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ANALYTICAL STUDY OF REVERSIBLE DATA HIDING TECHNIQUES USING DIGITAL WATERMARKING

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ABSTRACT: *In today's world computer networking has gained tremendous growth. Information and technology has crossed all barriers of distance. But measures of safety and security to long distance communication remains a major issue in case of confidential data [1]. With the growth of technology and computer networking, new techniques have been developed in impacting, confidentiality and integrity of critical data that poses a serious threats to the problem of safety. 'Safety' has now become vulnerable. In order to prevent important information to be intercepted by unauthorized person, it is important to use different techniques to secure our data. Secret information over a long distance produces a need of additional security mechanisms to secure secret information [1,2]. The prominent techniques are Cryptography, Steganography and Digital Watermarking. With the spread of multimedia contents, it has become important to save our data using above techniques. In this paper, reversible data hiding methods of Digital watermarking techniques are analyzed and seems many previous work can be expanded to reversible data hiding methods and performance of embedding capacity and digital image quality can be improved with reversibility. The experimental output shows that Che-Wei Lee et al.'s method and K.H.Jung's method were better then Ki-Hyun Jung's method for embedding capacity and image visual quality.*

I. INTRODUCTION

In today's world computer networking has gained tremendous growth. Information and technology has crossed all barriers of distance. But measures of safety and security to long distance communication remains a major issue in case of confidential data [1]. With the growth of technology and computer networking, new techniques have been developed in impacting, confidentiality and integrity of critical data that poses a serious threats to the problem of safety. 'Safety' has now become vulnerable. In order to prevent important information to be intercepted by unauthorized person, it is important to use different techniques to secure our data. Secret information over a long distance produces a need of additional security mechanisms to secure secret information [1,2]. The prominent techniques are Cryptography, Steganography and Digital Watermarking. With the spread of multimedia contents, it has become important to save our data using above techniques. Proposed research work target to study Digital Watermarking Techniques to present images.

Digital Watermarking schemes can be classified into Irreversible Digital Watermarking and Reversible Digital Watermarking. In irreversible Digital watermarking, after removing watermark from Watermarked Image (WI) it doesn't gives same Original Image [WI – W → OI'], while in Reversible Digital Watermarking, Original Image(OI) remains same after removing watermark from Watermarked Image [WI – W → OI].

The undertaken research work mainly focused on analytical study & implementation of different Reversible Watermarking Techniques. As shown in fig. 1. there is an Original image (OI) in which secret message as watermark (W) is embedded, after embedding a watermark we get Watermarked Image (WI). We send it to receiver and receiver gets a Watermarked Image. Receiver will do the process to extract the secret data, after extracting watermark it produced Original Image (WI – W = OI).

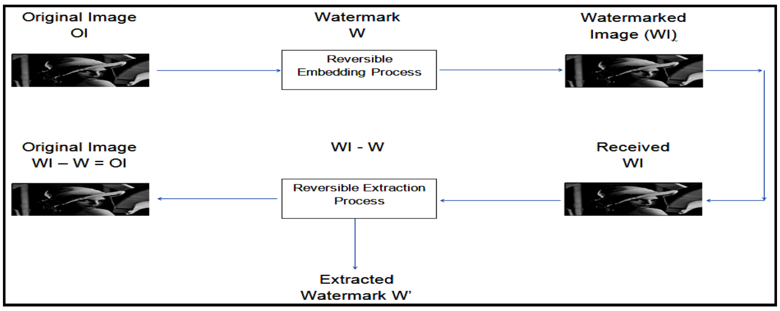


figure 1 General process of reversible watermarking

II. RELATED WORK

This analytical study is related to the reversible data hiding techniques using digital watermarking, which shows that histogram shifting with block division scheme method is better than other methods many researchers worked on reversible data hiding techniques for information hiding and achieved their target. Some of the researchers work progress towards the reversible watermarking is discussed below.

Adnan M. Alattar et al. [3] have implemented a very high capacity algorithm based on the difference expansion of vectors of and arbitrary size and concluded that the amount of data one can embed into an image depends highly on the nature of the image. Guorong Xuan et al. [4] has implemented a histogram shifting method for image lossless data hiding in integer wavelet transform domain and concluded that the method has a larger embedding payload in the same visual quality or has a higher PSNR in the same payload. Wei-Liang Tai et al. [5] has conceived the issue of virtually all histogram modification techniques is that they must provide a side communication channel for pairs of peak and minimum points. The researcher has implemented a binary tries that predetermines message and concluded that hiding capacity while keeping embedding distortion low. Ching-Chiuan Lin et al. [6] has implemented a reversible data hiding method based on expanding difference between a pair of neighboring pixels and concluded that both the capacity for embedding user message and the image quality are significantly improved. Yongjian Hu et al. [7] has conceived the issue of difference expansion embedding techniques that image quality may have been severely degraded even before the later layer embedding begins because the previous layer embedding has used up all expandable differences, including those with large magnitude. The researcher has implemented a dynamical expandable difference search and selection mechanism and concluded that their algorithm is more obvious near the embedding rate of 0.5bpp. K.H. Jung et al.[8] have proposed a novel reversible data hiding method based on neighbouring pixel value differencing, to increase embedding capacity with a good image quality and concluded that the proposed method has a higher capacity and still a good image quality. unresolved challenges the author has focused that the proposed method will be extended to authenticate for unauthorized attacks. Ki-Hyun Jung et al.[9] have proposed a novel reversible data hiding method using neighboring interpolation and pixel – value differencing on block expansion and concluded that the proposed method has higher capacity and maintains a better image quality. Unresolved challenges the author has focused that the proposed method will be improved to offer better robustness against unauthorized attacks. Li Liu et al.[10] has proposed a reversible data hiding scheme based on histogram shifting of n-bit planes and concluded that their proposed scheme achieved higher hiding capacity and also has a very satisfactory PSNR. Chin-Chen Chang et al[11] has conceived the issue in Lee and Huang's method, each set of four cover pixels can only embed five confidential bits, thereby restricting the embedding rate. to overcome the above issue researchers develops a reversible data hiding method based on the magic matrix and concluded that the proposed method has characteristics of an excellent embedding rate and good image quality.

III. REVERSIBLE DATA HIDING TECHNIQUE

Reversible data hiding techniques can be divided into various classifications depending upon critical issues. In this analytical study, it is focused on histogram shifting, neighbouring pixed and block based expansion data hiding methods in different images are explained with embedding capacity and image visual quality of an image .

A. K.H.Jung's method[8] in 2015.

Jung proposed a reversible data hiding in dual images to increase the embedding capacity and the image quality. The embedding capacity and the image quality are important measurements in data hiding methods. The proposed method uses a mean value of neighbouring pixel values as base criteria to decide the embedding bits. The proposed method is based on the sub-block embedding mechanism. The difference values are calculated by selecting basis pixel of the sub-block, and the number of secret bits is decided on three pixel pairs of the sub-block.

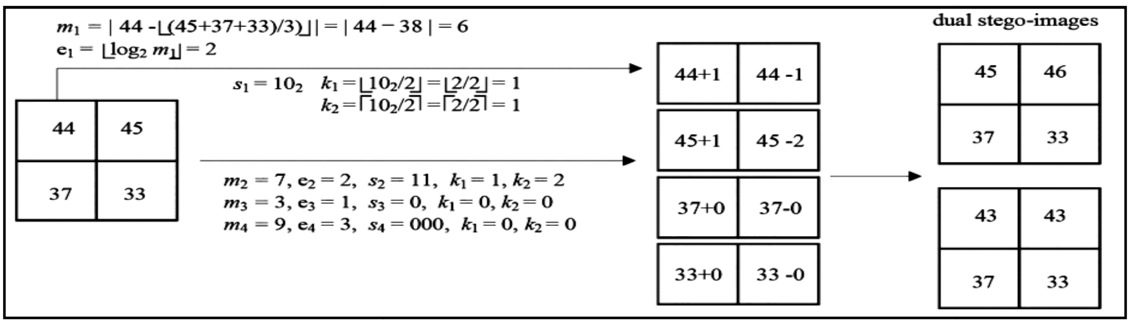


fig. 2. example of embedding procedure by Jung's in 2015

An example of the embedding algorithm is shown in Fig. 2. For a 2 × 2 sub-block, assume that (pi , pi+1) = (44, 45), (pi+2 , pi+3) = (37, 33) and the bit steams of the secret data s = 101100002 are given. First, the mean values of neighbouring pixels
m1 = |44 – [(45+37+33)/3]| = |44-38| = 6, m2 = |45 – [(44+37+33)/3]| = |45-38| = 7, m3 = |37 – [(44+45+33)/3]| = |37-40| = 3 and m4 = |33 – [(44+45+37)/3]| = |33-42| = 9 are calculated. Next, calculate the embedding size of the secret data, e1 = [log2 6] = 2, e2 = [log2 7] = 2, e3 = [log2 3] = 1, e4 = [log2 9] = 3 are obtained. For each pixel pi of the B × B sub-block, calculate the embedding integer values ki and ki+1. (ki , ki+1) = ([102 / 2], [102 / 2]) = (1, 1) for a pixel p1 = 44, (ki , ki+1) = ([3 / 2], [3 / 2]) = (1, 2) for a pixel p2 = 45, (ki , ki+1) = ([0 / 2], [0 / 2]) = (0, 0) and (ki , ki+1) = ([0 / 2], 0 / 2]) = (0, 0) are obtained for p2 and p2 respectively. For each two pixel pairs of the sub-block, a new pixel (pi1, pi2) is calculated.
(p11, p12) = (44+1, 44-1) = (45,43), (p21, p22) = (45+1, 45-2) = (46, 43), (p31, p32) = (37+0, 37-0) = (37, 37) and
(p41, p42) = (33+0, 33-0) = (33, 33) are calculated. Finally, new sub-blocks of dual stegoimages (p11, p21, p31, p41) = (45, 46, 37, 33) and p12, p22, p32, p42) = (43, 43, 37, 33) are obtained as a result.

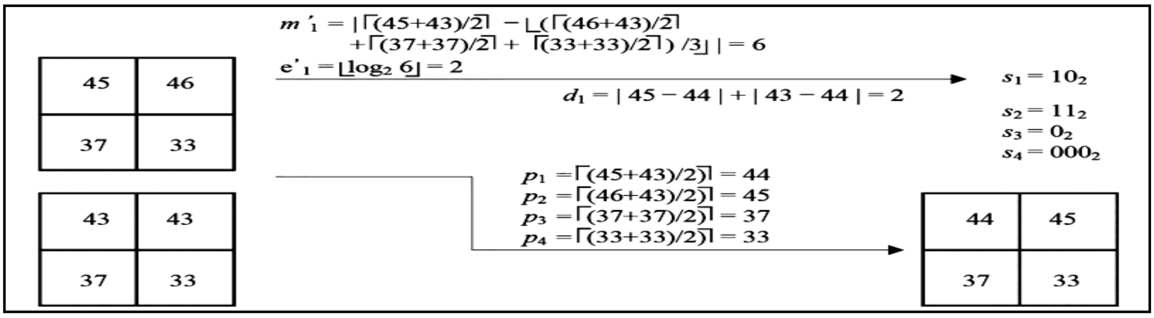


fig. 3. Example of extracting and recovering procedure Jung's in 2015

An example of extracting the secret bits and recovering the cover pixel for a 2 × 2 sub block is depicted in fig.17. The sub-blicks of dual stegoimages are given as (p11, p21, p31, p41) = (45, 46, 37, 33) and p12, p22, p32, p42) = (43, 43, 37, 33), which is obtained as given to the embedding example. First, mean values of neighbouring pixels m'1 = |[(45+43)/2] - |[(46+43)/2] + [(37+37)/2] + [(33+33)/2] /3| = |44 – [(45+37+33)/3]| = |44-38| = 6, m'2 = |45-38|=7, m'3 = |37-40| = 3 and
m'4 = |33-42| = 9 are calculated. Next, the embedding size of secret bits e'1 is calculated. e'1 = ||log26| = 2, e'2 = ||log27| = 2,
e'3 = ||log23| = 1, e'4 = ||log29| = 3are obtained as results. The cover pixel values of the sub-block can be recovered by pi = [(pi1 + pi2)/2] equation. p1 = [(45 + 43)/2] = 44, p2 = [(46 + 43)/2] = 45, p3 = [(37 + 37)/2] = 37 and p4 = [(33 + 33)/2] = 33 are obtained. The integer value of secret bit streams is calculated as follows. d1 = |45-44|+|43-44| = 2, d2 = |46-45|+|43-45| = 3,
d3 = |37-37|+|37-37| = 0, and d4 = |33-33|+|33-33| = 0 are calculated. Finally, integer values of the secret bit streams are changed to binary values by referencing the length of embedding bits, d1 = 102 , d2 = 112, d3 = 02, d4 = 0002 extracted as a result. The secret bit stream is 101100002.

B. Ki-Hyun Jung's method[9] in 2016

Ki-Hyun Jung proposed a high-capacity reversible data hiding method using block expansion in digital images. Assume that a scaling factor f = 2k(k≥0) and a secret key t are given. The proposed method repeats k times until the condition k ≤ t is satisfied. A correlated relation on k = 3 for four sub-blocks is shown in Fig. 4. as an example. If the image quality is of less distortion to the human visual system, k can be increased continuously to improve the embedding capacity. It means that the secret key t can be used to regulate the amount of embedding capacity. For a sub-block Bik of each scaling-up factor, four pixel values are defined as shown in Fig. 20 and it can be enu-merated as B00 = (p00, p10, p20, p30) for i = 0.A high embedding capacity with a good image quality is one of the most important measurements in the reversible data hiding method.

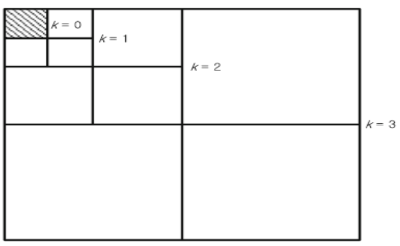


Fig. 4. A sub-block image depending upon k

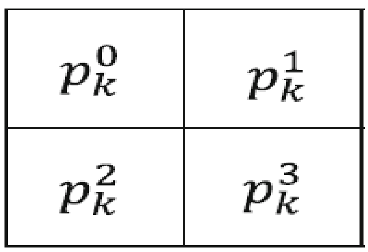


Fig. 5. Four pixel pairs of a sub-block

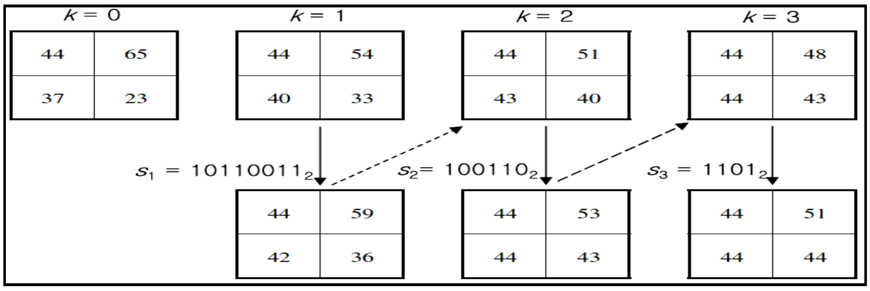


fig.6. an example of embedding algorithm by Ki Hyun Jung in 2016

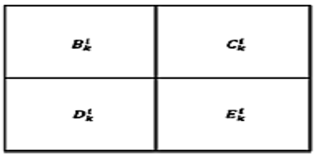


fig.7. The sub-blocks surrounding a sub-block B^i_k

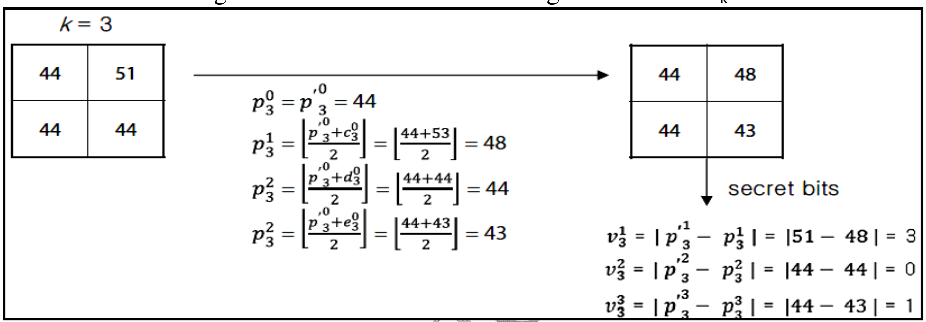


Fig .8. An Example of an extracting and recovering algorithm Ki Hyun Jung in 2016

C. Che-wei lee et al. 's method [47] in 2010.

A lossless data hiding method based on histogram shifting is proposed, which employs a scheme of adaptive division of cover images into blocks to yield large data hiding capacities as well as high stego-image qualities. The method is shown to break a bottleneck of data-hiding-rate increasing at the image block size of 8 × 8.

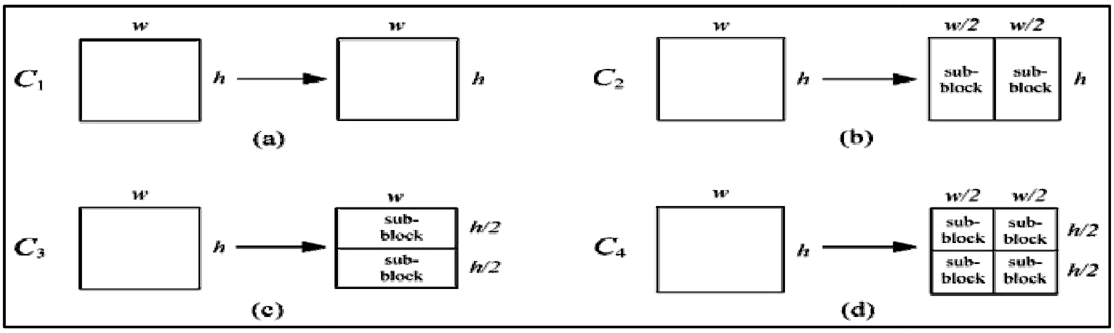


Fig. 9. Four ways of block divisions

The basic concept behind the proposed method is to divide each 8×8 block by four ways into 4 × 8, 8 × 4, 4 × 4, and the originally-adopted size 8 × 8. The four ways of block divisions are illustrated in Figure 9. The best way among the four, which provides the largest volume of space for data hiding, is then chosen adaptively to yield the best data hiding capacity.

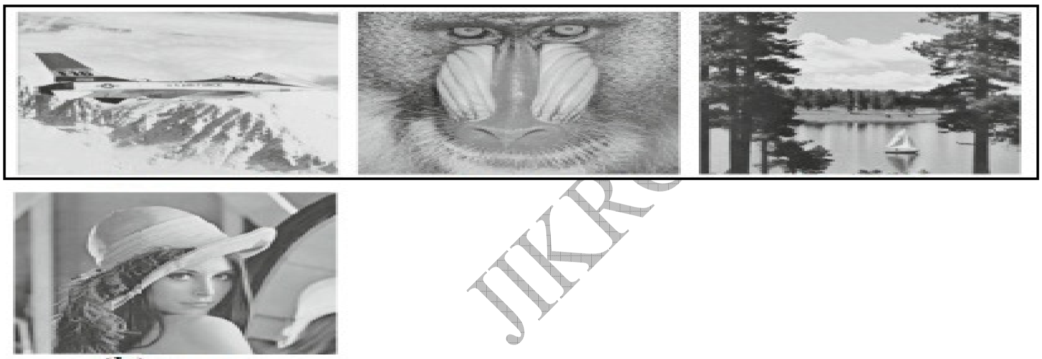
134	126	129	126	133	130	129	131
134	126	129	126	133	130	129	131
134	126	129	126	133	130	129	131
134	126	129	126	133	130	129	131
134	126	129	126	133	130	129	131
132	125	128	130	130	133	131	130
132	126	133	133	130	130	131	127
132	134	133	134	131	134	131	131

Fig. 10. Pixel values of a block of size 8 × 8 in image 'Lena'

Figure 10 shows a block in the image 'Lena' which we use to illustrate a case that a block of 8 × 8 can provide a larger data hiding capacity after it is divided into two 4×8 sub-blocks. Originally, the peak point of the entire block is found at the gray value of 126 with a hiding capacity of only 2 bits. This can be seen from the fact that there are only two pixels with gray values 125 and 127 next to 126 at its two sides. But after dividing the block horizontally by the way of block division of C3 shown in Figure 9, totally a hiding capacity of 13 bits can be generated from the upper and the lower sub-blocks with peak points 129 and 131, respectively, as can be seen from the gray values in the two sub-blocks where there are 13 pixels with gray values 128, 130, and 132, which are located next to 129 and 131.

IV. EXPERIMENTAL RESULTS

In the experiments, 512 X 512 images were used and divided in sub-blocks. The data about comparison of PSNR & Hiding Capacity of different gray scale images are shown in Table 1-4, and presented in Figure 11.



Airplane Baboon Boat Lena

To compare the imperceptibility of watermarked image, the system uses Peak Signal Noise Ratio(PSNR). Following is the formula to calculate the PSNR.

$$\mathrm{PSNR} = 10 \times \lg\left(\frac{255^2}{\mathrm{MSE}}\right)$$

Where

$$\mathrm{MSE} = \frac{1}{M \times N}\sum_{i=1}^{N}\sum_{j=1}^{M}\left[I(i,j) - I'(i,j)\right]^2$$

Higher the PSNR value means the watermarked image is closer to the original image.

Table 1 Comparison of PSNR & Hiding Capacity of Airplane image

Airplane		
Method	PSNR	Hiding Capacity
K.H.Jung's method	47.44	781964
Ki-Hyun Jung's method	33.11	477152
Che-Wei Lee et al.'s method	49.37	59397

Table 2 Comparison of PSNR & Hiding Capacity of Baboon image

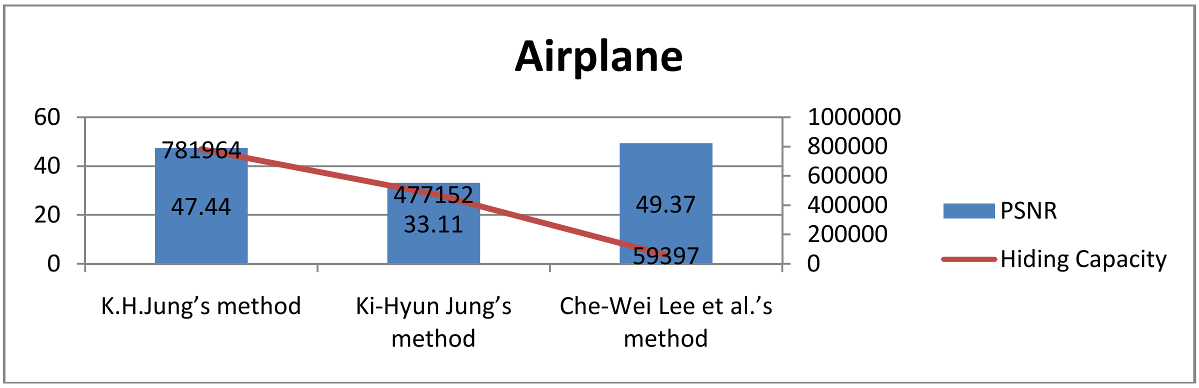
Baboon		
Method	PSNR	Hiding Capacity
K.H.Jung's method	47.49	772544
Ki-Hyun Jung's method	33.27	1054613
Che-Wei Lee et al.'s method	48.57	17455

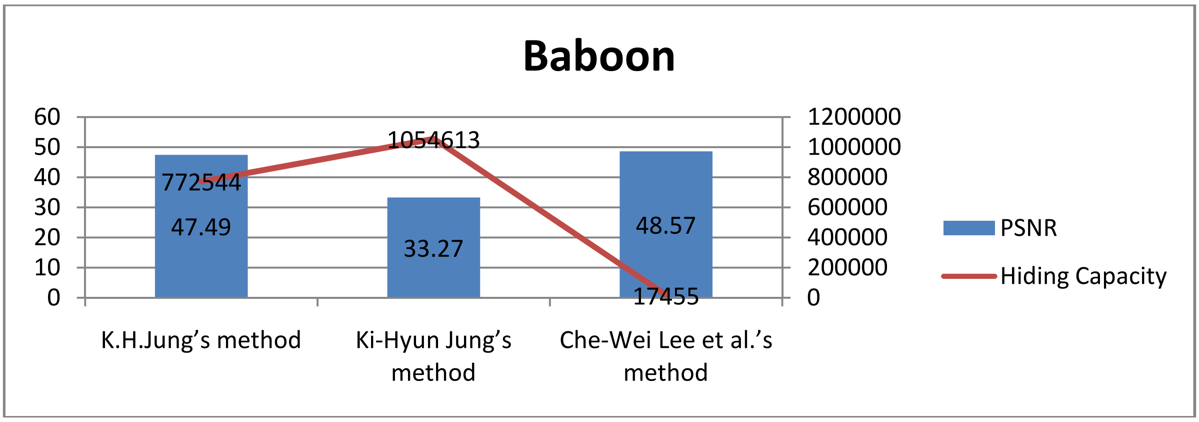
Table 3 Comparison of PSNR & Hiding Capacity of Boat image

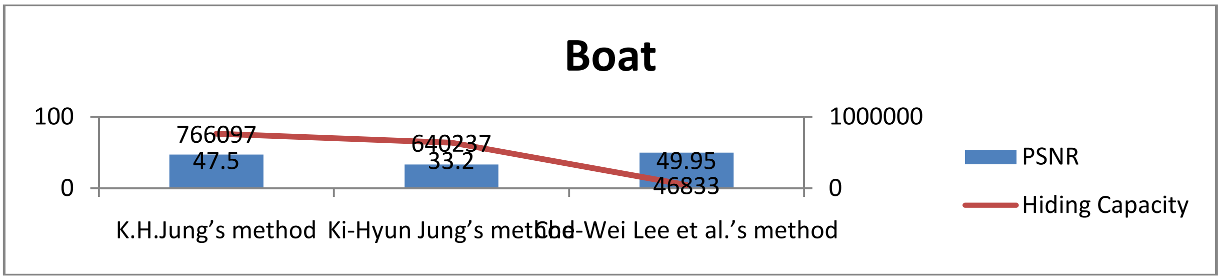
Lena		
Method	PSNR	Hiding Capacity
K.H.Jung's method	47.43	773666
Ki-Hyun Jung's method	33.15	474224
Che-Wei Lee et al.'s method	48.90	41257

Table 4 Comparison of PSNR & Hiding Capacity of Lena image

Boat		
Method	PSNR	Hiding Capacity
K.H.Jung's method	47.50	766097
Ki-Hyun Jung's method	33.20	640237
Che-Wei Lee et al.'s method	49.95	46833







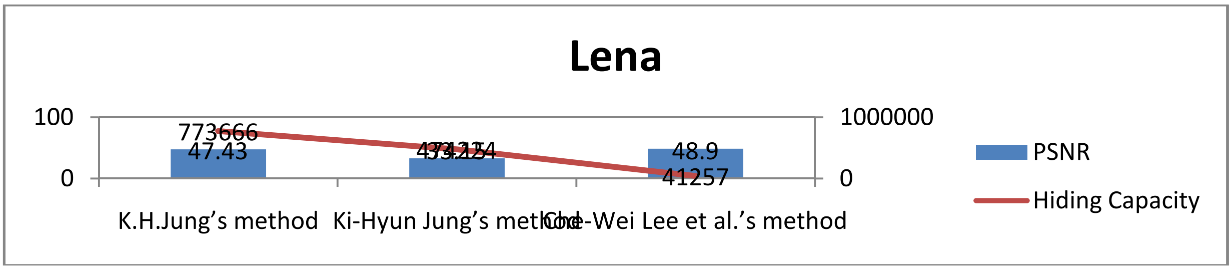


Fig. 11. Comparison of hiding capacity vs. PSNR (Image quality)

V. CONCLUSION

In this analytical study of reversible data hiding techniques has been described and analyzed. The performance of several approaches was compared in terms of the hiding capacity and the image visual quality. The Comparison of embedding capacity and the PSNR of Airplane, Baboon, Boat and Lena is presented in Figure 11. Che – Wei Lee et al.'s method and K.H.Jung's method were better then Ki–Hyun Jung's method. Ki – Hyun Jung's method had a very less capacity and PSNR values as compared to other methods.

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