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A Study onFace Detection and Image Steganographyusing Discrete Wavelet Transform

Arjun S.[1], Sherry Varghese George[2]
[1,2]*(Department Of Electronics &Communication Engineering,*
Mar Baselios College OfEngineering And Technology, Trivandrum, India)
Corresponding author:Arjun S.

Abstract:*There are many methods available for secret data hiding and transfer, among which steganography stands out in various aspects. Steganography is used for secret data transfer in a cover object which may be an image, video, audio, text or a network protocol, with an additional advantage of even hiding the existence of such a secret data. Selfies are commonly trending via social media nowadays and can be utilized for image steganography in many cases. A study of face detection using Viola-Jones object tracking method and then embedding secret image into it based on Discrete Wavelet Transform(DWT) technique is executed in MATLAB. Finally, using the steganographic characteristics such as the MSE (Mean Square Error) and PSNR (Peak Signal-to-Noise Ratio) values, the different input cover image formats like JPG, PNG, BMP with secret images of JPG, BMP, PNG formats are analyzed.*

Keywords *- Discrete Wavelet Transform(DWT), MSE (Mean Square Error), PSNR (Peak Signal-to-Noise Ratio) Steganography, Viola-Jones object tracking method.*

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I.Introduction

Steganography is considered as the art of hiding the existence of data in another transmission medium to achieve secret communication**.** Steganography is known as "covered writing" as it is coined from the two words "steganos" and "graphtos" of Greek origin. Steganography is the embedding of messages within safe cover objects like, images, audio/video files, text, network protocols in such a way that it cannot be detected by an outsider without knowledge about the exactsteganographic key.In contrast to cryptography, where the enemy isallowed to detect, intercept and modifymessages without being able to violatecertain security premises guaranteed by acryptosystem, the goal of steganography isto hide messages inside other harmlessmessages in a way that does not allow anyenemy to even detect that there is a secondmessage present.In the images, skin color indicateshuman and human like existence, so extensive research havebeen focusedon skin detection in images and itsuses in detecting face and non-face likefeatures. Skin detection using color information can be a challenging task as theskin appearance in images is affected byvarious factors such as illumination, background, camera characteristics, andethnicity [4]. Numerous techniques arepresented in literature for skin detectionusing color.The Discrete Wavelet Transform (DWT) is a powerful tool for signal processing and has applications in various fields such as audio compression, texture discrimination, pattern recognition, computer graphics etc. DWT yields efficient multi-resolution subband decomposition of signals on the basis of time-scale representation. In most of the image and video coding applications, 2-D DWT and its complement 2- D Inverse DWT (IDWT) are extremely important.The first ever real-time object detection method primarily for face detection is the Viola-Jones object tracking method. The method was suggested by Paul Viola and Michael Jones in the year 2001.

II. Steganography

One of the most challenging tasks in today's world is the secure way of sending & displaying the hidden information especially in public places. There are different methods that have been proposed so far for hiding information in different cover media among which steganography and cryptography are the among the core ones. In the case of cryptography, individuals may notice the information by seeing the coded information but still won't be able to understand the information. But in the case of steganography, even the existence of such information won't be noticed at all. The main aim of steganography is to hide information in another cover media so that an outsider shouldn't even notice the presence of the information. The main requirements of steganography techniques are: a) Thehidden information after it is embedded inside the stego object must be trustworthy. b) The common vision mustn't detect any alteration in the stego object. c) Considering the case of watermarking, any changes in the stego object should not have any effect on watermark. d) Finally, there must be an assumption that the attacker might know that there is hidden information inside the stego object [1]. The various types of steganography based on the cover object are:1) Image steganography: Here, the cover object is an image. Mostly, pixel intensities are used to hide the information.2) Video steganography: Here, Video(a combination of pictures) is used as carrier for hidden information. Here, H.264, Mp4, MPEG, AVI or other video formats are used.3) Audio steganography**:** Here, Audio is the carrier for information hiding. Here, digital audio formats such as WAVE, MIDI, AVI MPEG etc. are utilized.4) Text steganography:To achieve information hiding, factors like number of tabs, white spaces, capital letters, etc. are used.5) Network steganography:Here, the cover object is network protocol, used as a carrier, such as TCP, IP etc. [2]

III. WaveletTransform

Wavelet Transform technique works by taking many wavelets to encode a whole image. The main advantage is that the coefficients of the wavelets are altered with the noise within the tolerable levels. The Discrete wavelet transform (DWT) on the basis of functional and numerical analysis, is any wavelet transform for which the wavelets are discretely sampled. The key advantage it has over Fourier transforms is the property of temporal resolution: it captures both frequency and location information (location in time).A mathematical function useful in digital signal processing and image compression is called a wavelet. A Wavelet transform is considered as the depiction of a function by means of wavelets. The waveletsarescaled and translated copies (known as "daughter wavelets") of a finite-length or fast-decaying oscillating waveform (known as the "mother wavelet") and each scale component can be studied with a resolution that matches its scale.The Haar wavelet is considered as a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. The Haar sequence was proposed in 1909 by AlfrédHaar. Haar used these functions to give an example of an orthonormal system for the space of square-integrable functions on the unit interval [0, 1].The Haar wavelet is the simplest possible wavelet is also known as Db1as a special case of the Daubechies wavelet. The main demerit of the Haar wavelet is that it is not continuous, and hence not differentiable. There is an advantage for this fact as it can be advantageous in the analysis of signals with sudden transitions, such as monitoring of tool failure in machines.

IV. Methodology

The entire study comprises of three main divisions:
1) Face detection from the cover image using Viola-Jones object tracking method.
2) Secret image embedding on the face.
3) Secret image retrieval from the face.

4.1 Face detection from the cover image using Viola-Jones object tracking method.

The important characteristics of the method are:i) Very high detection rate isalways obtained using this method.ii) In case of practical applications, not less than two frames/sec must be processed.iii) The main aim is to distinguish between faces and non-faces only and not face recognition.The main steps in Viola-Jones algorithm are:
Step 1: Load the input cover image.
Step 2: Haar feature selection.
Step 3: Creating an integral image.
Step 4: Adaboost training.
Step 5: Cascading classifiers.
Step 6: Detect the face portion of the image.

4.1.1 Haar feature selection.

In the Haar feature selection technique, only the simple rectangular features similar to the Haar basis functions are used.There are certain Haar features which are common to human faces like, the eye region is darker than the upper cheeks and the nose bridge region is brighter than the eyes, etc. There are also certain properties that form matching facial features like the location of eyes, mouth, bridge of nose and also values of oriented gradients of pixel intensities. These features are equivalent to the difference in intensity readings and are quite easy to compute. There are three feature types used with varying numbers of sub-rectangles, two, two rectangles, one three and one four rectangle feature types. Using rectangular features instead of the pixels in an image provides an increased speed over pixel based systems.

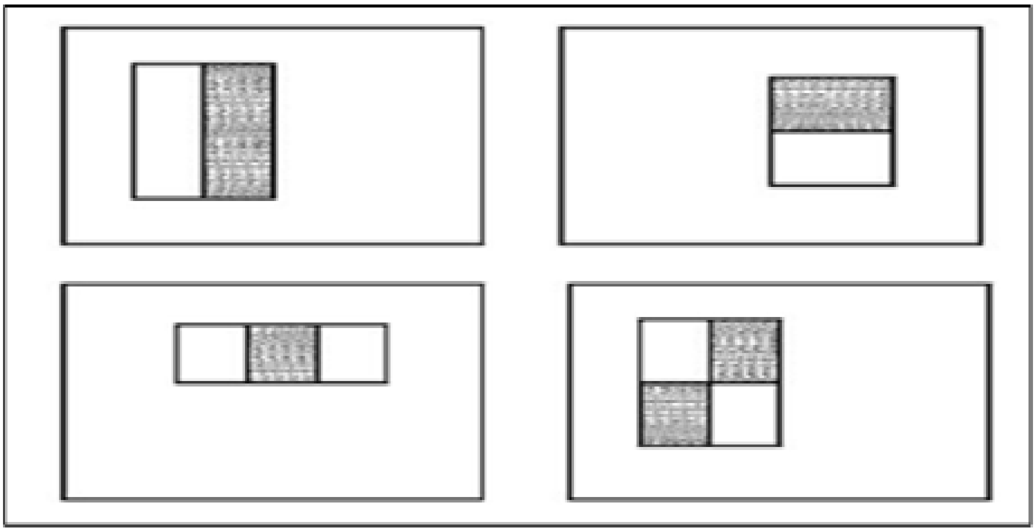

Fig.1: The four basic Haar rectangular features

4.1.2 Creating an integral image.

The calculation of the features is done by the use of an "integral image". With the introduction of a integral image, Viola and Jones are able to calculate in one pass of the sample image, and is one of the keys to the speed of the system. An integral image is similar to a "summed are table", used in computer graphics but it is used in pixel area evaluation.Creation of an integral image makes feature-extraction easier and also a Haar-like feature of any size can be calculated in constant time.The value at any point (x, y) in the summed-area table is the sum of all the pixels above and to the left of the point (x, y), inclusive:

$$I(x,y) = \sum_{\substack{x' \le x \\ y' \le y}} i(x', y')$$

where, i(x,y) is the pixel intensity at (x,y).
The summed-area table can be computed efficiently in a single pass over the image, as the value in the summed-area table at (x, y) is just:

$$I(x,y) = i(x,y) + I(x,y-1) + I(x-1,y) - I(x-1,y-1)$$

4.1.3 Adaboost training.

The implementation of a system that used such integral features would provide a large feature set, hence it must be restricted to a small number of critical features. This is done by making use of the boosting algorithm, AdaBoost.The main aim of Adaboost training is to select the best facial features and to train and build an efficient classifier to use them. The redundant features are eliminated as it determines the relevance or irrelevance of various features. Interference is enhanced with the use of Adaboost and in doing so a strong hypothesis is formed and thereby resulting in a strong classifier.

4.1.4 Cascading classifiers.

In the cascading process, based on some important features we can determine whether a face is present or not. Also the background regions of the image can be quickly discarded. The process results in increased speed and false positive rate reduction.Viola and Jones describes it as a degenerative tree, and sometimes referred to as a decision stump, its use also speeds up the detection process. A degenerative tree is the linear connecting chain of general to specific classifiers, whereby the first few classifiers are general enough to markdown an image sub window and so on the time of further observationsby the more specific classifiers down the chain, this can save a large extent of computation [6].

4.2Secret image embedding on the face.

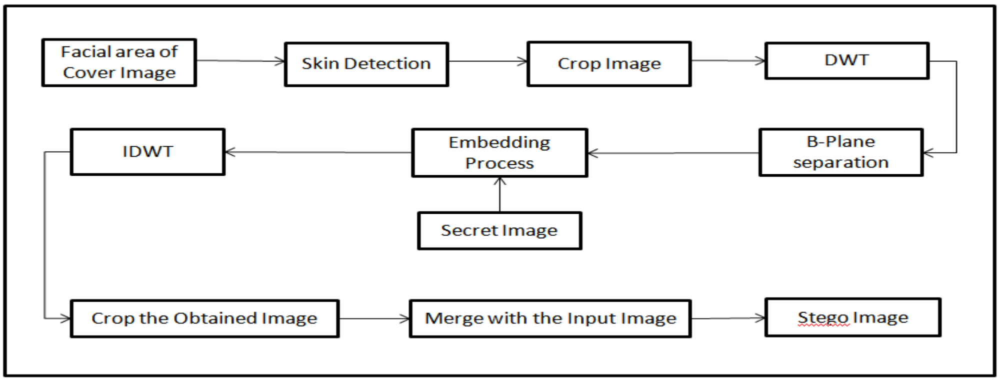

Fig. 2: Block diagram for embedding the secret image on the face.

The first step in secret image embedding algorithm is to load the face detected RGB image. Now this image is converted to HSV color space model.Skin tone detection technique is applied on the HSV image, and the skin and non-skin pixels are separated. Now, the detected facial skin area is cropped using rectangular cropping (i.e. key). Now DWT is applied to the cropped RGB face detected image which yields 4 sub bands LL,LH,HL,HH in the first level decomposition. Now apply the 2-level DWT to the LH sub band which further yields 4 sub bands. The secret image of any of the available formats is loaded and is converted to its binary form. Now, the secret image is resized to the available face area detected according to the key.The secret image is then embedded into the B-plane of the available RGB color image sub band.The merged image is obtained as the combination of the embedded image and the original cover image. This is the stego image which is used at the start of the retrieval process [5].

4.3Secret image retrieval from the face.

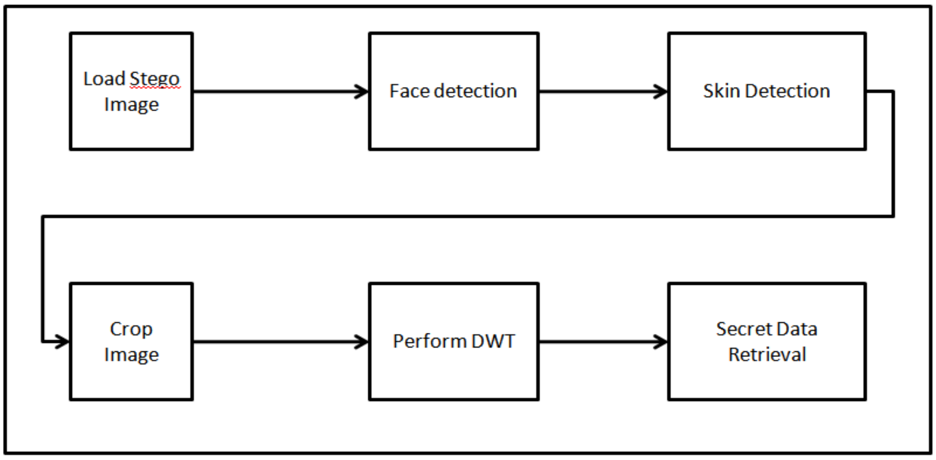

Fig. 3: Block diagram for retrieving the secret image from the face.

For the secret image retrieving scenario, first load the stego image obtained as the outcome of the embedding phase. Now apply Viola-Jones method and once again the face is detected and the facial area is cropped.The face detected RGB image is converted to HSV color model. Skin detection technique is now applied on the HSV image and the skin and non-skin pixels are separated.Now the detected facial skin area is cropped using rectangular cropping (i.e.the same key used in embedding). Apply 2-level DWT to the cropped stego image and finally the secret image is retrieved [7].

V. SimulationScenario

MATLAB R2016a is used for the simulation purpose. The steganographic characteristics (MSE, PSNR) have to be evaluated and finally the MSE, PSNR values for different combination of cover images and secret images of BMP, JPG and PNG formats are analyzed.

5.1 Mean Square Error(MSE)

MSE isthe cumulative squared error between the compressed image and the original image is known as Mean Square Error. A lower value for MSE indicates lesser error. MSE value is computed by the following formula:

$$MSE = (1|(M \times N)) \sum_{i=1}^{M} \sum_{j=1}^{N} (X_{ij} - Y_{ij})^2$$

(MSE = Mean Square Error)

where, X_{ij}, Y_{ij} represents the pixel values of the input image and the image retrieved at the output.
(i, j) are the pixel coordinates,
MXNis the resolution of the input image.

5.2 Peak Signal to Noise Ratio(PSNR)

PSNR is a measure of the peak error and is most commonly used to measure the quality of reconstruction in the case of image compression. The PSNR value if high is a good indication. PSNR is computed by the following formula:

$$PSNR = 10 \log((M - 1) * (N - 1)|MSE)$$

(PSNR = Peak Signal to Noise Ratio)

Table 1: MSE and PSNR values for the various cover image and secret image formats

Cover Image format	Secret Image format	Mean Square Error (MSE)	Peak Signal to Noise Ratio (PSNR) [in dB]
BMP	bmp	0.0031	74.67
BMP	jpg	0.0032	74.57
BMP	png	0.0039	73.4
JPG	bmp	0.0026	74.81
JPG	jpg	0.0028	74.77
JPG	png	0.0033	73.65
PNG	bmp	0.0025	75.07
PNG	jpg	0.0028	74.88
PNG	png	0.0032	73.85

VI.Conclusion

Thus the main aim of steganography is to hide information in another cover media such as image, audio, video, text, network protocol, etc. so that an outsider should not even notice the presence of the information. In the present scenario, face detection in color images has alsogained much attention. By embedding data in only the faceregion and not in whole image, security is enhanced here. Dataembedding with cropping is considered here rather than a less secure non-cropped data embedding as no one can extractthe secret message without having value of croppedregion.Steganography is used in many important areas such as copyright, preventing e-document forging in addition to being used in the surreptitious exchange of information.According to simulation results,proposed approach provides a well implemented imagesteganography.A combination of steganography and the other methods are in use these days to enhance information security.

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