Information Hiding Based on Chan-Vese Algorithm

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الملخص

أصبحت عملية تناقل البيانات عبر الانترنت عملية سهلة نتيجة التطور الكبير فـــي تقنيـــات الـــشبكات، وبات بإمكان الكثيرين الاتصال مع بعضهم البعض بسهولة وسرعة عبرها.

ولان الانترنت بيئة عامة ومفتوحة فبإمكان أي شخص غير مخول مراقبة معلومات متناقلـــة بـــين اي طرفين واعتراضها أو الحصول عليها ولهذا ظهرت الحاجة إلى الكتابة المغطاة والتي هي علم إخفاء المعلومات السرية في غطاء رقمي مثل الصور بحيث لا يمكن للشخص العادي والغير مخول أن يكتشفه أو يراه.

في هذا البحث، تم استحداث تقنية جديدة في مجال الكتابة المغطاة للإخفاء في الصور، حيـــث تـــم أولاً تقطيع الصورة الغطاء (PNG, BMP) باستخدام خوارزمية جان-فيس (Chan-Vese) ومن ثم إخفاء الـــنص في هذه الصورة بالاعتماد على مناطق التقطيع.

تم استخدام المقاييس (PSNR, BER) لقياس كفاءة التقنية. بالإضافة إلى ذلك خوارزمية هذه التقنية طبقت بـــ Matlab.

ABSTRACT

The process of data transfer via the Internet becomes an easy process as a result of the great advances in networking technologies, and now many people can communicate with each other easily and quickly through them.

Because the online environment is general and open, the unauthorized one can control information were transmitted between any two parts and interception of getting access for it, because of that there is an emergency need for write covered, which is the science of hiding secret information in a digital cover such as an images, so it is impossible for the normal person and others unauthorized to detected or perceives.

In this paper, the technology in the field of information hiding in the images is developed, where first, the cover (PNG, BMP) image is segmented using Chan-Vese algorithm, then the text will hide in the segmented image depending on the areas of clipping.

The standards (PSNR, BER) are used to measure technical efficiency. In addition the algorithm of this technique is implemented in Matlab.

1. Introduction

As digital multimedia works (video, audio and images) become available for retransmission, reproduction, and publishing over the internet, a real need for protection against unauthorized copy and distribution is increased. These concerns motivate researchers to find ways to forbid copyright violation. The most promising solution for this challenging problem seems to lie in information hiding techniques. Information hiding is the process of embedding a message into digital media. The embedded message should be imperceptible; in addition to that the fidelity of digital media must be maintained.[8]

Information hiding is unlike cryptography. In cryptographic techniques significant information is encrypted so that only the key holder has access to that information, once the information is decrypted the security is lost. In information hiding, message is embedded into digital media, which can be distributed and use d normally. Information hiding doesn't limit the use of digital data.[7]

One of the most important and ubiquitous tasks in image analysis is segmentation. Segmentation is the process of partitioning an image into a set of distinct regions, which are different in some important qualitative or quantitative way. This is a critical intermediate step in all high level object-recognition tasks. For example, if we want to locate the face of a particular person in an image of a crowd, we must first determine which parts of the image correspond to human faces. Other common segmentation tasks include segmenting written or typset characters on a page, segmenting tumors from healthy brain tissue in an MRI image, etc.[4]

2. Steganography

Steganography is the art of hiding information in ways that prevent the detection of hidden messages. The main purpose of steganography is to hide the fact of communication. The sender embeds a secret message into digital media (e.g. image) where only the receiver can extract this message. The warden of communication channel will notice the transmitted media, but he/she will never perceive the buried secret message inside this media. Figure(1) illustrates a simple steganographic system. In this system the message *m* is embedded into the cover-object *C* (could be image, audio or video) to produce the stego-object *S* that should has the same fidelity of *C*. The cover-object is only used for the stego-object generation and is then discarded. The embedding operation is parameterized by the key *k* that is known for both ends of communication: sender and receiver. On receiver side the buried message is extracted from Stego-object in detection process. Embedding message should be perceptually and statistically undetectable for the warden. An ideal steganographic system would embed a large amount of information perfectly securely with no visible degradation to the cover-object. [8][10]

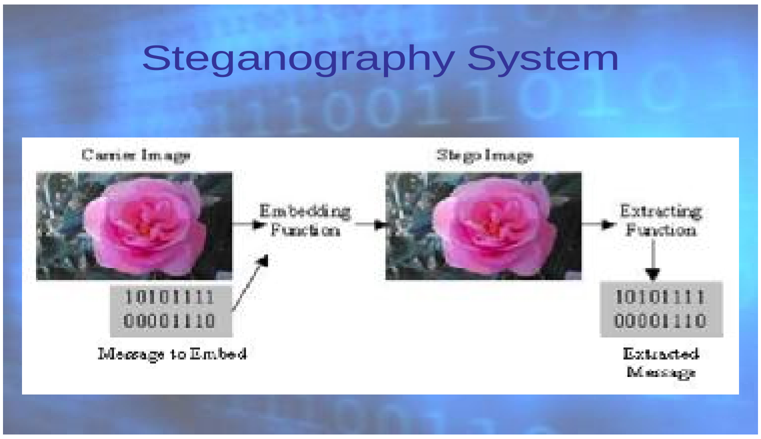


Figure (1): Steganographic system

3. Related Works

In (2004), Tri V. Le, showed a performance evaluation of popular information hiding schemes in prevalence today.[7] In (2008), Xiao-Feng Wang and De-Shuang

Huang execute a novel multi-layer level set method for image segmentation which gives a simple results.[14] While in (2009), Juneja, M., et. al., present an application of LSB based steganographic technique for 8-bit color images.[5] In the same year, Robert Crandall give a survey that focusing on image segmentation using the Chan-Vese algorithm.[2]

In (2010), Saurabh Singh and Gaurav Agarwal present the technique which works by using the image to secure text message with the help of LSB replacement.[12]

4. The Least Significant Bit (LSB) Insertion

The simplest approach to hide data within an image file is called *least significant bit (LSB) insertion*. In this approach, we can take the binary representation of the hidden data and overwrite the LSB of each byte within the cover image. When using 24-bit color, the amount of change will be minimal and indiscernible to the human eye. As an example, suppose that three adjacent pixels (nine bytes) with the following RGB encoding: [6]

10010101 00001101 11001001
10010110 00001111 11001010
10011111 00010000 11001011

Now suppose to "hide" the following 9 bits of data: 101101101. If these 9 bits overlay over the LSB of the 9 bytes above, the result will be (where bits in **bold** have been changed): [5][12]

10010101 0000110**0** 11001001
1001011**1** 0000111**0** 1100101**1**
10011111 00010000 11001011

This description is meant only as a high-level overview. Similar methods can be applied to 8-bit color but the changes, as the reader might imagine, are more dramatic. Gray-scale images, too, are very useful for steganographic purposes. One potential problem with any of these methods is that they can be found by an adversary who is looking. [6]

5. Segmentation

Image segmentation has always been a central problem and a complex task in computer vision. Its goal is to change the representation of an image into something that is more meaningful and easier to analyze. In other words, it is used to partition a given image into several parts (objects) in each of which the intensity is homogeneous. [14]

There is no theory of image segmentation. As a consequence, no single standard method of image segmentation has emerged. Rather, there are a collection of ad hoc methods that have received some degree of popularity. Haralick and Shapiro have established the following qualitative guideline for a good image segmentation: "Regions of an image segmentation should be uniform and homogeneous with respect to some characteristic such as gray tone or texture. Region interiors should be simple and without many small holes. Adjacent regions of a segmentation should have significantly different values with respect to the characteristic on which they are uniform. Boundaries of each segment should be simple, not ragged, and must be spatially accurate."

Unfortunately, no quantitative image segmentation performance metric has been developed. [11]

Up to now, a wide variety of algorithms and methods have been developed to solve the image segmentation problem, which often fall into the elementary segmentation methods such as pixel-based methods, region-based methods, and edge-based methods. [4]

Pixel-based methods only use the gray values of the individual pixels. Region-based methods analyze the gray values in larger areas. Finally, edge-based methods detect edges and then try to follow them. The common limitation of all these approaches is that they are based only on local information. Even then they use this information only partly. Pixel-based methods do not even consider the local neighborhood. Edge-based methods look only for discontinuities, while region-based methods analyze homogeneous regions. [14]

6. The Level Set Segmentation Method

Level set method was introduced by Osher and Sethian. The goal of a level set segmentation method is to find a curve that describes the boundary of the object of interest.[1] It becomes increasingly popular and been proved to be a useful tool for image segmentation.[14] The basic idea of the level set method (any active contour method) is to evolve a curve over time so that the curve moves towards its interior normal and when the stopping conditions are met the curve forms an outline around the object of interest. [1] For a given image *f*, we can create a level set function *Ø(x,y)* with the same size of the image *f* to describe the contour. The contour is defined as the zero level set of the function *Ø* as:

$$C = \{(x, y) | f(x, y) = 0\}, \qquad \ldots(1)$$

The inside and the outside regions of the curve are explicitly defined as:

$$\begin{cases} f(x,y) > 0 & \textit{inside the contour} \\ f(x,y) = 0 & \textit{contour} \\ f(x,y) < 0 & \textit{outside the contour} \end{cases} \qquad \ldots(2)$$

As shown in Figure(2), by changing the *Ø* values, some regions that are originally negative will turn into positive, and vice versa. Therefore, the contour will change according to the update of the level set function. [3]

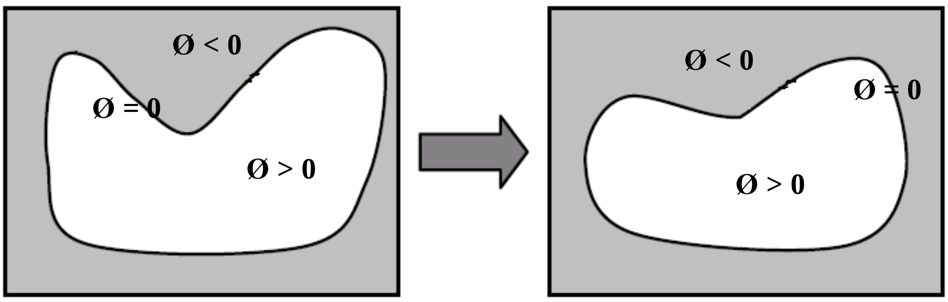


Figure (2): Illustrations of the level set method and the contour change

Level set method can automatically split or joint regions of the image. Also complex topologies such as three way junctions and rings are easily managed with this method. [1] The user can easily know whether a point is inside or outside the contour by checking its *Ø* value. [3]

7. The Chan-Vese Segmentation Model

The Chan-Vese model segments the image domain $\Omega \subset R^2$ into two regions by minimizing the difference between the image intensity $f:\Omega \to R$ and its average value in each region. Additional constraints are imposed on the length of the region boundary C and on the area inside C . [13] the energy functional is defined by:

$$E^{CV}(c_1,c_2,C) = l_1.\int_{inside(C)} \left| f(x,y) - c_1 \right|^2 dxdy + l_2.\int_{outside(C)} \left| f(x,y) - c_2 \right|^2 dxdy \\ + m.Length(C) + n.Area(inside(C)), \qquad \ldots(3)$$

where μ & ν ≥0, λ_1 & λ_2 >0 are fixed parameters. c_1 and c_2 are two constants that approximate the image intensities inside and outside the boundary C, respectively. [15]

The first two terms in equation (3) are often referred as global binary fitting energy terms that seek to separate an image into two regions of constant image intensities. [9]

To solve the minimization problem in equation (3), the level set method is used which replaces the unknown curve *C* by the level set *Ø(x,y)*, considering that *Ø(x,y)>o* if the point *(x,y)* is inside *C*, *Ø(x,y)<0* if *(x,y)* is outside *C*, and *Ø(x,y)=0* if *(x,y)* is on *C* (see Figure(2)). Thus, the energy functional $E^{CV}(c_1,c_2,C)$ can be reformulated in terms of the level set function *Ø(x,y)*:

$$E_e^{CV}(c_1,c_2,f) = l_1.\int_\Omega \left| f(x,y) - c_1 \right|^2 H_e(f(x,y))dxdy \\ + l_2\int_\Omega \left| f(x,y) - c_2 \right|^2 (1 - H_e(f(x,y)))dxdy \\ + m.\int_\Omega d_e(f(x,y))\left|\nabla f(x,y)\right|dxdy + n.\int_\Omega H_e(f(x,y))dxdy \qquad \ldots(4)$$

where $H_\varepsilon(Ø)$ and $\delta_\varepsilon(Ø)$ are the regularized approximation of Heaviside function and Dirac delta function, respectively. These two functions are defined as in equation (5).[14]

$$H(f) = \begin{cases} 1, & f \geq 0 \\ 0, & f < 0 \end{cases} \quad , \quad d(f) = \frac{d}{df}H(f), \qquad \ldots(5)$$

This minimization problem is resolved by taking the Euler-Lagrange equations and updating the level set function *Ø*(*x*, *y*) by the gradient descent method:[15]

$$\frac{\partial f}{\partial t} = d(f)\left[m \quad div\left(\frac{\nabla f}{|\nabla f|} \right) - v - l_1(f(x,y) - c_1)^2 + l_2(f(x,y) - c_2)^2 \right], \qquad \ldots(6)$$

$$c_1(f) = \frac{\int_\Omega f(x,y)H(f(x,y))dxdy}{\int_\Omega H(f(x,y))dxdy} \quad , \quad c_2(f) = \frac{\int_\Omega f(x,y)(1 - H(f(x,y)))dxdy}{\int_\Omega (1 - H(f(x,y)))dxdy}, \qquad \ldots(7)$$

The main advantages of this model are: it automatically detects interior contours, the initial curve can be placed anywhere in the image and it detects both contours with, or without gradient. [14]

8. Chan-Vese Segmentation Algorithm

- No.iteration=n_{max};
- Initialization n=0;
- Set the value of $\lambda_1 = \lambda_2 = 1$;
- Set the value of μ=0.25, ν=0;
- *Repeat*
  - n++
  - evolving the level set function
    - *Initialize the values of the level set function*
      - inside=1;
      - outside=-1;
      - curve=0;
    - *Any shape can be the initialization shape*

```
initial( )
for all (x,y) in Img
    if (x,y) is inside
        Img(x,y)=1;
    else if (x,y) is outside
        Img(x,y)=-1;
    else
        Img(x,y)=0;
    end if;
  end if;
end for;
```

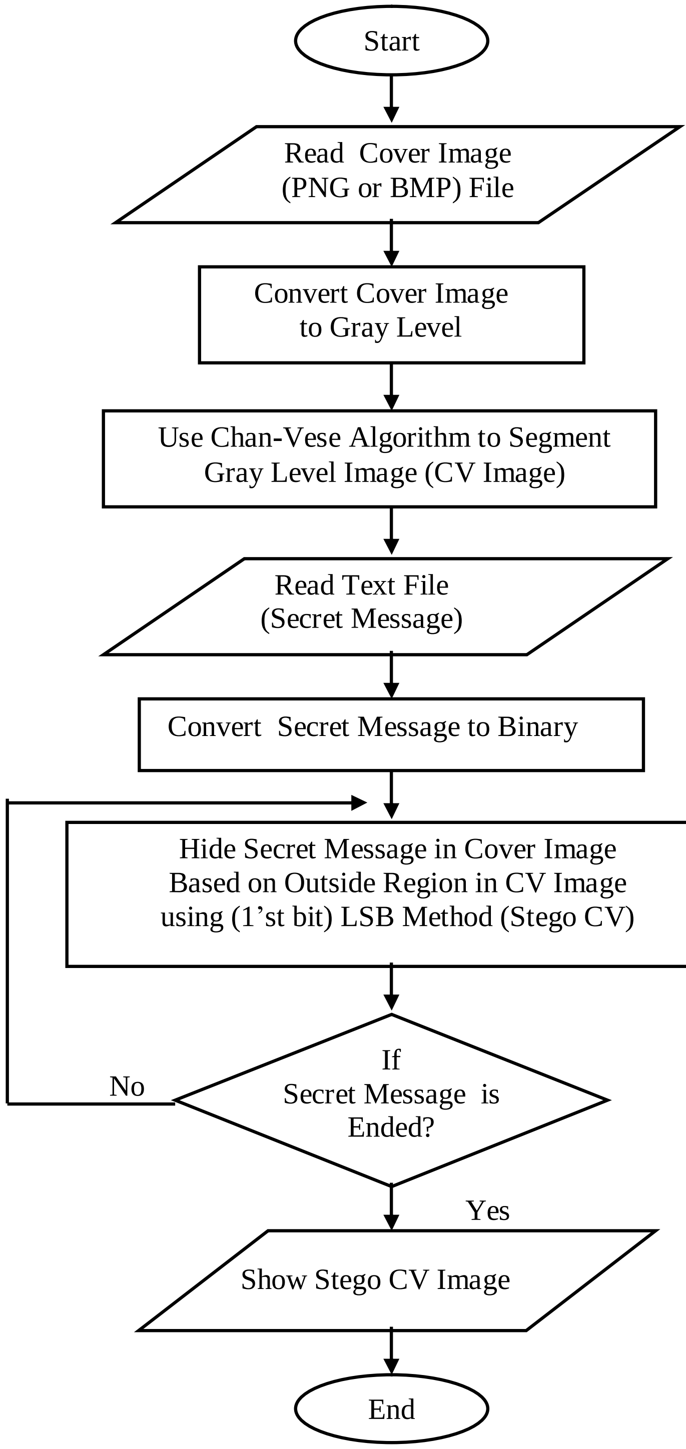
  - computing c_1 and c_2
    - *The mean intensity of the image pixels inside and outside*

```
in=find(Img>0);
out=find(Img<0);
c1=sum(Img(in))/size(in);
c2=sum(Img(out))/size(out);
```

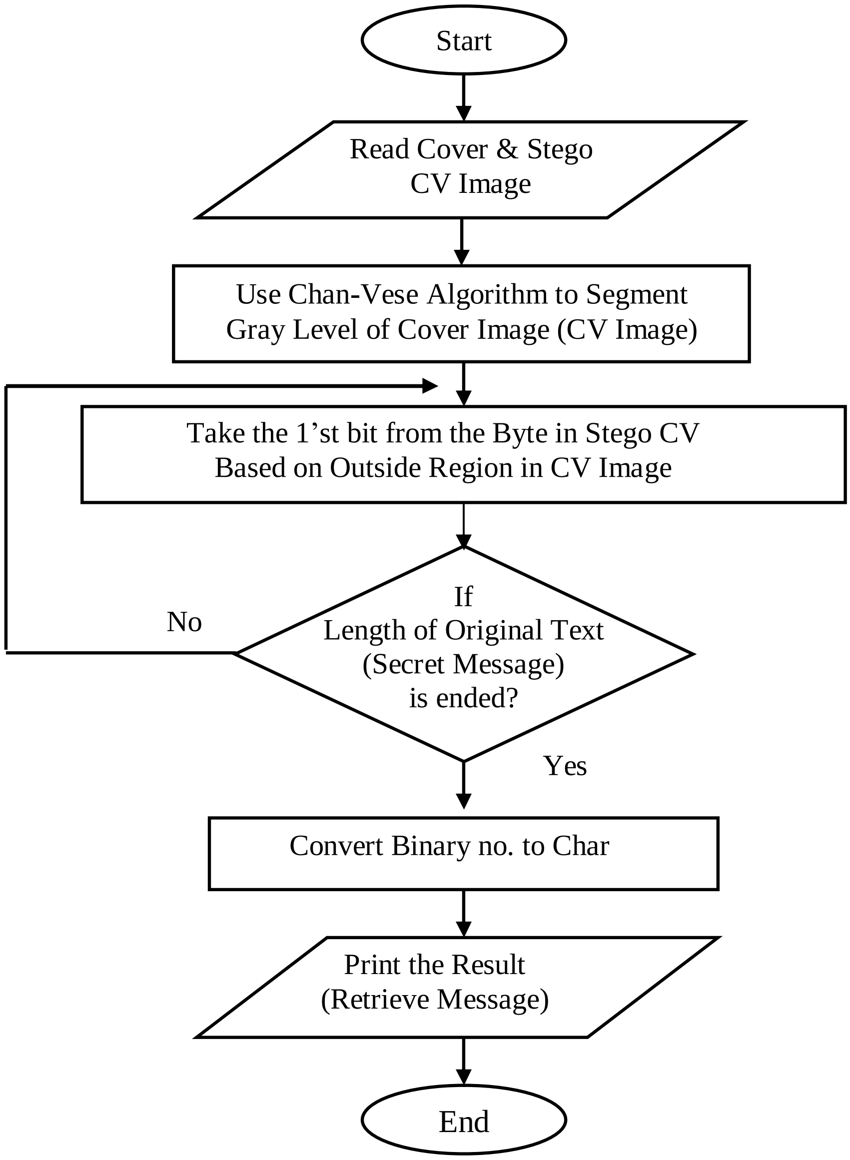
- Until the solution is stationary, or n> n_{max}

9. Hiding and Retrieving Text in Image based on Chan-Vese Model

This section details the implementation of steganography scheme, which can be used to hide auxiliary information within an image file. The scheme hides text in the cover image of types "**BMP**" or "**PNG**" based on the outside region(black region)in CV image and retrieved it.See Figures(3& 4).



Figure(3): Flowchart for hidden the text in cover image (PNG, BMP) based on Chan-Vese algorithm

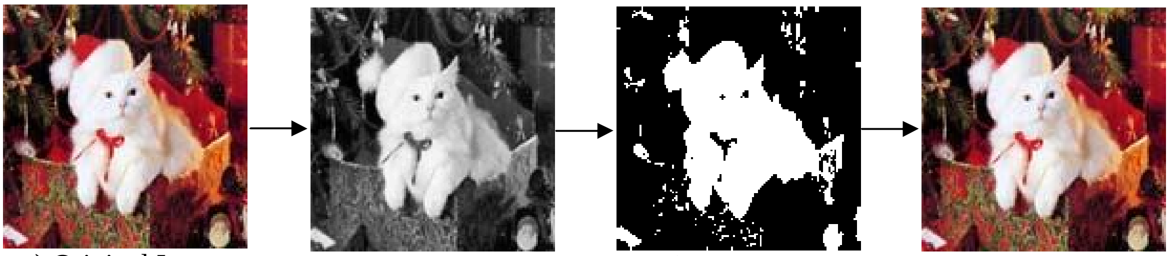


Figure(4): Flowchart for retrieve the hidden text from stego CV (PNG, BMP**)** image

10. Experimental Results

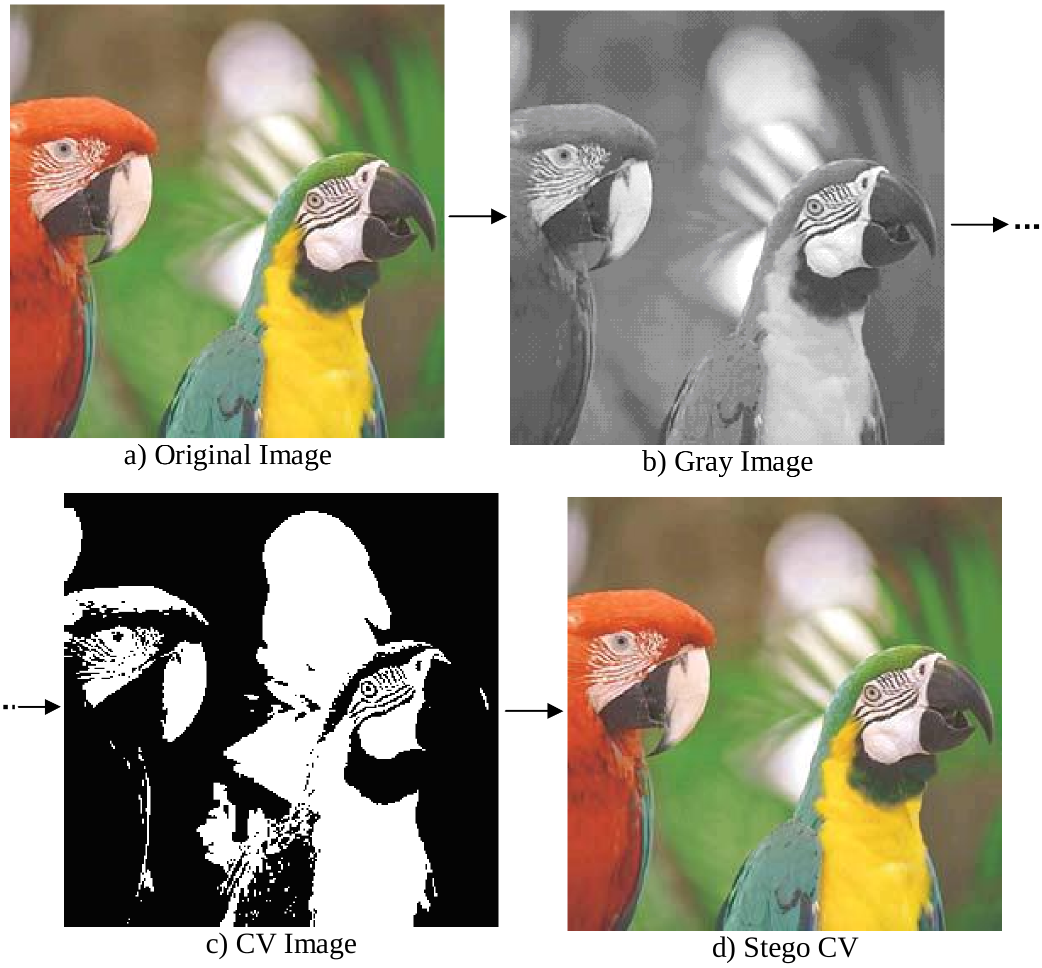
In this section, the results of text hiding in images of types “**BMP**” and “**PNG**” segmented using Chan-Vese method are presented. Chan-Vese was used to segment images because it is a powerful, and flexible method that can successfully segment many types of images, including some that would be difficult or impossible to segment with classical thresholding or gradient-based methods. The results of hiding the secret message below are given in Figures(5,6,7,8). The secret message is:

Portable Network Graphics (PNG) is a bitmapped image format

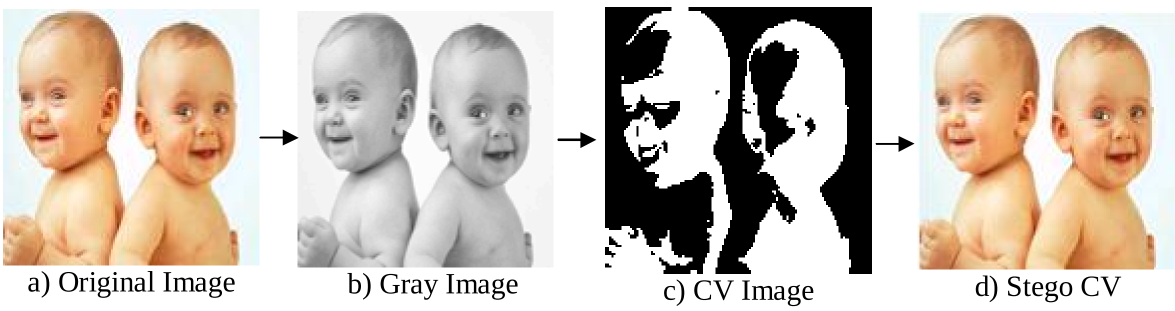


a) Original Image b) Gray Image c) CV Image d) Stego CV

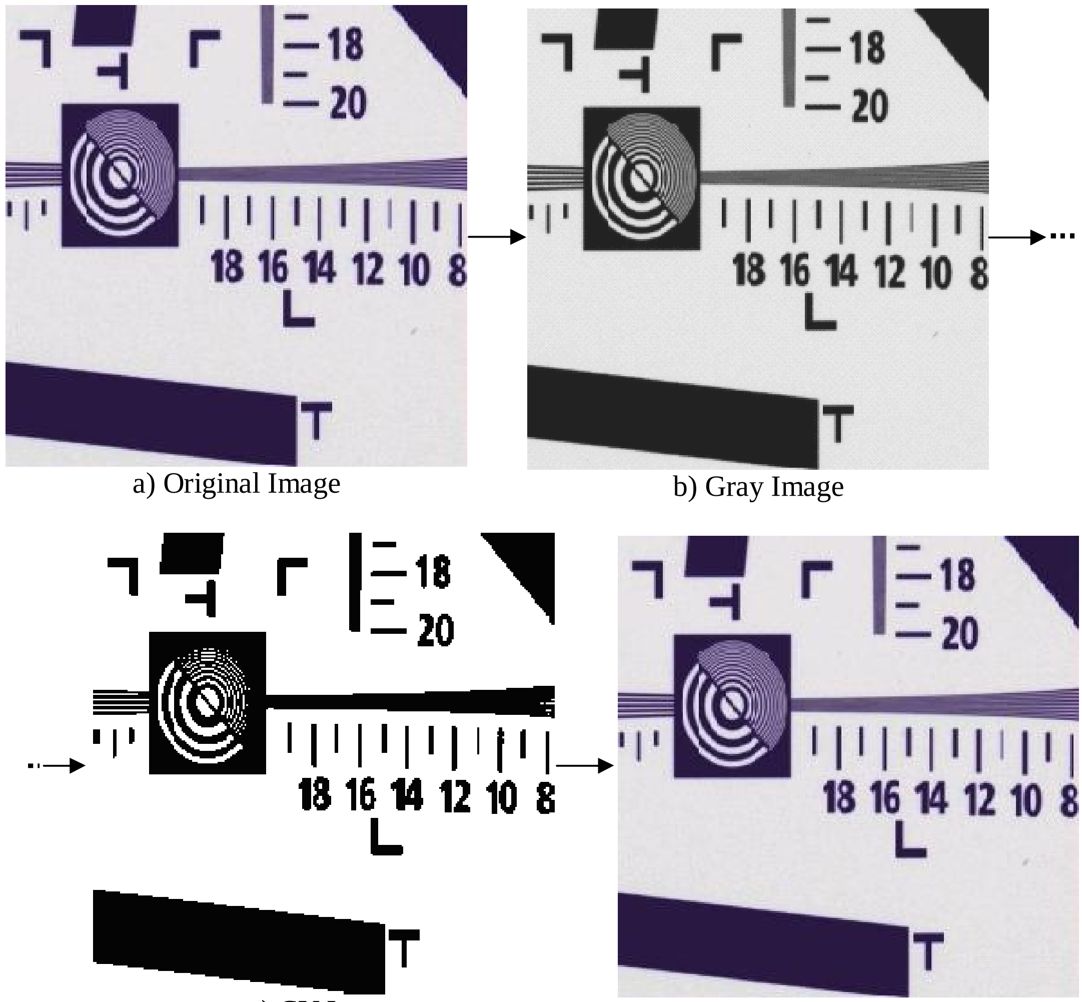
Figure(5): Results of the secret message hiding in **Img1.*PNG*** (128×128) image segmented using Chan-Vese segmentation method.



Figure(6): Results of the secret message hiding in **Img2.*PNG*** (256×256) image segmented using Chan-Vese segmentation method.



Figure(7): Result of the secret message hiding in **Img3.BMP** (128×128) image segmented using Chan-Vese segmentation method.



a) Original Image b) Gray Image

c) CV Image d)Stego CV

Figure(8): Result of the secret message hiding in **Img4.BMP** (256×256) image segmented using Chan-Vese segmentation method.

11. Summary

After applying the Chan-Vese segmentation technique for steganography, a summary can be given for the results using Peak Signal-to-Noise Ratio (PSNR) and Bit Error Rate (BER), as performance measures shown in Table (1) below:

Table (1): Results of applying the performance measures

Images	*Image Size*	performance measures	
		PSNR	*BER*
Img1 (PNG)	128×128	62.860	0
Img2 (PNG)	256×256	62.962	0
Img3 (BMP)	128×128	64.316	0
Img4 (BMP)	256×256	68.729	0

Note that the value of BER depends on length of the secret message, so it will remaine equal to zero until that the secret message will excced a certain length (depends on cover image size) .

12. Conclusions

The Chan-Vese method is especially useful in cases where an edge-based segmentation algorithm will not suffice, since it relies on global properties (graylevel intensities, contour lengths, region areas) rather than local properties such as gradients. This method can segment out adjacent objects successfully. The experimental results of this paper demonstrate the powerful of using the Chan-Vese method to segment image that will be used as a cover for hiding a secret message. Also the results show the performance looks promising both in terms of segmentation and steganography.

In particular, the technique is easy to implement, which is satisfied when the background image layer is reached. It can work well on the specific shape image segmentation.

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