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Development of Universal Steganalysis using Co-Occurrence Matrix Features for the Corner Image Pixel and Performance Analysis

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Abstract— *A very versatile kind of hidden data detection technique which can detect any hiding technique is known as universal steganalysis. Universal hiding technique development is preferred in the transform domain because after transformation the image coefficients gives the information about the frequency distribution of the different pixel values which appears in the image in the spatial domain. The designing and testing of the developed technique is implemented for the JPEG steganographic techniques i.e. F5, Jsteg, Outguess and DWT based. The corner matrices is evaluated from the the original image matrix and then discrete wavelet transformation is implemented as transformation function. The co-occurrence statistical features are calculated from these transformed corner matrices. These features are the second order statistical features which captures the variations in the image pixels due to hiding. The Support Vector Machine is then implemented for the evaluation of detection scheme. The proposed technique is compared with the related existing technique and quite appreciable result is obtained.*

Keywords— *Steganography, Steganalysis, DWT, SVM, Stego Image, Cover Image*

1. INTRODUCTION

The reverse technique of the data hiding is known as steganalysis i.e. the detection of the hidden data. The blind detection technique is the general class of steganalysistechniques that can be implemented for any hiding algorithm. The hidden data whether it is a text or image and in any format can be detected.If the data hiding is done after applying any mathematical transformation such as discrete cosine transform(DCT), discrete wavelet transform(DWT) and then quantization to the image pixel coefficients, comes under the category of transform domain steganography. The DCT is the most common one. As per the history of this technique, it is found that the terrorist very much use the hiding technique for communicating the secret information since last 15 years. Since passed years, various techniques were implemented to stop the secret data transmission by detecting the secret data using data hacking technique. Though there is vast development in the designing of the hiding technique, in the same space the improvement in the detection technique is also going on.For the favour of society and country and for the whole world, the work in the hidden data detection technique will be helpful. Day by day from small village to a metropolitan city, the use of internet is becoming popular.

The work discussed here is based on the designing of a blind detection scheme for the gray scale JPEG image in transform domain.If we analyze any image in detail, it is the finding that the corner pixel values of the objects within an image also carry the statistical information about the image.The statistics of the image get changed due to hiding the secret data. The DWT is the domain transformation mathematical tool which represents the image in both spatial and frequency domain.The wavelets obtained after DWT transformation carries the image information. The coefficient dimension depends on the various levels of orientations and scales that can be selected according to the requirement.For the blind steganalysis, the statistical detection is powerful. These aspects of the image are mathematically explained by statistical parameters known as image features since the features of natural images get violated when embedding process is applied. So, for designing an efficient detection technique, the statistical features of the images are calculated before and after implementing the hiding technique.

Support vector machine is a powerful multiclassification data mining tool. The performance computation of the detection scheme is done by using by commonly used classifier support vector machine (SVM).

The organization of the paper is as follows. The literature review of the related to various JPEG steganographic scheme and blind steganalysis techniques for JPEG images work is discussed in section - II. Then in the methodology, an overview of the proposed technique is discussed section - III. The image feature extraction technique is discussed in detail with mathematical formulae and classification technique in section - IV i.e. Image statistics section. In the experiments and results section-V, the classifier result for the proposed technique is shown along with the comparison performance result

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with the[7], [8], [10] and [12] performance result. Finally conclusion is derived in section-VI.

2. LITERATURE REVIEW

The present work targeted four steganographic methods. They are Outguess[1], F5[2], Jsteg[3] and DWT [4] is used for generating stego image. In Jsteg [3] data hiding technique, zero and one coefficient is not used for hiding. In Outguess[1], The secret data is embedded into the redundant bits of data sources such that the global histogram is preserved. It adjust untouched coefficient to preserve the histogram. F5[2] modifies the block-DCT coefficients to embed messages. This technique is based on straddling and matrix coding.Straddling scatter the message as uniformly distribution and matrix coding improves embedding efficiency. In DWT based steganography, the secret data bits are hidden in the wavelet coefficients of the image after implementing three levels of scaling and rotation. This technique also preserves global histogram after and before hiding. This detection percentage is less as compared to other mentioned technique.

The smoothness, regularity, continuity, consistency and periodicity of an image are the few image features which get very much varied when the pixel values of cover image get changed due to the embedding process. Their exist the intra and inter pixel correlation with respect to the above parameters. Any statistical parameter which represents this relationship may become a good tool for the detection purpose.All the statistical parameters can be categorized as first order and higher order statistics. Fewsteganalysis approach for detecting the JPEG steganography in transform domain is discussed. All the paper used SVM as data mining tool. Almost in all the paper it is tried to improve the detection percentage by modifying the existing statistical methods or by changing the domain or by changing the classifier. There is some technique which is very specific to frequency domain and spatial domain separately but some are domain independent.

A universal steganalyzer is proposed which is based on image's higher order statistics [5]. The high order statistics are calculated for each high frequency subband which is obtained by the decomposition of the image by quadrature mirror filters and another set of statistics are calculated for the errors in an optimal linear predictor of the coefficient magnitude.Fridrich has proposed a set of distinguishing features from the BDCT domain and spatial domain from the calibrated image [8]. This scheme performs better than [9] in attacking JPEG steganography.In [10], Shi et.al. presented a universal steganalysis system by calculating the statistical moments of characteristic functions of the image from its prediction-error image in DWT domain. This steganalyzer provides a better performance than [5], [8] in general.In[6,12,13], the inter-pixel and intra-pixel dependencies are used as features by Markov chain model. In the markov's process, the average transition probability matrix is calculated for the horizontal, vertical, main diagonal and minor diagonal difference JPEG 2-array [8].This approach provide better result.The mean, variance, kurtosis and skewness are calculated from the calibrated DWT image which gives better result than with the calibrated DCT imagein [7]. In [12], Mahindra Kumar improved the blind steganalysis technique using the two step transition probability matrix and extended DCT features in DCT domain. The results of this paper are very appreciable as compared with the previous detection techniques. In [14], co-occurrence matrix and statistical moment is calculated from the contourlet coefficients of the image and further SVM is used for classification.

3. METHODOLOGY

In the proposed technique, the co-occurrence parameters which explain the image characteristics [14] isused as statistical features and the concept of the corner matrix is also implemented. The discrete wavelet transformation is used as transformation function to the image. So, the proposed technique includes the extraction of the statistical features from the corners pixels of the image object in the DWT domain [7]. The proposed method is implemented to attack the advanced JPEG steganographic methods.

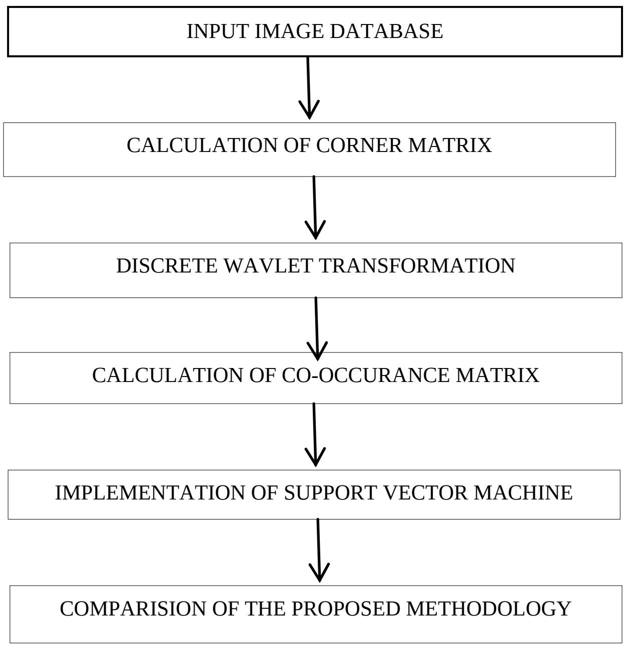

Fig. 1: Block Diagram of the Proposed Scheme

Finally the performance analysis of proposed detectiontechnique is performed with support vector machines (SVM) over a diverse data set of 4000 JPEG images for each technique. The better results have demonstrated the effectiveness of our proposed scheme. The proposed scheme is represented in Fig 1.

4. IMAGE STATISTICS

4.1 Corner Characteristics of an Image

In an image, the corner pixel values are also one of the parameter which evaluates the relationships among the outline of each character in an image. The large variations in the neighbourhood are captured in the corner matrix. The corner detection block can be findout in an image using the Harris corner detection, which maintains the tradeoff between accuracy and computational complexity.Theblock finds the corners in the image based on the pixels that havethe largest corner metric values. The corner matrixdimension is similar to the image dimensions for the grayscale image.

Let A,B and C are the parameters calculated using the equation (1).

$$A = (I_x)^2 \otimes w$$

$$B = (I_y)^2 \otimes w$$

$$C = (I_x I_y)^2 \otimes w \quad (1)$$

Where I_x and $I_y$are the gradients of the input image, I, in the x and y direction, respectively. The $\otimes$ symbol denotes a

convolution operation.Harris corner detection calculates the corner matrix using the formulae in equation (2).

$$R = AB - C^2 - k(A + B)^2 \quad (2)$$

The variable k corresponds to the sensitivity factor.

You can specify its value using the sensitivity factor (0<k<0.25) parameter. The smaller the valueof k, the more likely it is that the algorithm can detect sharp corners. The default value is 0.04.

4.2 Discrete Wavelet Transformation

For an image, wavelet Transform represents it with respect to different locations and scales. The wavelet decomposition of an image contains wavelet function ψ which represent the high frequencies. The detailed parts of an image are represented by wavelet function whereas the scaling function ϕ which represents the low frequencies or smooth parts of an image. At the resolution level i, the approximation of the one dimensional function f(t) is fi(t) and its details denoted by di(t) are included in approximation at resolution level such that fi + 1(t) = fi(t) + di(t).The two dimensional DWT can be derived from one dimensional wavelet function It can be obtained by multiplying the two 1D DWT function. Three wavelet functions are obtained. Since images are two dimensional so 2D DWT can be implemented for the analysis.Haar filter is used for obtaining second level four bands at each level i.e. low-low (approximation sub-bands), low-high (vertical sub-bands), high-low (horizontal sub-bands) and high-high (diagonal sub-bands).

4.3 Co-Occurrence Matrix

Co-occurrence matrix is defined over an image as thedistribution of co-occurring values at a given offset. Mathematically, a co-occurrence matrix C is defined overan n x m image I, parameterized by an offset (Δx, Δy) is represented in the equation (3).

$$C\ \Delta x, \Delta y\ (x,y) = \sum_{p=1}^{n} \sum_{q=1}^{m} X$$

Where X = 1;if I (p, q) = i andI (P +Δx, q +Δy) =j

X = 0; Otherwise (3)

The co-occurrence matrix is determined using a set of 4 offsets sweeping through 180 degrees (i.e. 0, 45, 90, and 135 degrees) at the same distance to achieve a degree of rotational invariance. Also four statistical features (homogeneity, contrast, angular second moment, and correlation) are extracted from co-occurrence matrix of DWT coefficients of corner metric matrix respectively. Homogeneity measures the closeness of the distribution of elements in the matrix. Contrast shows the amount of local variation present in an image. Angular second moment (ASM) is a measure of uniformity of the image and correlation is a measure of gray-tone linear dependencies in the image.

Homogeneity $= \sum_{i,j} \left(\frac{1}{1+|i-j|}\right) p\ (i,j)$

Contrast $= \sum_{i,j} |\ i-j\ |\ 2\ \ p\ (i,j)$

Energy ASM $= \sum_{i,j} \{\ p\ (i,j)\}2$

Correlation $= \frac{\sum_{i,j} (ij)\, p\, (i,j) - \mu x\, \mu y}{\sigma x\, \sigma y}$

Where σ_x and σ_y are the standard deviations and μ_x and μ_y are the means of p_x and $p_y$respectively. P (i, j) is the (i, j) the entry in a normalized gray – tone spatial dependence matrix which is p (i, j) = $p_{\Delta x, \Delta y}$ (i, j) / R, where R is the total number of pixel pairs (i, j).The gray-level co-occurrence matrix is calculated. The value (i, j) in the matrix denotes that how many times the pixel with value i occurs horizontally adjacent to a pixel of value j.Energy is also known as uniformity, uniformity of energy, and angular second moment. Contrast is also known as variance and inertia.

4.4 Data Classification using Support Vector Machine

A well-known multiclassfieris Support Vector machine is used for training and testing the datasets. SVM is carrying the property of robustness.SVM is a classification and regression prediction tool that uses machine learning theory to maximize predictive accuracy which avoids the over fitting to the data. Implementing this technique each image of the dataset is used as training data and testing data. From the information of the confusion matrix the classifications parameters can be calculated using TN (True Negative), FP (False Positive), and FN (False Negative), TN (True Negative) value. Cross validation is used while selecting the training and testing dataset. The parameters discussed here are:

$$\text{Sensitivity} = \frac{TP}{TP+FN}$$

$$\text{Precision} = \frac{TP}{FP+TP}$$

$$\text{Fall Out} = \frac{FP}{FP+TN}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+FN+TN} \quad (5)$$

The performance of a steganalysis classifier can also be visualized by ROC(Receiver Operating Characteristic) curve. More the area of the curve more is true prediction.

5. EXPERIMENTS AND RESULTS

5.1 Image Set

The image set of 4000 JPEG images with quality factors ranging of 90 is used for the implementing the algorithm and testing.All the resizing and cropping of the images are in same order. The dimensions of the images are kept at 640 X 480. The cropping is done such that the information of the central portion of images is retained. Some sample images are given in Fig 2.

Fig. 2: Some Sample Images used in this Experimental Work

5.2 Stego Images Generation

The images from the database are gone through various well known JPEG hiding techniques. They are Outguess, F5, Jsteg and DWT based of different capacities 0.05, 0.1, 0.2 bpnc. The texts and images are hidden in the image dataset using the above algorithm [1], [4].

5.3 Steganalysis on the Stego Image Database

Matlab code is generated for implementing the proposed scheme. The obtained features are used for the SVM classification with the help of WEKA data mining software [11]. The cross-validation is selected for the better result.The images from the database have been used for both training and testing of the SVM classifier. The performance parameters of classification are shown in the Table I. for the proposed scheme.

The obtained accuracy of the proposed scheme is compared with C. Chen et.al [10], J.Fridrich et.al. [8], M.Kumar [12]and G.T.Kumar et.al [7]. The comparison result is represented in the Table 2.

Where bpnc stands for bit per non zero coefficient. roc stands for receiver operating characteristic.

Table 1: Performance of the SVM Classifier for the Proposed One

Hiding Method	*Ebedding Rate (bpnc)*	*Sensitivity*	*Precision*	*Fall Out*	*Accuracy*	*ROC Area*
DWT Based	0.05	0	0	0	66.6667	0.5
	0.1	0	0	0	66.8874	0.5
	0.2	0	0	0	67.2131	0.5
Outguess	0.05	0	0	0	66.9967	0.5
	0.1	0	0	0	67.2131	0.5
	0.2	0	0	0	67.4342	0.5
F5	0.05	0	0	0	66.7774	0.5
	0.1	0	0	0.01	66.8852	0.495
	0.2	0	0	0	67.2131	0.5
Jsteg	0.05	0	0	0.001	66.6667	0.495
	0.1	0	0	0.005	66.8852	0.498
	0.2	0	0	0	66.9	0.495

Table 2: Comparison of the Accuracy of the Proposed Detection Technique with the References.

Hiding Method	*bpnc*	*C. Chen [10]*	*J. Fridrich [8]*	*M. Kumar [12]*	*G.T. Kumar [7]*	*Proposed*
DWT Based	0.05	60.20	64.88	60.4167	65.5518	66.6667
	0.1	58.67	65.00	64.5485	67	66.8874
	0.2	58.86	65.89	66	67.2241	67.2131
Outguess	0.05	58.00	64.90	68	65.5629	66.9967
	0.1	58.61	65.33	66.6667	65.667	67.2131
	0.2	60.00	65.67	67.6871	66.333	67.4342
F5	0.05	57.19	66.81	69.2308	66.5541	66.7774
	0.1	57.43	66.89	69.8997	66.8896	66.8852
	0.2	66.89	67.56	69	67.893	67.2131
Jsteg	0.05	60.07	63.76	73.9726	67.4497	66.6667
	0.1	60.00	63.73	79.3333	66.1017	66.8852
	0.2	62.67	65.75	72.1649	69.5205	66.9

6. DISCUSSION AND CONCLUSIONS

Since JPEG images are used widely which for the data restoration and transmission, so in the proposed scheme the JPEG image format is preferred. For developing Jsteg [3] stego image set, the optimized quantization table is used on the Block DCT coefficient. For DWT based, F5, Jsteg and Outguess hiding technique, the detection accuracy is better than [8] and [7] but slightly better than [7].The Table 2. shows that the better response is obtained for the proposed one.

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