A Secure Binary Image Data Hiding and Comparison Technique

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Abstract — Binary images are increasingly common in everyday life, such as signatures, drawings, and scanned documents. Hiding data in binary images can facilitate authentication, annotation, and tracking of many important documents. However, hiding data in binary images is much more difficult than hiding data in color images because black and white are the only two colors and drastically different to our eyes. One method of hiding data in binary images is to identify flippable pixels first and then manipulate them in a certain way to hide a message. After identifying the flippability of pixels, we want to manipulate them in a certain way to hide data in binary images. Here, extract the complement, rotation and mirroring-invariant local texture patterns (crmiLTPs) from the binary image, the weighted sum of crmiLTP changes when flipping one pixel is then used to measure the flipping distortion corresponding to that pixel. Based on the proposed measurement, a practical data hiding scheme is developed. The data hiding scheme generates the cover vector by dividing the scrambled image into super pixels. Thereafter, the syndrome-trellis code is employed to minimize the designed embedding distortion. Experimental results shows that the proposed data hiding scheme can achieve higher security without losing the image quality or the embedding capacity. A new binary image comparison method is also proposed. For binary images, intensity information is poor and shape extraction is more difficult. Therefore binary images have to be compared without using feature extraction. Due to the fact that different types of patterns can be present in the images, several applications in image processing, deals with binary images. The proposed method is tested on a dataset and compared with other methods to show its efficiency.

Keywords— Binary image, binary similarity measure, binary distance measure, complement,rotation, and mirroring invariant local texture pattern(crmiLTP), flipping distortion measurement.

I. INTRODUCTION

The binary image similarity and dissimilarity or distance plays an important role in pattern analysis problems like classification, clustering, etc..., many researchers have taken more efforts to determine the most important binary similarity and dissimilarity over a one hundred years. Most of the binary similarity measures and dissimilarity measures have been used in various fields.

Calculation of image similarity is a main problem in image processing. Measurement of comparison between two images is useful for the comparison of algorithms used in minimizing noise, matching of two images, coding of image and restoration. Visual tasks are usually based on the determination of uniqueness between image objects used in a corresponding feature space. In recent years, more data hiding techniques have been proposed for binary images [1]–[7], they are used to protect digitally stored hand written documents, Computer Aided Design graphs, digital signatures etc.... Image after data hiding is obtained by these methods have been reported to get better visual qualities. However, these methods remove the security against steganalyzers. The high undetectability of the secret data can minimize the suspicion from attackers and thus improve the security.

In the case of spatial domain, secret message bits are attached directly by flipping pixel values in a binary image. Unlike gray scale images, a pixel in binary images has two states such as black (1) and white (0). Content based query systems may operate a query on the basis of a classification technique. The performance of the total query system depends on the definition of suitable matching method based on Image Distance Functions .Here divided the cover image into overlapped and non overlapped blocks, finally found the most appropriate flipping location in each block.

By using 2×2 size blocks and double image processing, the technique used nearly all the shifted edges to embed message bits and hence obtained a large payload. Matrix embedding is commonly used to generate a high embedding performance. Filler used a practical matrix embedding, syndrome trellis code (STC), to embed near the capacity distortion bound with respect to the specified distortion measurement.

The above technique measures the embedding distortion score according to the human visual system (HVS). Therefore, the image after data hiding is present high visual qualities and usually cannot be differentiated from the cover images by human eyes. To make a data hiding technique secure, a proper way is to model the image statistic and minimize the embedding capacity on that model .Binary images usually represent the texture, here uses the texture model to determine the embedding distortion measurement. There are 3 types of methods defining the texture of an image: geometry based, statistic based, and model based techniques. In the proposed measure, the first and second types are joined together to define the texture with respect to spatial structure and statistical distribution. To extract the local texture pattern (LTP) first, as the texture primary. The histogram of LTPs is used to describe the texture distribution. The LTP is motivated by the concept of the local binary pattern (LBP), which has been efficiently applied in texture classification, face detection, etc... Binary images has different visual appearance compared with gray scale images, an extension of the Local Binary Pattern, the complement, rotation, and mirroring invariant local texture pattern (crmiLTP), is developed suitable for binary image data hiding. The texture portion is more suitable for binary image data hiding. So, it is expected that a good image after data hiding can be obtained in the texture model.

Here, a spatial domain based binary image data hiding method is used. This method minimizes a novel flipping distortion measurement .This method considers both Human Virtual System (HVS) and statistics. This measurement uses the weighted addition of complement, rotation, and mirroring invariant local texture pattern changes to measure the flippability of a pixel. The weight value according to each complement, rotation, and mirroring invariant local texture pattern is set to that pattern's sensitivity to the embedding distortion measurement. To calculate the sensitivity, a collection of generalized embedding simulators are organized to generate image after data hiding with different distortion types and strengths. In the embedding phase, syndrome trellis code is employed to minimize the flipping distortion. To delete the unexpected flipping incurred by syndrome trellis code, the concepts of scrambling and super pixels are used to guarantee that flippable elements present usually in a cover vector. By incorporating the new distortion measurement with the syndrome trellis code framework, the proposed data hiding technique presents a better performance compared with existing data hiding methods.

II. IMPLEMENTATION

In this paper, presents the texture property of binary images and propose an efficient binary image data hiding with similarity matching method based on texture. The proposed complement, rotation, and mirroring invariant local texture pattern is tolerant of binary image processing and describe the local structure of binary image texture. Then, find that the change in the complement, rotation, and mirroring invariant local texture pattern distribution value varies with the detectability of the embedding distortion measure. So, the proposed flipping distortion measurement related to the weighted addition of complement, rotation, and mirroring invariant local texture pattern changes, where the weight is empirically assigned corresponding to the discrimination power of the complement, rotation, and mirroring invariant local texture pattern histogram.

By comparing with existing Human Virtual System based methods, it can be shown that the proposed distortion measurement performs best on image quality as well as its security. It is noting that, giving statistical model is used to design distortion measurements may cause the problem of embedding in the clean edges, which minimizes the data hiding security in gray scale images [10]. However, this characteristic provides a reasonable tradeoff between the image quality and the image security in binary images, since distortions not on the boundary are easily to be detected. At last, a practical data hiding technique is developed by combining the proposed flipping distortion measurement with the syndrome trellis code (STC). Experiments on the constructed image dataset have shown that this data hiding technique can give more secure image after data hiding with better, at least similar, image qualities when the same length of message bits are hidden. The complement, rotation, and mirroring invariant local texture pattern and the proposed distortion measurement are further used for other binary image applications, like binary image classification and the assessment of error diffusion methods.

III. DISTORTION MEASUREMENT

A. *Complement, Rotation, and Mirroring-Invariant Local Texture Pattern*

As a property of areas, the texture contains the spatial distribution of pixels or pixel groups [17]. The invariance against various visual appearances is needed for a texture descriptor. For example, the gray scale, rotation invariant local binary pattern technology has been commonly used in texture classification and provided noticeable results [15], [16]. Therefore, here introduce this technique, which is herein known as the local texture pattern (LTP), to this texture model. Binary image processing commonly refers to complement, rotation, and mirroring, as shown in Figure. 1. As a result, a LBP which is invariant against these processing, namely a complement, rotation, and mirroring invariant local texture pattern, is developed to suitable for application in binary images.

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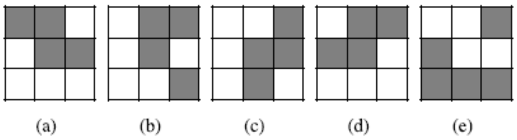

Fig. 1. Demonstration of different binary image processing. Patterns (b) and (c) are the 45° and 90° rotated versions of pattern (a), respectively. Pattern (d) is obtained by mirroring pattern (a) (i.e., flipping the columns of pattern (a) in the left-right direction) and pattern (e) by inverting pattern (a). According to the proposed crmiLTP, Patterns (a), (c), (d), and (e) have the same value as 47 while the value of pattern (b) is 61.

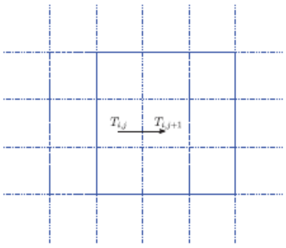

Fig. 2. One time scanning along the horizontal direction.

The Local Texture Patterns are received by scanning the image with a 3 × 3 grid pattern size. Previous work has represents that, if the scanning step is greater than 2, many interested patterns cannot be found [4], [7]. Further, the generated patterns vary with the location the scanning starts. To guarantee that all the patterns can be found in both original and cropped images, the scanning step is set 1 pixel length, as demonstrated in Figure 2. Let the pattern *Ti, j* represents a local neighborhood of a monochrome texture that is centered at the location *(i, j)*and covered by a 3 × 3 size grid. That is

$$T_{i,j} = \{I_c, I_0, I_1, \dots, I_7\} \qquad (1)$$

Where the pixel *I*c represents the center pixel of T*i, j*, and I*k* ,k = 0, 1, ... , 7, denote the 8 neighboring pixels, which are depicted in Figure. 3. Herein, the white and black pixels are assigned with ZERO and ONE, respectively. Consider the image complement processing first. Inverting all the pixels in a binary cover image does not depend on the representation of the binary image content. However, this processing usually changes the texture distribution dramatically, which confuses the Local Texture Pattern based statistics. As a result, the complement invariance is necessary. For this purpose, an exclusive OR operation is performed on the center pixel and all the pixels in *Ti, j* to generate the new pattern $T_{i,j}$, written as

$$T_{i,j} = \{Ic \oplus Ic, I_0 \oplus Ic, I_1 \oplus I_c, \dots, I_7 \oplus Ic\} \quad (2)$$

All the normalized patterns possess the similar center pixel value and are invariant of pattern complement.

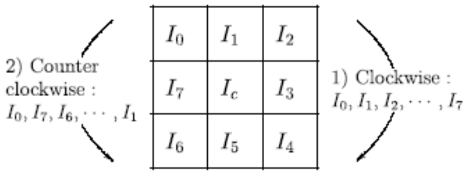

Fig. 3. The neighborhood of $T_{i,j}$. Neighboring pixels are labeled with 0, 1, . . . , 7. These numbers also indicate the scanning sequence used in Eqs. (3) and (4).

Different values need to be assigned to these complement invariant patterns. The technique in [16] is designed to prevent arbitrary degrees rotation. However, each pixel in a binary image is a black or white square and delicate towards rotation, as shown in Figure. 1(b) and (c). As a result, here only consider 90 degrees rotation invariance, a unique value will be assigned to a pattern and all its multiples of 90 degrees rotated versions. As shown in Figure. 3, there are 8 neighborhood pixels in one 3×3 size grid pattern, in which adjacent neighborhood pixels are 45 degree apart. Therefore, the neighborhood pixels are 2 bits wise rotated in the clock wise direction by 4 times. The value according to each time rotation is determined and the value of $T_{i,j}$ is set with the minimal one. Mathematically, the value of $T_{i,j}$ traced in the clockwise direction, denoted as $LTP^{c}_{i,j}$, is calculated as shown in eq(3).

$$LTP^{c}_{i,j} = \min_{b=0,1,2,3} \sum_{k=0}^{7} (I_c \oplus I_{(k+2b) \bmod 8}) \times 2^k \qquad (3)$$

The mirroring processing refers to flipping the rows of an image in the up-down direction, or the columns in the left right direction. To get the mirroring invariance, we scan the neighboring pixels in $T_{i,j}$ in the counter clockwise direction again, as shown in Fig. 3. Similar to the clockwise direction, these neighboring pixels are then two bits wise rotated in the counter clockwise direction and the score of counter clockwise is $T_{i,j}$, denoted as $LTP^{cc}_{i,j}$, is set with

$$LTP^{cc}_{i,j} = \min_{b=0,1,2,3} \sum_{k=0}^{7} (I_c \oplus I_{(-k-2b) \bmod 8}) \times 2^k \qquad (4)$$

The final value corresponding to $T_{i,j}$ is assigned with

$$LTP^{crmi}_{i,j} = \min\{LTP^{c}_{i,j}, LTP^{cc}_{i,j}\} \qquad (5)$$

An example, patterns in Figures. 1(a), 1(c), 1(d), and 1(e) are all equal to value 47 after the above calculation, finding the invariance property of the complement, rotation, and mirroring invariant local texture pattern. We know that there are many extensions to the local binary pattern, like the multiresolution and high dimensional versions [15]. Experimentally we show that, due to the simple representation of binary images and the lack of samples, these extensions will not perform more benefits and sometimes even not stronger the working performance when they are utilized in binary images.

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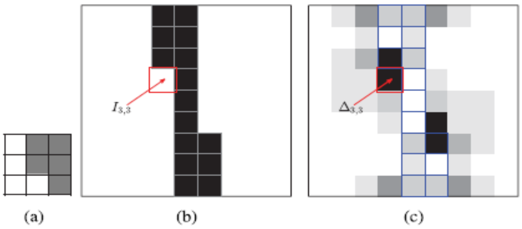

Fig. 4. (a) An example of the "*l*-shape" pattern. (b) A binary image that contains 2 "*l*-shape" patterns. (c) The corresponded changing map Δ. In (c), pixels are represented by squares, of which the black pixels are surrounded by solid lines. The grayscale of the square face represents the value of $\Delta_{i,j}$, which varies from 4 to 18. The smaller the $\Delta_{i,j}$, the darker the square face.

It is noting that prior measurements also get these invariance properties. Further, the flipping invariance in a binary image has been discussed in [4], [5], and [7] in the perspective of better visual quality. In the complement, rotation, and mirroring invariant local texture pattern, the purpose of image processing invariance is to avoid the problems of calculating both visual quality and statistics.

B. Definition of Flipping Distortion

An embedding working that can better preserve an image model is usually more secure [9], [12], [13]. Again, data hidden in the image texture portion has been known not easy to be detected [10], [20]. Based on these the proposed flipping distortion methods is formed as the noticeable embedding changes in the complement, rotation, and mirroring invariant local texture pattern distribution. It can be seen that the change in the number of complement, rotation, and mirroring invariant local texture patterns when flipping one pixel can simply represent the flippability of that pixel. It is usually suggested that the best flippable pixels are situated at the center of *l*-shape patterns shown in (e.g., Fig. 4(a)) [3], [4], [7].According to the scanning strategy shown in Figure.2, most of the appearances or disappearances of patterns will be maintained in the next scanning when flipping the center pixel of a *l*-shape pattern. Let the letter **X** denote the cover image and **Y***i, j* denote the image after data hiding is received by only changing the pixel located at *(i, j)*, i.e., *Ii, j* , of the cover image **X**. The change in the number of crmiLTPs when flipping *Ii, j* can be calculated as

$$\Delta_{i,j} = \sum_{t=0}^{255} \left| H_t^{\mathbf{X}} - H_t^{\mathbf{Y}_{i,j}} \right| \qquad (6)$$

where $H^{\mathbf{X}}_t$ and $H^{\mathbf{Y}_{i,j}}_t$ are the histogram coefficients corresponding to the complement, rotation, and mirroring invariant local texture pattern s with value similar to *t* which are calculated from images **X** and $\mathbf{Y}_{i,j}$, respectively, computed by

$$H_t = \sum_{i=1}^{l_w-2} \sum_{j=1}^{l_h-2} \delta(LTP_{i,j}^{\mathrm{crmi}} = t) \qquad (7)$$

Here now associate the distortion value with the statistical security. The histogram is a generally give statistic for the Local Binary Pattern [15], [16], [18]. Again, more practical data hiding methods try to offer security by preserving the histogram [12], [13]. Therefore, the statistical security is herein determined on the complement, rotation, and mirroring invariant local texture pattern histogram defined in Equation. (7).

$$F_t = \frac{(\mu_{H_t^{\mathrm{X}}} - \mu_{H_t^{\mathrm{Y}}})^2}{\sigma^2_{H_t^{\mathrm{X}}} + \sigma^2_{H_t^{\mathrm{Y}}}} \qquad (9)$$

where $H_{\mathrm{X}}{}^t$ and $H^{\mathbf{Y}}{}_t$ stand for the histogram coefficients calculated from the cover and image after data hiding images, respectively.

Let *Wt* represents the weight corresponding to the complement, rotation, and mirroring invariant local texture pattern whose score is *t*. It is set with the larger Fisher's criterion over determining all the given simulators, since this work is experimentally found to give image after data hiding with the better visual qualities. Observing that only a small of complement, rotation, and mirroring invariant local texture pattern present considerable performances in the above evaluation, here simply assign non zero weights to the highest 20 complement, rotation, and mirroring invariant local texture pattern. These crmiLTPs and their weight values are shown in Figure. 6. For the remaining, here set their weights to 0. The larger the weight is, the more heavily it penalizes the corresponded complement, rotation, and mirroring invariant local texture pattern changing. At last, the flipping distortion related with pixel *Ii, j* is used with the weighted addition of complement, rotation, and mirroring invariant local texture pattern changes, formed as

$$D_{i,j} = \left(\sum_{t=0}^{255} W_t \left| H_t^{\mathbf{X}} - H_t^{\mathbf{Y}_{i,j}} \right| \right)^{\alpha} + \beta \qquad (10)$$

Where the *α* and *β* can be used to control the sensitivity of the distortion value to the boundary structure. They are empirically set as *α* = 1/2 and *β* = 1/2, which can attain the better image quality. Further, here define the distortion score map named **D** as the matrix that consists of *Di, j* as its *(i, j)* th element. A data hiding technique should only change the pixels with the minimum distortion scores.

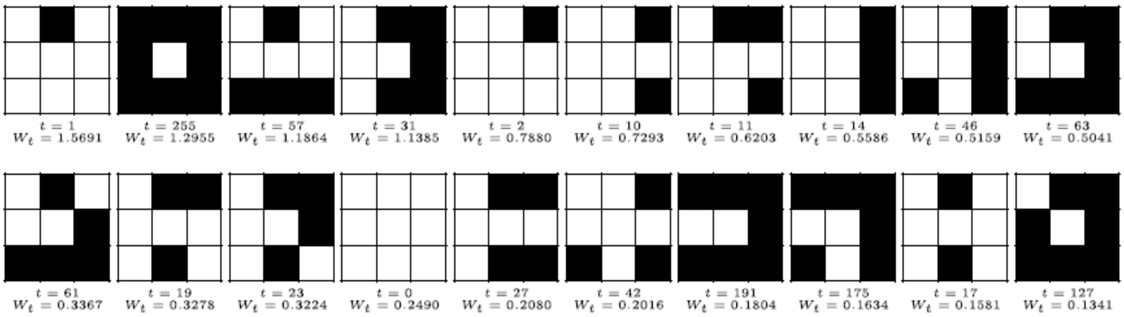

Fig. 6. The 20 crmiLTPs whose corresponded histogram coefficients perform best in the evaluation phase. Their values t and the corresponded weights W_t are given below each pattern. For those not included in this figure, we set their weights to 0. Note that this weight is not directly used to measure the flippability of the center pixels in that pattern, which is different from [3] and [4].

IV. PROPOSED TECHNIQUE

1) Binary Image Data Hiding

Matrix embedding can be used to minimizes the embedding impact on the designed distortion measurement when the payload is given a practical optimum code, namely Syndrome trellis code (STC), is used to embed near the Payload distortion bound. The Syndrome trellis code uses the convolutional code with a Viterbi algorithm based encoder to minimize the additive distortion function.

A. Embedding and Extraction Procedure

Based on the proposed distortion measurement and STC, the data hiding technique is constructed in this subsection. It consists of the embedding and extraction procedures, whose block diagrams are shown in Figures. 7 and 8,

i. Embedding Procedure

Given a $l_w \times l_h$ size binary image **X**, we first divide **X** into non-overlapped blocks.

Step 1: Calculate Distortion score map named (D) of input image (X).
Step 2: Divide X and D into non overlapped blocks.
Step 3: Select all non-uniform blocks.
Step 4: Scrambling X and D with same seed.
Step 5: Embed secret message segment with cover vector using STC encoder.
Step 6: Flip the pixel with lowest distortion score.
Step 7: Repeat 5 and 6 until all message segments have been embedded.
Step 8: Descrambling the embedded image blocks.
Step 9: Reconstruct the image (Image after data hiding).

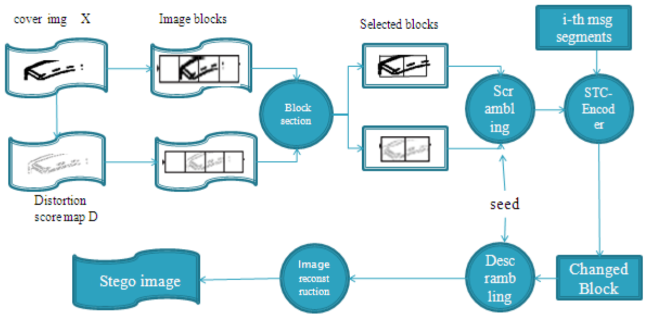

Fig. 7 .Embedding Block Diagram

ii. Extraction Procedure

In the extraction procedure, I_C, I_I, Im, and the scrambling seed are required so that same STC can be constructed.

Step 1: Divide the image after data hiding into non overlapped blocks.
Step 2: Select the blocks and perform scrambling.
Step 3: To extract i th message segment using STC decoder.
Step 4: Repeat 3 until all the message segments have been completely extracted.

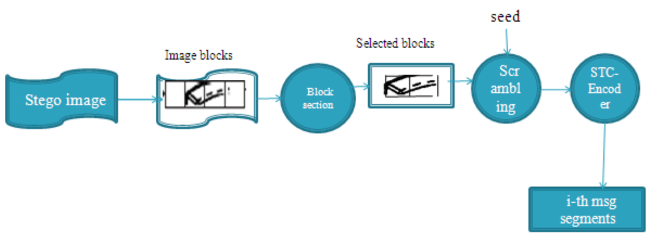

Fig. 8 Extraction Block Diagram

Fig 9 shows the testing result of different binary cover images .Different types of dimensions are taken. Testing result shows that the proposed technique has higher embedding security.

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Cover image	Original width	Original height	Embedding efficiency
River	694	633	2.00
Chick	446	535	2.66
Dog	506	568	2.00
Pig	381	622	2.00
Rabbit	311	252	2.00
Tiger	1580	1420	2.00
Squirrel	571	610	2.00

Fig: 9 Testing Analysis

2) Binary image matching method

Comparing two binary images has a lot to contribute to the image processing community. In this paper we propose an efficient binary image similarity matching technique based on the Manhattan distance of the pixel values in the images compared.

Manhattan distance is the distance between two points in a grid based on a strictly horizontal or vertical path, which means that along with the grid lines, as opposed to the diagonal distance. The Manhattan distance is the addition of the horizontal and vertical components, where the diagonal distance is computed by using the Pythagorean Theorem

<u>Working Procedure</u>

1. Read the binary image and resized into 72x144.
2. Extract the feature
   2.1. Calculate the distance map using equation 10.

$$D_{i,j} = \left(\sum_{t=0}^{255} W_t \left| H_t^{X} - H_t^{Y_{i,j}} \right| \right)^{\alpha} + \beta \qquad (10)$$

3. Repeat steps 1 and 2.
4. Calculate the Manhattan distance from these two measures.
5. Empirically set a threshold value.
6. If Manhattan distance less than the threshold value.
   6.1. Print “Images are same”.
   6.2. Else Print “Different images”.
7. End.

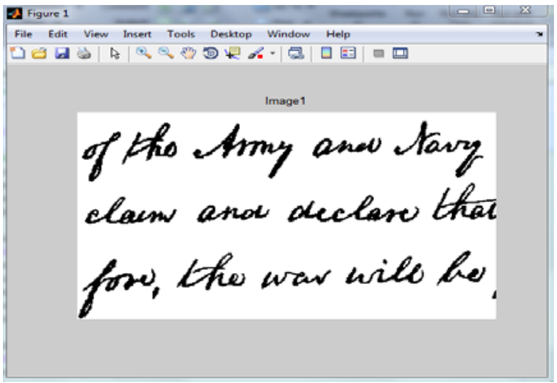

Fig 10: First Image

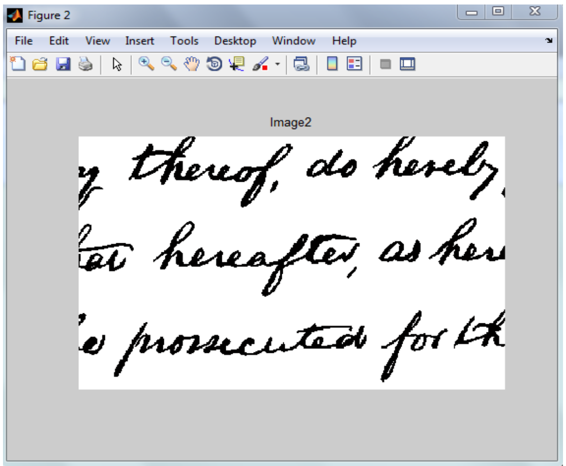

Fig 11: Second Image

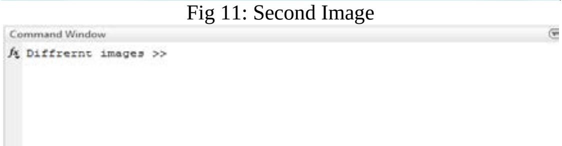

Fig 12: Comparison Result

V. EXPERIMENTAL RESULTS

HVS stands for human virtual systems it is presented in [3].DRD calculates the reciprocal distance measurement presented in [18].SBIS secure binary image data hiding in [10].LBP stands for local binary pattern in [15].EBID represents the Efficient Binary Image Data hiding technique.

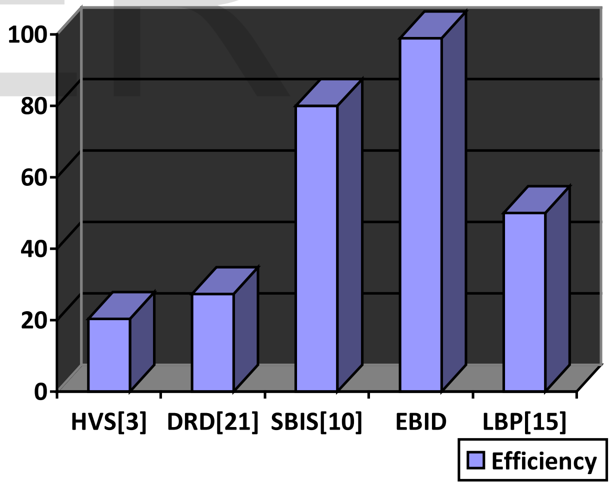

Fig 12: comparison graph

Experimental result shows that proposed efficient binary image data hiding technique gets the best distortion measurement. As a result, the proposed technique can provide efficient comparison technique.

VI. CONCLUSION

An efficient binary image data hiding with similarity matching method is proposed in this paper. This method is based on the distortion measure that provides an efficient way to select the flippable pixels in embedding. Experiments on the constructed image have shown that the proposed data hiding scheme can give more secure image after data hiding with better image qualities when the equal length of message bits are embedded. A new similarity method is presented that enables the distortion measurement of the dissimilarities in the case of binary images. It based on the Manhattan distance. This method can be applied for the retrieval of different kinds of binary images from a large data set.

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