

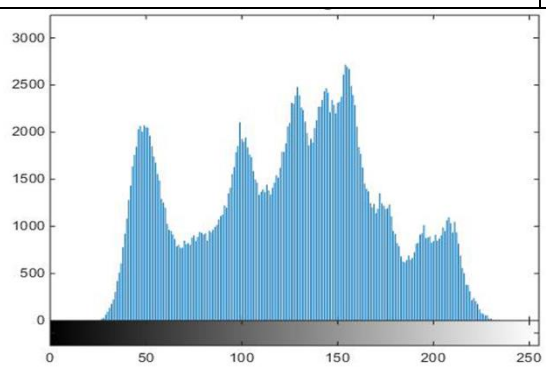
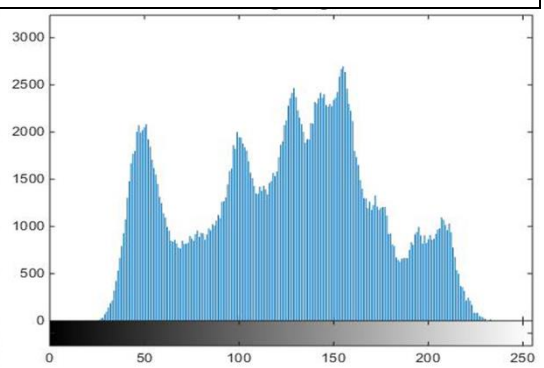
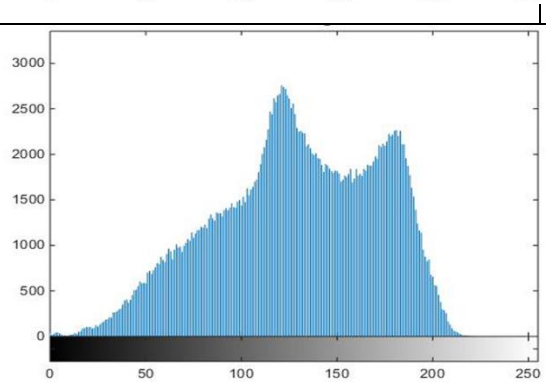
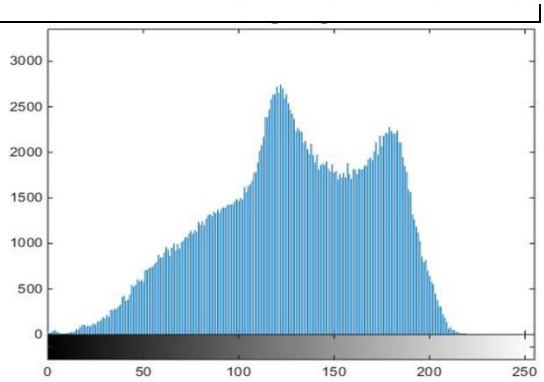
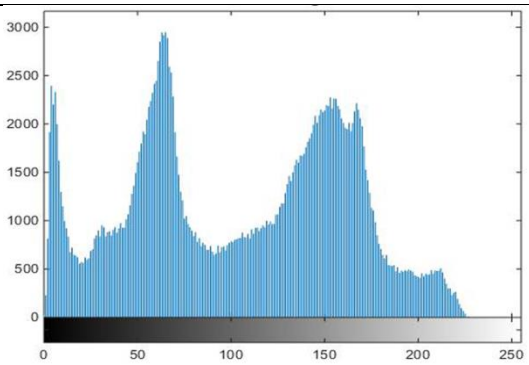
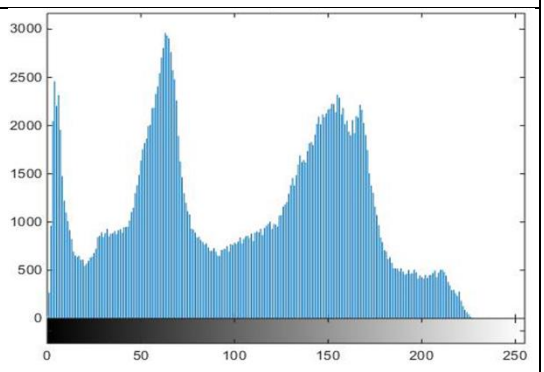
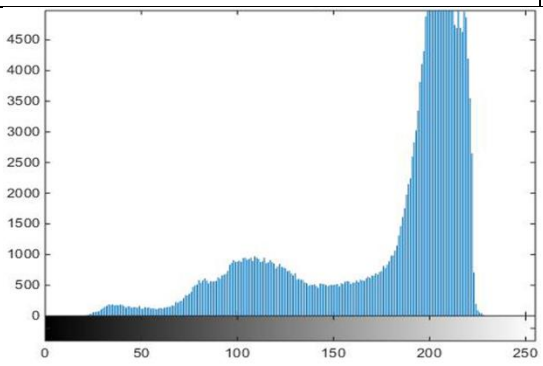
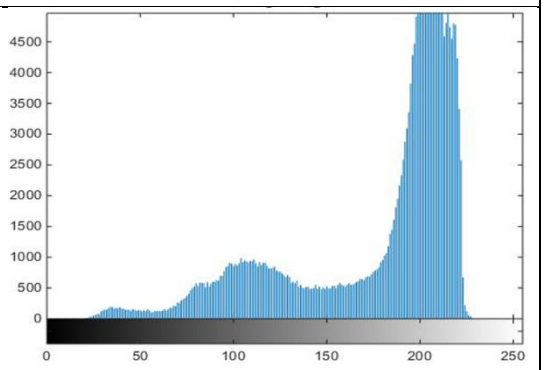
The experiments were carried out on standard reference images measuring 512x512 from USC-SIPI image database. To test the efficiency of the proposed algorithm and to obtain reliable results, tests were carried out on various embedding methods on 50 images, 4 of which are presented in this article in Figure 1. These images were used as input images to test the proposed reversible embedding algorithm. To test the reliability of the obtained results, test experiments were carried out on the same images of the compared algorithms. Each image was processed according to the proposed method. As competitors, we have chosen the most successful algorithms of recent years [13; 15; 16]. The results are given in Table 1. As can be seen from table.1 for both indicators, the proposed method has higher value .This in turn is direct proof of the advantage of the algorithm presented in this article The goal of the development of the new method of information concealment was to achieve more amount of embedding capacity with minimal distortion of the stego image. The goal of the development of the new method of information concealment was to achieve more amount of embedding capacity with minimal distortion of the stego image. As seen from the table 1 the goal has been achieved.

Table 1. Comparisons of PSNR (dB) and HC (bpp).

Cover image	Metrics	Yong-qing Chen et al.[16]	Malik A.и et al. [15]	Sabeen G.et al.[13]	Proposed method
Lena	PSNR HC	32.18 0.38	31.33 0.12	48.01 0.75	49.56 1.15
Baboon	PSNR HC	24.69 0.46	26.85 0.43	48.21 0.75	50.47 1.08
Airplane	PSNR HC	33.32 0.37	30.26 0.25	46.05 0.75	48.88 1.00
Peppers	PSNR HC	32.82 0.78	27.39 0.32	47.69 0.75	49.32 1.5
Average	PSNR HC	**30.75** **0.49**	**28.95** **0.28**	**47.49** **12.458**	**48.05** **11.825**

Figure 4. Test Images

Figure 5. Histogram comparison

Images	Histogram of CI	Histogram of SI
Lena		
Baboon		
Peppers		
Airplane		

Conclusion

Here we presented a reversible steganography method of data concealment in digital images. As usually authors use interpolation technic for image resolutions improve. In contrast, we used the secret message compression method in combination

with the method of identifying and using the minimal pixel bit. Data is embedded and extracted using a quorum function with three inputs. Data is embedded and retrieved using a quorum of a function with three inputs. The efficiency of our algorithm was tested on 50 standard images. The algorithm provided for the reversibility of the built-in information and full recovery of the original image. The visual quality of the image was tested by the Peak Signal Noise Ratio (PSNR) metric. The histograms method was used simultaneously to make the estimation of this indicator more reliable. The amount of the embedded date was determined in the DB. The indicators of the developed algorithm method were compared with algorithms based on interpolation and have certain advantages. The results of the comparison with current methods in recent years showed the superiority of the proposed method in terms of HC and PSNR. In our next work we will try to increase the values of these indicators in order to use in medical images, where the accuracy of diagnosis requires high image quality and a large amount of patient data to be introduced.

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