

Adaptive Image Steganalysis for LSB Embedding Technique using Enhanced Canny Operator

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Abstract

Objectives: Adaptive image steganalysis retrieves concealed content from the adaptable regions of cover image. To identify adaptive regions, Enhanced canny operator is used and which identifies the false edges accurately. **Method/Analysis:** Adaptive image steganography is the method of hiding the content, based on the adaptable regions of the colour image. The edges in the cover image are used for hiding the secret information by considering two LSB (Least Significant Bit) bits. In the existing method, canny edge detectors were used to extract the features of the image but it fails to identify the false edges and smoothes the boundaries with noise. **Findings:** In the proposed method, Adaptive regions are identified using enhanced canny operator which identifies the false edges accurately and thus reduces the overhead in payload location identification and content retrieval. This enhanced canny operator outperforms the other edge detectors for the retrieval of content which are embedded using LSB embedding method during steganography. The performance of the operator is measured using Positive Predictive Value (Precision). The precision is calculated after identifying the adaptive region with its payload location and hidden content using ensemble classifier. **Applications/Improvements:** The performance of the method can be improved by using different classifier combinations as ensemble classifier for multi class classification.

Keywords: Adaptive Steganography, Enhanced Canny Operator, Ensemble Classifier, Least Significant Bit, Positive Predictive Rate

1. Introduction

The art of retrieving the hidden information from the image which acts as a cover media is called as Image Steganalysis. Adaptive steganography plays a confident role in hiding the information from the vision of human. This makes a great impact and success of steganographic attempts. The adaptive regions are the sub regions of an image whose intensities are closer with its neighbouring pixels. This intensity level of the adaptive regions helps the steganography process to touch the hike in the success rate of hiding the information in a colour image. The Steganalysis methods that are intended for grey scale images can also be considered for colour images by considering the colour images in three times of greater grey

scale images¹. Multimedia signals were embedded in colour images based on adaptive regions which deceive the visual systems of human². Blind Steganalysis tries to crack the stego images without any former understanding about the steganographic algorithm used. Blind Steganalysis is a blend of feature extraction and feature classification³. Features are extracted based on its adaptive region identification. Adaptive regions are identified using enhanced canny operator for edge detection. Feature classification helps in classifying the image as cover or stego image.

Himanki et al.⁴, experimented a variable length embedding in the RGB colour images. This type of embedding was done using canny edge detection algorithm. The security of embedding was increased by random selection of pixels. The cover images were subjected twice to canny

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edge detection algorithm with different threshold values. Smoothing, Searching for gradients, Non Maximum suppression and hysteresis were the four stages of canny edge detection algorithm.

Nitin et al.⁵, proposed the mechanism of hiding the text messages using edges of image in steganography. The grey image was presented to hide the message. First binary value of text message was found and then, dark places of the grey image were found and it was converted to RGB image. At last each 8 pixels of dark places were considered as a byte and binary value. Least significant bit insertion method was used to embed the message into the image.

Philip et.al.⁶, presented the modified version of the canny edge detector algorithm which was the base level for the adaptively-smoothed gradient field then the second derivatives were found from the tuned gradient directions by means of curvature consistency. Every pixel zero crossings were calculated. Sparser sets of edges were calculated in every iteration and then Gaussian smoothing was applied. Finally multi-scale Gaussian smoothing was done.

Mamta et.al.⁷, Hough transform was used to refine the edges obtained from canny operator. The aim of the canny operators used in this method was to achieve optimization such as increasing the signal to noise for true positives. Accomplish high-quality localization to perfectly mark edges. Diminish the responses count to a single edge for the identification of true negatives. The Canny operator uses a multi-stage method to detect a wide variety of edges in images. On accounting the good detection, good localization and minimal Canny edge detector was considered as an optimal multi-stage edge detector.

Ehsan et.al.⁸, proposed the colour space intensity was used to find the region where the content should be embedded. Intensity based edge detection was done optimally by canny edge detection algorithm. It read the colour images and split it into three unique colour channels then canny edge detector was applied on each channel to finish the edge map. At last, the individual edge maps were grouped into a complete edge map for better results.

2. State of Art

In this proposed work, enhanced canny edge detector for adaptive region identification for blind Steganalysis is compared with simple canny edge detector for Steganalysis. It accounts identifying the changes in the

intensity levels in the image. Enhanced canny operator find the boundaries between two regions of an image accurately so that the adaptive region could be found wherein the information may or may not be hidden. Human Visual System may not be aware of the presence of the hidden information¹⁰. This method helps in identifying the payload locations. Payload locations in an image are identified using reversible process of LSB (Least Significant Technique) steganography⁹. Each pixel value is compared for identifying the payload locations of adaptive region for better precision. In the proposed work, Ensemble Classifier is used for classifying the stego images as images with hidden information or no hidden information¹¹. The Ensemble classifier is a best classifier for one class classification of stego image. Precision (Positive Predictive Value) is metric is used for measuring the accurateness hidden information based on adaptive regions which lies between 0.65 to 0.85. Thus the proposed method is better than the simple canny edge detection operator in finding the adaptive region for blind image Steganalysis along with Ensemble Classifier.

3. Adaptive Steganography and Steganalysis

Adaptive region of an image is the sub region of the image where in the intensity level of every pixel in that region is closer with the neighbouring pixel. This helps steganography for embedding the information in adaptive region. Adaptive region embedding results in higher success rate of steganography. Adaptive Steganalysis the process of identifying the adaptive region from where the hidden information should be retrieved. Adaptive steganalysis is done by classifying the image into cover or stego image. Intensity level of the image plays a major role for finding the adaptive region. Adaptive steganalysis is the deft progression of adaptive steganography in which same colour regions are concentrated. Adaptive region identification using canny edge detection operator, Ensemble classification of the stego image with or without hidden information, Payload identification and message retrieval plays a major role in adaptive Steganalysis. Position dependent and position independent embedding methods were used to find the payload locations for Jpeg images by using Compatibility detection algorithm to find and retrieve the hidden information and message length estimation¹²⁻¹⁶. Adaptive regions are identified for retrieval of hidden information which is shown in Figure 1.

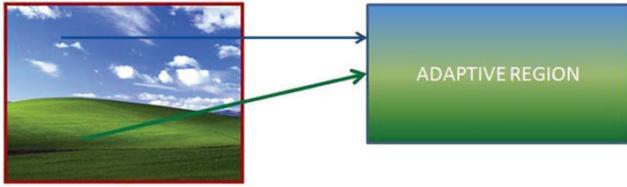


Figure 1. Adaptive region of an image based on colour.

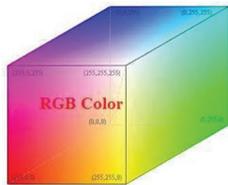


Figure 2. RGB colour Space.

4. Colour Components

Colour plays an important role in image analysis. Colour of an image is based on the intensity level of the image. In our proposed work, colour play very important role for identification of adaptive regions. Colour features are considered for the accuracy in results. Colours model are used to denote colour of an image, in the sub space of a 3D coordinate system where colour model correspond to the colour of an image by a single point¹⁷. Figure 2 shows the RGB colour space i.e. Red, Green, and Blue which forms colour space.

5. Enhanced Canny Edge Detection Operator

Edges are the representation of changes in the intensity level of an image which are represented in the form of boundaries of various regions in an image. Important features can be extracted from the image based on the edges. In our proposed work the edges are used to find the regions of similar colour i.e. adaptive regions. The features that are extracted from the edge detection are used mainly in computer vision algorithms. Object boundary and Surface boundary are the geometrical events whereas specularly shadows and inter-reflections are the non-geometric events. Edge descriptors are used to describe about the edge direction, normal, position or centre and its strength. Based on the intensity nature of the edges it

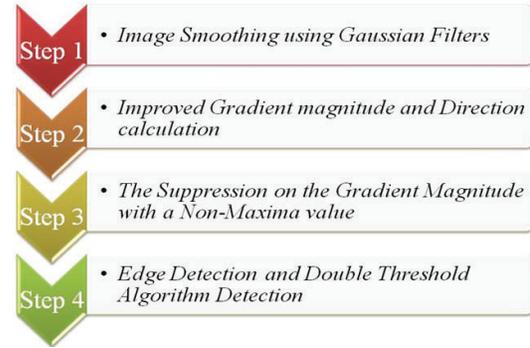


Figure 3. Steps for enhanced canny edge detection operator.

can be modelled as step, ramp, ridge and roof edges. The following Figure 3. Represents the steps for Enhanced Canny Edge Detection Algorithm.

5.1. Image Smoothing using Gaussian Filters

Image smoothing is the process of suppressing noise in the images without affecting the real edges of the images. This method is also called as Noise Reduction. Before detecting edges noise from the original image must be reduced. Canny algorithm uses Gaussian filter which uses simple mask. By standard convolution method Gaussian smoothing is done. Larger the Gaussian mask width, lesser the detector's reactivity to noise which leads to higher error rate in edge detection. To identify the sharp intensity transitions the standard deviation (σ) value should be less and which could be positive¹⁸ real numbers 0, 1, 2 or 3.

$$G(x, y) = \frac{1}{2\pi\sigma^2} \exp\left[-\frac{x^2 + y^2}{2\sigma^2}\right] \quad (1)$$

Gradient Vector¹⁸ is calculated as

$$\nabla G = \begin{bmatrix} \frac{\partial G}{\partial x} \\ \frac{\partial G}{\partial y} \end{bmatrix} \quad (2)$$

$$\frac{\partial G}{\partial x} = kx \exp\left(-\frac{x^2}{2\sigma^2}\right) \exp\left(-\frac{y^2}{2\sigma^2}\right) = h_1(x)h_2(y) \quad (3)$$

$$\frac{\partial G}{\partial y} = ky \exp\left(-\frac{x^2}{2\sigma^2}\right) \exp\left(-\frac{y^2}{2\sigma^2}\right) = h_1(y)h_2(x) \quad (4)$$

5.2. Gradient Magnitude and Direction Calculation in Canny Edge Detection

After being smoothed out, the calculation of gradient magnitude and direction of individual points¹⁸ are done using first order differential operator. The partial derivatives of two directions of the point (x, y) are as follows,

$$D_x(p, q) = \frac{[I(p, q+1) - I(p, q) + I(p+1, q+1) - I(p+1, q)]}{2} \quad (5)$$

$$D_y(p, q) = \frac{[I(p, q) - I(p+1, q) + I(p, q+1) - I(p+1, q+1)]}{2} \quad (6)$$

The Magnitude and Direction of the point p, q

$$M(p, q) = \sqrt{((D_x^2(p, q) + D_y^2(p, q)))} \quad (7)$$

$$\theta(p, q) = \arctan\left(\frac{D_x(x, y)}{D_y(x, y)}\right) \quad (8)$$

$M(p, q)$ stands for magnitude and $\theta(p, q)$ stands for direction angle at $M(p, q)$

5.2.1. Enhanced Gradient Magnitude and Direction

Improved canny edge detection operator for a 2×2 pixel consideration is about six level i.e. horizontal two points, vertical two points and in diagonal zones two points¹⁸. Based on these values new enhanced gradient and directions are calculated as follows for first order derivative.

$$M_x(p, q) = \frac{[I(p, q+1) - I(p, q-1) + I(p-1, q+1) - I(p-1, q-1) + I(p+1, q+1) - I(p+1, q-1)]}{2} \quad (9)$$

$$M_y(p, q) = \frac{[I(p+1, q) - I(p-1, q) + I(p+1, q-1) - I(p-1, q-1) + I(p+1, q+1) - I(p-1, q+1)]}{2} \quad (10)$$

Gradient magnitude and direction is calculated as follows

$$M(p, q) = \sqrt{((M_x^2(p, q) + M_y^2(p, q)))} \quad (11)$$

$$\theta(p, q) = \arctan\left(\frac{M_x(x, y)}{M_y(x, y)}\right) \quad (12)$$

5.3. The Suppression on the Gradient Magnitude with a Non-Maxima value

Canny operators have interpolation with respect to gradient direction and magnitude¹⁸. If $M(p, q)$ is greater than two subsequent interpolation in the direction of $\theta(p, q)$ at the point (p, q) is the candidate edge point or else it is a non-edge point.

5.4. Edge Detection and Double Threshold Algorithm Detection

For connecting the edge points follow the steps given below¹⁸,

1. Set the High Threshold (T_h) and Low Threshold (T_l).
2. Consider any pixel (p, q) and mark the edge point and non-edge point.
 - 2.1. Points are noted as Edge point when Gradient magnitude $M(p, q) > T_h$.
 - 2.2. Points are noted as Non - Edge point when Gradient magnitude $M(p, q) < T_l$.
 - 2.3. Points are noted as suspect when Gradient magnitude $M(p, q)$ lies between T_h and T_l .
3. Connect the Edge points.

6. Proposed Method

Block diagram for adaptive Steganalysis of stego images which used LSB technique is shown in Figure 4. The

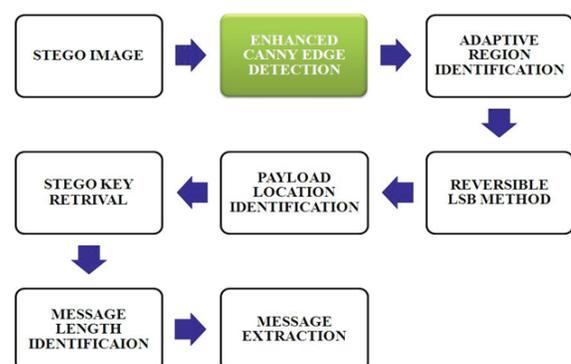


Figure 4. Block diagram for adaptive Steganalysis of stego images.

proposed method aims in identification of adaptive region using enhanced canny edge detection method which considers the stego images and identifies the adaptive region. Reversible LSB (Least Significant Bit) method is used for retrieving the information by identifying payload locations. The stego key gets retrieved using which message length and the embedded message gets extracted.

7. Algorithm for Adaptive Steganalysis for LSB Embedding

The following algorithm discuss about the edge detection in adaptive steganalysis for LSB embedding

Algorithm 1: Adaptive Steganalysis for LSB Embedding

1. Consider the stego image and divide it into blocks.
2. Apply Enhanced Canny Edge Detection Operator to find the adaptive regions of the image.
3. Consider the adaptive regions that are identified.
 - 3.1. Extract the pixel values. Apply Reversible LSB Embedding method to identify the payload locations.
 - 3.2. Compare the pixel values with every other pixel of the same region.
 - 3.3. **Repeat** Step 3 to find the number of bits used for embedding in a pixel i.e. bits per pixel (bpp).
4. Extract the stego key to extract the hidden information.
5. Estimate the length of the hidden message by identifying payload location.
6. Extract the message.
7. **Return** the hidden message

8. Algorithm for Enhanced Canny Edge Detection Operation

The following algorithm discuss about the Enhanced Canny Edge detection for adaptive region Identification.

Algorithm 2: Enhanced Canny Edge Detection Algorithm

1. Consider the stego image on which Gaussian Filter is applied to reduce noise i.e. Image smoothing is done.
2. Calculate Improved Gradient magnitude $M(p,q)$ and Direction $\theta(p,q)$.

3. Calculate High Threshold (T_h) and Low Threshold (T_l).
 - 3.1. Consider any pixel (p,q) and mark the edge point and non-edge point.
 - 3.2. Points are noted as Edge point when Gradient magnitude $M(p,q) > T_h$
 - 3.3. Points are noted as Non - Edge point when Gradient magnitude $M(p,q) < T_l$
 - 3.4. Points are noted as suspect when Gradient magnitude $M(p,q)$ lies between T_h and T_l
4. Connect the Edge points using Double threshold algorithm function
5. Repeat step 3 for identifying the adaptive region.

9. Experimental Results

The Enhanced Canny edge detection algorithm performs better for identifying the adaptive region. In the adaptive region LSB reversing for information retrieval is used so that fast and efficient information retrieval is done. Figure 5 shows the edge detection for adaptive region using Canny Edge Detection and Enhanced Canny Edge Detection Algorithm with different threshold values.

Adaptive region using enhanced canny edge detection algorithm is detected and regions are identified based on which payload location and the hidden information length can be identified and computed¹⁹. The Identified adaptive regions of colour image for Steganalysis based on enhanced canny edge detection operator is shown in the Figure 6. The represented regions are used to hide the information. Colour based region is considered for hiding information.

The performance measure of the proposed algorithm is calculated using the identification of adaptive region so that the LSB reversing can be concentrated on a particular region which enhances the performance of Steganalysis. This leads to higher true positive rate with lesser time. Precision (Positive Predictive Value) is used to identify the detection rate of hidden information from the stego images based on adaptive region identified using enhanced canny edge detection algorithm. The Positive Predictive value is calculated by using the Formula 13,

$$P = \frac{TP}{TP + FP} \quad (13)$$

Where, P is Positive Predictive Value (Precision), FP is False Positive and TP is True Positive. Precision is calculated based on two metrics called True Positive and False Positive.

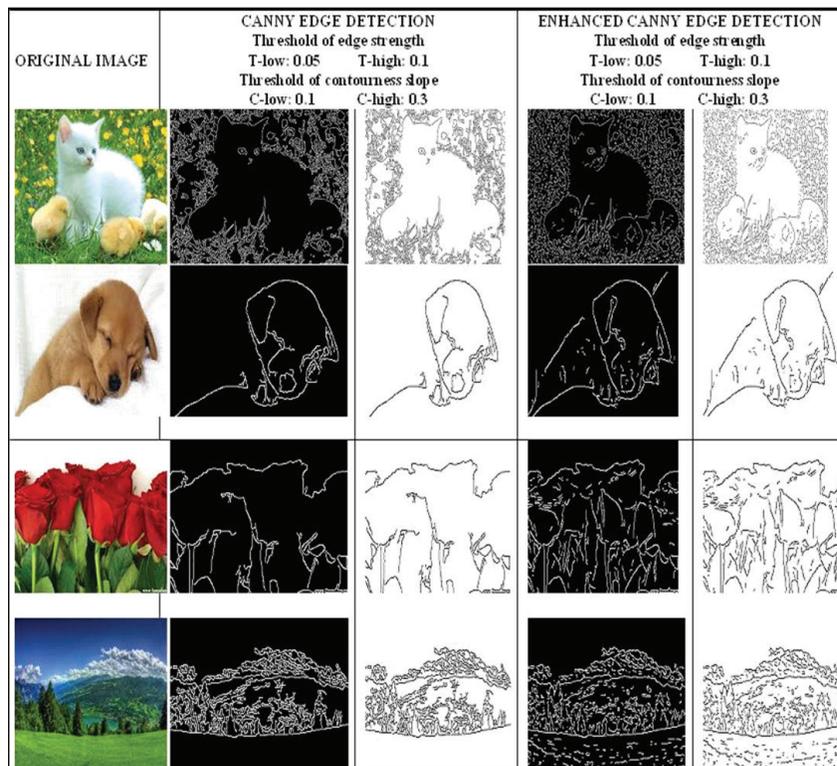


Figure 5. Adaptive region identification using canny edge detection and enhanced canny edge detection..

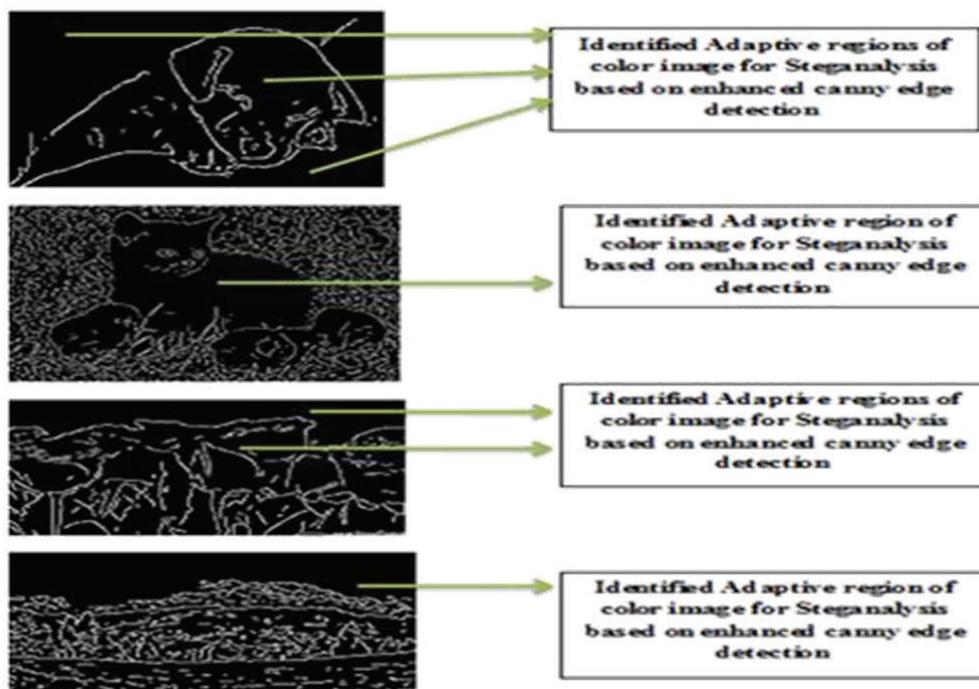


Figure 6. Identified adaptive region using enhanced canny edge detection.

10. Ensemble Classifier

The Kodovsky’s Ensemble classifier is used as ensemble classifier. The performance of this classifier is simple and it is similar to Support Vector Machine (SVM) Classifier with low computational complexity²⁰. This classifier is used for identifying the hidden data from the images. Figure 7 identifies the Metrics for classification representation of Precision.

10.1. Kodovsky’s Ensemble Classifier Algorithm

- Step 1: Consider the images which are to be analyzed.
- Step 2: Extract the intensity values of the adaptive region to identify whether the region has any hidden information.
- Step 3: Classify the stego images with hidden information.

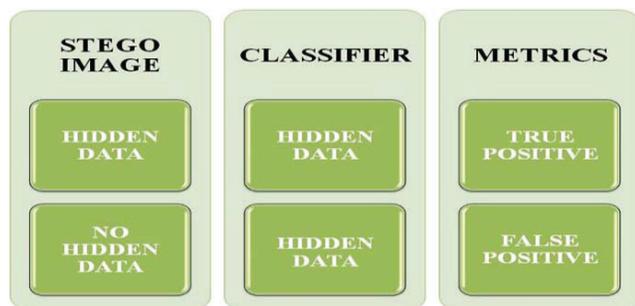


Figure 7. Metrics for classification representation of Precision.

- Step 4: Assign Weights to the weak classifier
- Step 5: Learning is done based on weights using Least Square Problem.
- Step 6: Calculate the score for every feature for the learned weak classifier.
- Step 7: Selected features are ordered to find the better subset.

In the proposed work, Precision for the Steganalysis is calculated for two data sets which contains 500 stego and non stego images each with two different embedding ratio of about 0.05 bpp (bits per pixel) and 0.1 bpp(bits per pixel) i.e. For every 100 pixels 5 pixels are used for embedding and 0.1bpp.i.e. For every 10 pixels 1 pixel is used for embedding. The analysis table is as shown in Table 1 and its corresponding graphical representation is shown in Figure 8,

11. Conclusion

The Graph implies that Enhanced Canny edge detection operator works better in identifying adaptive region in effective and faster rate. When compared to Canny edge detection with Reversing LSB Embedding the Proposed method determines the payload location of jpeg images with Positive Predictive Value of about 85% when the bit per pixel is 0.10 for Enhanced Canny edge detector operator. The proposed method works better in identifying payload location from an adaptive region. Experimental analysis shows that Enhanced Canny Edge Detector Operator is an effective method which is used to detect the adaptive regions. Though every edge detection algorithm

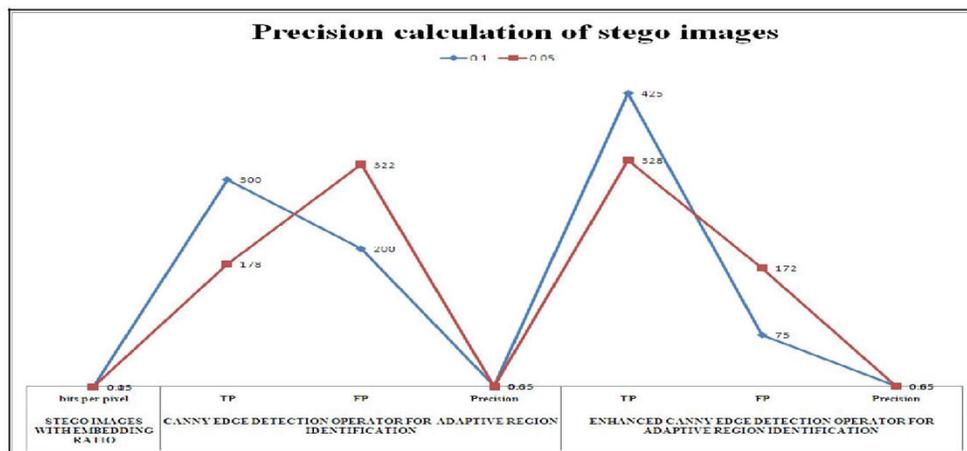


Figure 8. Graphical representation of precision.

Table 1. Precision calculation of stego images

Stego Images With Embedding Ratio	Canny Edge Detection Operator For Adaptive Region Identification			Enhanced Canny Edge Detection Operator For Adaptive Region Identification		
	TP	FP	Precision	TP	FP	Precision
0.1	300	200	0.6	425	75	0.85
0.05	178	322	0.35	328	172	0.65

is considered as the better one on various conditions²¹, the enhanced canny operator outperforms different edge detection algorithms.

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