UNIVERSAL STEGANALYSIS: DEFEND AGAINST ADAPTIVE STEGANOGRAPHIC ATTACK USING MX-QUADTREE NEIGHBOR FINDING MECHANISM

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Abstract

In the world of information security, Trapping of Illegal secret communication plays an imperative role. Especially, defending against such type of attacks plays important role in the area of defense. Steganalysis is the countermeasure against steganography. Steganalysis deals with the extraction of hidden data from the cover media. The cover media could be an image or an audio or a video file. Human Visual System (HVS) may not clearly identify the images with hidden information. Universal steganalysis is the method of attacking the stego images regardless of the method used for embedding secret information into the cover media. Universal steganalysis is a combination of two methods; they are feature extraction and classification. Adaptive steganography is a perceptual masking technique which is based on color contrast of the image. This type of steganography does not modify the image quality, which has higher rate of embedding capacity and unperceivability. In the existing method, payload locations of JPEG stego images were identified using Point Region quad tree (PR quad tree) mechanism in which more levels in tree should be identified to split two closely spaced points. In PR quad tree mechanism, each node has 2^n pointers to represent ‘n’ dimensions. In this proposed method, a new steganalytic method called MatriX quadtree (MX quadtree) neighbor finding technique is used to reveal the hidden information from adaptive steganographic stego images. The MX quad tree mechanism helps to concentrate on individual pixel values of densely populated color contrast values. Image quality ratio is between original and stego image is analyzed using True Positive Rate (TRP).

Keywords:- Adaptive Steganography, Steganalysis, Stego Images, Universal Steganalysis, MatriX Quad tree, Point Region Quad Tree, Embedded Capacity, True Positive Rate, Local entropy.

1. Introduction

Steganalysis is a method of extracting the unrevealed messages from the cover media. Adaptive steganalysis attempts to extract the concealed messages which are embedded based on the color nature of the cover media [32]. Universal steganalysis also called as blind steganalysis, which attempts to attack the stego images without any prior knowledge about the steganographic algorithm used. Universal steganalysis is a combination of feature extraction and feature classification [1].From the data set of images; a group of statistics is obtained based on the features of the image. These extracted features are used to train a classifier to identify the cover and stego image. The neighboring joint features are extracted on intra block and inter block from the Discrete Cosine Transform Coefficient arrays [27]. Quad tree mechanism is an optimized technique, which reduces the number of recursive calls.

2. Related works

Shen et al.[35], experimented a block based coding method with lossless code for binary shape mask was proposed with quad tree mechanism which reduced the spatial redundancy in shape mask. Content based arithmetic coding was used to reduce the number of bits required. Idquobinary shaperdquo was used to identify the pixel position whether it is inside the object or outside object.Video encoding was done by identifying the boundaries of the video MPEG-4.

G.M Hunter et al.[19], proposed the quad tree for pictures in which each leaves of the quad tree represents the color of the picture area which it represents. Warnock-type algorithms were used to build the quad tree for the image of the edge of a polygon and to color it. This algorithm is asymptotically optimal by considering vertices, perimeter and resolution parameter which was kept as constant.

Ashraf A. Kassim et al.[2], proposed a quad binary tree which facilitated adaptive representation of images. In this method, recursive fine partitioning was avoided and the presentation of images was improved. The proposed work was compared with wedgelets tree based representation and proved that the method was efficient for broad range of outline features at low bit rates.

Fengyong Li et al.[15], presented a high dimensional features and Bayesian ensemble classifier in JPEG image steganalysis, which worked on the principle of inter and intra block dependencies by considering 15700 dimension features derived from co-occurrence matrices of DCT coefficients. The method proposes an ensemble classifier with a Bayesian mechanism which integrates a group of sub-classifiers that are trained on features and it produces better performance.

Jie Chen et al. [21], proposed a block-wise representation to decrease complexity and which helped for fast extraction and low memory foot print was achieved. It supports parallel process. Point detection is the basic method to extract feature in images by processing scale-space representation. Laplacian of Gaussian filter was used to find the block-wise scale-space representation. This method effectively and efficiently finds the interested points by considering memory and by reducing time complexity.

D.-C. Lou et al.[12], proposed Bitplane Complexity Segmentation Steganalysis method using statistical characteristics of the image with hidden encrypted information based on Least Significant Bitplane.Two BPCS steganalysis schemes were proposed to improve the Bitplane Complexity Segmentation steganalysis. The effectiveness of the detection, its feasibility and accuracy of the proposed method was proved.

3. State of the art

In this proposed work, MX-Quad tree based image segmentation for blind steganalysis is compared with wavelet based, empirical transition matrix, and feature based image segmentation for steganalysis. It accounts for tree structure based image segmentation and information retrieval. Moreover, MX- Quad tree based image segmentation helps in accurately finding the adaptive region in the form of blocks so that the payload locations can be easily identified compared to the wavelet based, empirical transition matrix, and feature based image segmentation. Payload locations are identified from the blocks of quad tree using neighbor finding mechanism. In which, each pixel value is compared for recognizing the payload locations of adaptive region for better accuracy. It is indeed to consider the performance of the existing methods for classification of stego images and cover images, In the proposed work binary classifier named Support Vector Machine (SVM) is used for better performance. The metrics used to measure the performance is True positive Rate (TPR) which lies between 0.85 to 0.95.Thus the proposed method should be considered as an alternative method for point region based image segmentation in blind image steganalysis along with neighbor finding mechanism and Support Vector Machine (SVM) Classification.

4. Adaptive Steganalysis

Adaptive steganography is the process of embedding information into the cover image based on the color adaptability of the image i.e. Color contrast of the image. Similar color region of the image can be used for hiding the information which prevents Human Visual System to identify the presence of the hidden information**.** Adaptive steganalysis is the counter process of adaptive steganography in which color adaptable region is concentrated [7]. Cover data, steganography key and the embedding algorithm plays a vital role in steganographic algorithm, for adaptive steganographic algorithm the features of the hiding function considered are pixel identification, message bits representation and cover modification [28]**.**

Local information about the pixel was used to select the best region of the image in which single pixel was not concentrated instead a block of pixels were considered in which segmentation and clustering algorithms were used to detect the perfect segments for blind steganalysis [30]. Efficient image steganalysis methods are dependent on the powerful interpixel dependencies of images [31].Least Significant Bit Matching Revisited proposed an edge adaptive steganography which produces higher performance in embedding the message compared to that of Least Significant Bit insertion [23],[34].

The embedding distortion is the change in the image intensity during the process of embedding the message in to the image [3].The efficiency of the data-hiding method is calculated based on its visual and statistical detection [33] for producing an adjustable payload [29].

The hidden secret messages can be revealed from JPEG decompressed images for which Jpeg Compatibility detection algorithms were used to classify payload locations based on position dependent and position independent embedding methods [22],[24],[20],[16],[17]. Adaptive stegnalysis can be done on the region where the adaptable color region is found for retrieving the hidden information from the stego image which is shown in Fig.1.

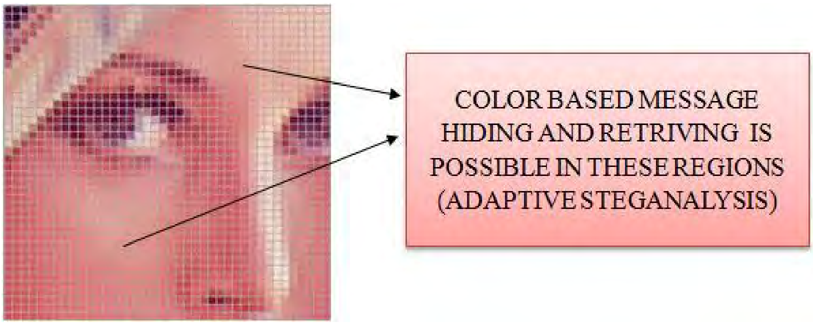

Figure 1. Adaptive steganalysis region identification based on color

5. Color Feature

Color is the significant feature for image analysis. It plays most important role in the retrieval of veiled information from the images in adaptive steganalysis. Color features have its own reward such as simplicity in working out and performance, accurateness in results and robustness. Colors model are used to symbolize color of an image, in the sub space of a three dimensional coordinate system where in color model represent the color of an image by a single point [32]. Fig. 2 shows that the color of a pixel is perceived by combination of three color stimuli, they are called as *RGB* color space i.e. Red, Green, and Blue which forms color space and are called as primary colors

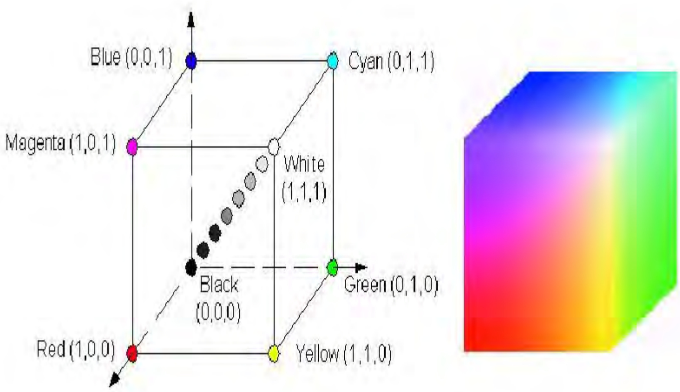

Figure 2. *RGB* color Space.

Many methods show that the relationship of low-level features gives better performance compared with other features [10],[4],[5],[19],[35]. Learning distance metrics [11], [6] and feature selection [13], [18] are the two important concepts that are used in 3D model retrieval. These methods can also be used in adaptive steganalysis to find and extract from the payload locations.

6. Quad Tree Mechanism

Image segmentation based approximation is of two types and are 1) Region based Image segmentation-explains about the interior part of the region by constructing a tree structure. 2) Curvilinear based image segmentation-describes about boundaries of the region [2]. A quad tree is a tree data structure in which nodes are leaves or 4 children. The root is the image taken for consideration and the children of the node represents 4 quadrants. Leaves of the tree identify the uniform region of the image. For binary images zero ‘0’ represents black and one ‘1’ represents white. For color images it is shown in Fig. 3.

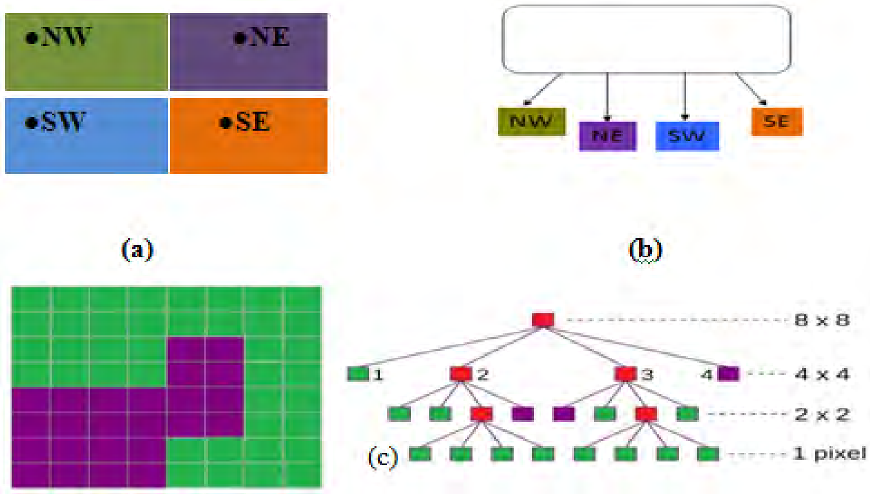

Figure 3a) Quadrant directions b) Quad tree representation of quadrant directions c) Quadtree representation

a) **Point-Region Quadtrees (PR Quadtrees):** This method subdivides the image into cells of 4 equal-sized sub cells recursively. Recursive sub division leads to either a node with 4 child pointers or contains „no point‟ node. There are possibilities of empty leaf node which should have data for consideration is the main drawback.

b) **Split and Merge Decomposition:** This method subdivides the image into uneven blocks and the merge similar neighbor blocks**.**

c) **MatriX Quadtrees:** MatriX Quad tree is good for image data in which pixels of the image are considered for analysis. The MatriX Quad tree method subdivides the image into smallest unit. The structure of the final tree is independent of the insertion order. Faster matrix transposition can be done. Lower level of the tree structure gives more detailed information about the image.

Point Quadtrees: Point Quadtree method is similar to Point-Region Quadtree and the only difference in this method is to split on points in the data set than dividing the blocks equally. When the points are inserted randomly, the tree structure may not be balanced**.**

7. Proposed Method

Block diagram for adaptive steganalysis is shown in Fig. 4. The proposed method considers the stego images for the identification of adaptable color region from where the hidden information can be found. Feature Extraction plays a vital role in the analysis of stego images before classification. The classifier separates the image into stego and cover based on the features obtained [9]. In this proposed work, adaptive steganalysis works on the basis of feature extraction based on identification of adaptive color of the image using MX quad tree neighbor finding mechanism followed by classification, adaptive steganographic method identification for embedding, Hidden message length estimation, stego bearing pixel identification, retrieval of stego key and message extraction as shown in Fig.4.

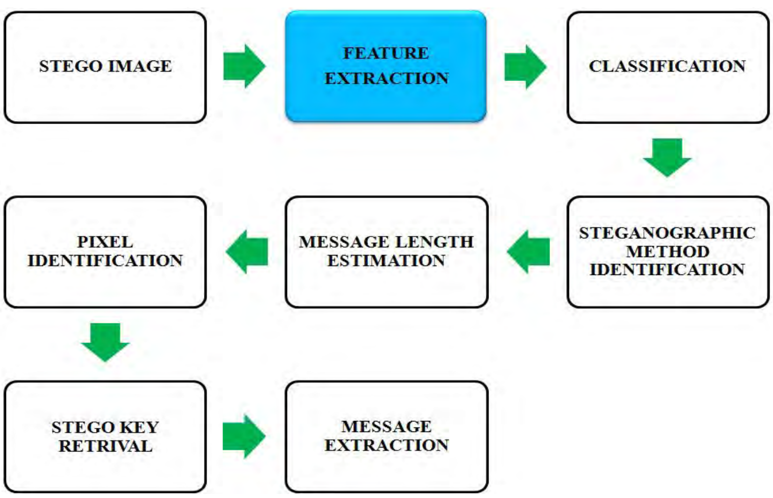

Figure 4. Block diagram for adaptive steganalysis

8. Algorithm for adaptive steganalysis

The following algorithm discuss about the feature extraction in adaptive steganalysis

Algorithm 1: Adaptive Steganalysis

1: Consider the stego image and divide it into blocks.

2: Apply MX Quad tree mechanism to find the sub regions of an image of same color.

3: **For** each Quadrant of stego image.

4: Extract the pixel values.

5: Compare the pixel values with every other pixel of the same quadrant.

6: **Repeat** Step 3 to find the number of bits used for embedding in a pixel i.e. bits per pixel (bpp).

7: Classify the stego image as regions with embedded message and the regions without embedded message.

8: Estimate the length of the hidden message by identifying payload location.

9: Extract the message.

10: **Return** the hidden message

9. Feature extraction using MX QUAD TREE neighbor finding mechanism

In this proposed work, Features of the stego image is extracted using MX Quadtree neighbor finding mechanism. In which, image gets split into blocks of *2 X 2* then applies MX Quadtree mechanism recursively to get the non overlapping Quadrant squares based on color, select a pixel in the quadrant then check its value with the neighbor pixel value which should be same. If not, verify the pixel value with next non overlapping block of same color then we could find the Least Significant Bit (LSB) embedded ratio of adaptive steganography in number of bits per pixel (bpp). MatriX Quadtree mechanism is shown in Fig.5

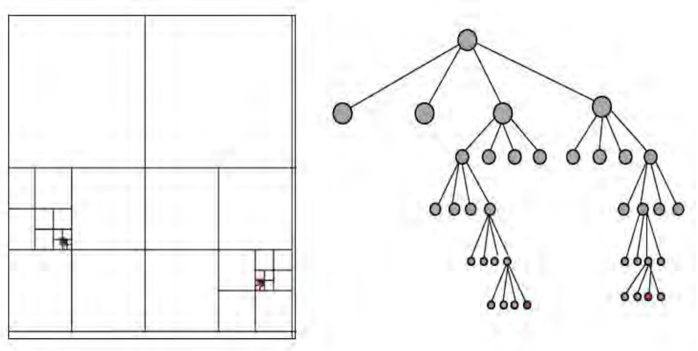

Figure 5. MatriX Quadtree Representation.

10. Algorithm for MX QUADTREE neighbor finding mechanism

The following algorithm discuss about the feature extraction in adaptive steganalysis using MX Quadtree mechanism.

Algorithm 2 : MX Quadtree Neighbor Finding Mechanism

1: Consider the stego image which has to be divided it into blocks of (2^k X $2^{k)}$.

2: Padding of image is done so that the image can be represented in a standard size format.

3: Initialize XLB=0, XUB=2^k, YLB=0, YUB=2^k. Where,

- i) XLB is Lower Bound along X-axis
- ii) XUB is Upper Bound along X-axis
- iii) YLB is Lower Bound along Y-axis
- iv) YUB is Upper Bound along Y-axis

4: Consider '*N*' is the original stego image and then find the XLB, XUB, YLB, YUB of four Quadrants (North West, South West, North East and South East) of the image, as given in Table 1.1,

Table 1.1 Quadrant calculations of '*N*'

QUADRANT	XLB	XUB	YLB	YUB
NW	N.XLB	N.XLB+(w/2)	N.YLB+(w/2)	N.YLB+w
SW	N.XLB	N.XLB+(w/2)	N.YLB	N.YLB+(w/2)
NE	N.XLB+(w/2)	N.XLB+w	N.YLB+(w/2)	N.YLB+w
SE	N.XLB+(w/2)	N.XLB+w	N.YLB	N.YLB+(w/2)

Where w is the width of the block represented by '*N*'.

5: Repeat step 3 for getting the individual pixel value.

6: Identify the adaptive region blocks by considering maximum sized block to minimum sized blocks so that the adaptive region could be found.

7: Apply from Step 3 of adaptive steganalysis algorithm.

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11. Experimental results

The MX quadtree structure of the stego images based on their Color models are shown below.Fig.6 Represents the stego images which gets padded into a standard size, as shown in fig.7. MX Quadtree algorithm is applied on padded images to identify the color block i.e. adaptive regions of the image where the hidden messages could be, which is represented in fig.8.Payload location identification is represented in Fig.9

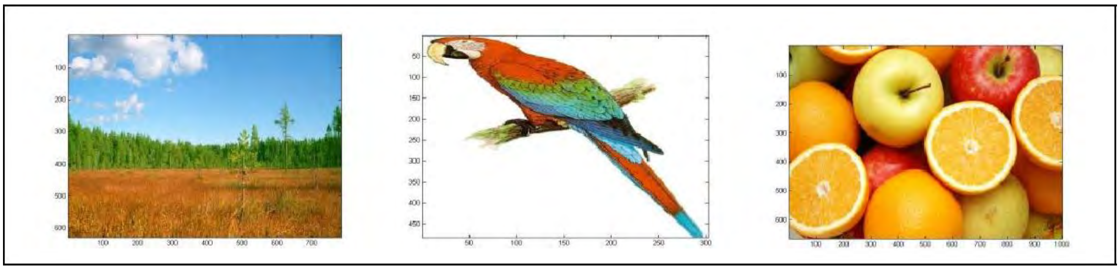

Figure 6. Stego images

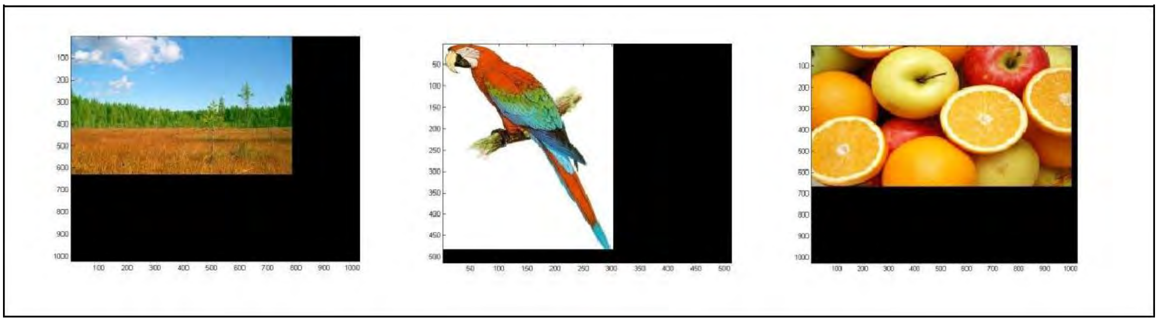

Figure 7. Padded Stego images

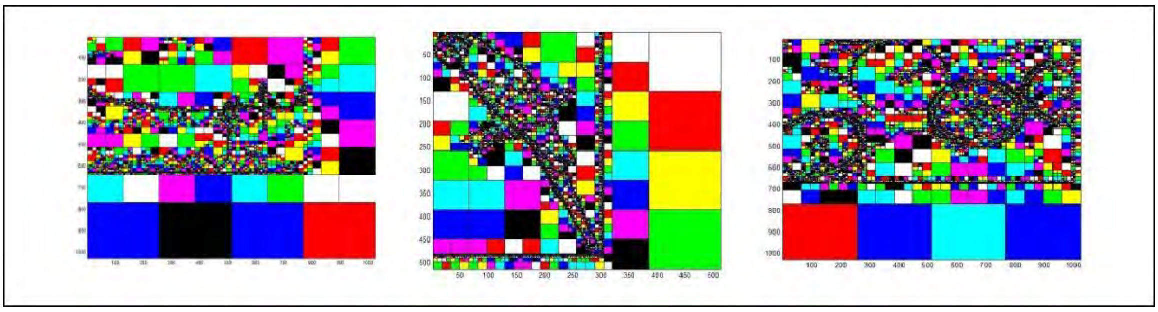

Figure 8. MX Quad tree representation of Padded Stego images

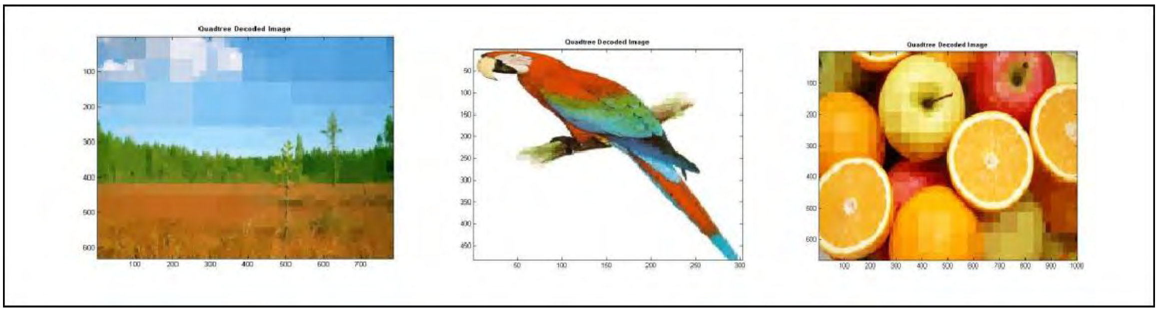

Figure 9. MX Quad tree decoded image which represents the payload location in form of blocks.

The performance of the proposed algorithm is measured on color adaptability during embedding the messages, which are formed as quadrants on adaptive steganalysis. The accuracy is estimated by considering bits per pixel (bpp) on the stego images. The quadrants of adaptable regions are grouped on which analysis can be done for identifying the stego messages. True positive rate (TPR) is used to identify the detection rate of stego images from the set of stego images and cover images. If TPR value is very close to 1 then it means that the detection accuracy and sensitivity is higher and the TPR is calculated by using the formula 1,

$$\mathbf{TPR} = \frac{\mathbf{TP}}{\mathbf{(TP+FN)}} \quad (1)$$

Where, TPR is True Positive Rate and FN is False Negative

Classification of images with and without embedded message is done by using Support Vector Machine Classifier (SVM) [8],[14].The SVM classifier trains the images based on inter pixel dependencies and classify it as stego or cover images [8],[26].Metrics of classification is shown in the following Table 1.2, in which True Positive, False Positive, False Negative and True Negative are explained for identifying the stego images using classifier output. Pearson correlation, mean square error (MSE), Structural SIMilarity Index (SSIM) , false positive and false negative were proposed to produce the performance of comparison between original and watermarked images[25].

Table 1.2 Metrics for classification representation

Feature Extraction methods such as Wavelet Based, Empirical transition Matrix, Feature Based and proposed MX Quad tree method are compared with three different steganalysis method with different embedding ratio of about 0.05 bpp i.e. For every 100 pixels 5 pixels are used for embedding and 0.1bppi.e. For every 10 pixels 1 pixel is used for embedding. Dataset of about 900 images is used for analysis in which 500 images are stego images and 400 images are cover images.

The analysis table is as shown in Table 1.3 and its corresponding graphical representation is shown in Fig.10,

Table 1.3 True positive Rate analyses for the dataset with different Steganalysis methods

FEATURE EXTRACTION		Wavelet Based			Empirical Transition Matrix			Feature Based			MX Quadtree		
Steganalysis Methods	Embedding ratio	TP	FN	TPR	TP	FN	TPR	TP	FN	TPR	TP	FN	TPR
Outguess	0.05	433	82	0.84	436	84	0.84	386	152	0.72	872	65	0.93
Outguess	0.1	450	120	0.79	400	150	0.73	432	89	0.83	923	52	0.95
F5	0.05	487	53	0.9	462	198	0.7	523	114	0.82	500	33	0.94
F5	0.1	365	72	0.84	350	300	0.54	586	147	0.8	432	45	0.91
MB1	0.05	536	95	0.85	493	152	0.76	682	152	0.82	300	52	0.85
MB1	0.1	458	83	0.85	384	83	0.82	735	69	0.91	275	35	0.89

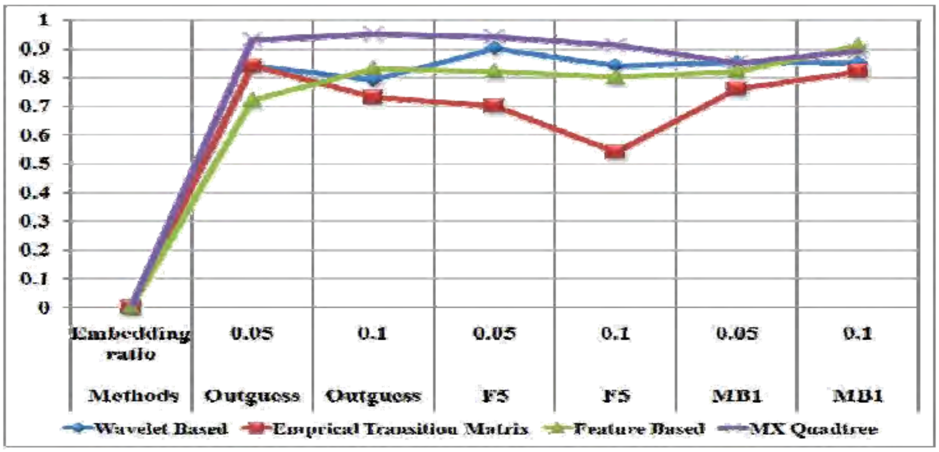

Figure 10. Graphical Representation of True Positive Rate Analyses.

12. Conclusion

The Graph implies that MX Quadtree Feature Extraction method works better when compared to rest of three steganalysis methods with different feature extraction techniques and different embedding rate. The Proposed MX Quadtree method determines the payload location of jpeg images with True Positive Rate of about 95% when the bit per pixel is 0.10 for outguess steganalysis method. The proposed method works well in identifying payload location for an adaptive steganography. Experimental analysis shows that MX Quadtree mechanism is an effective method which is used to detect the payload locations. Extraction of Embedded message could be the future work after finding the payload location Identification.

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