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Coverless Information Hiding Based on Deep Learning Approach: Review

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Abstract. *The proliferation of digitalization in the realm of information has paved the way for numerous types of multimedia data to be attacked. Hence, the security of information has become a critical concern. Over the years, image steganography has been widely acknowledged as one of the most effective techniques for securing confidential information. This methodology comprises the integration of sensitive information into a cover image via the manipulation of specific pixels, resulting in the formation of a steganography image. However, it is imperative to note that such manipulations could be identified by steganalysis algorithms, thus undermining the security of the message. To address the aforementioned concern, the notion of coverless image steganography has been introduced, which serves as a promising solution. The coverless image steganography technique entails the establishment of a mapping correlation between the content of the clandestine message and the cover images, while leaving the cover images unaltered. This review article meticulously scrutinizes the recent studies on coverless image steganography, thereby furnishing significant and profound insights into the techniques.*

Keywords: *Steganography, coverless image steganography, information hiding, information security..*

1. INTRODUCTION

Traditionally, steganography for images involves hiding messages within images. The traditional process of concealment is carried out by hiding the message inside the graphics, that is, inside the image, for example, in a way that is not visible to the human eye. This results in unauthorized persons being unable to obtain the hidden message. This process can be implemented by following one of two methods, which are either spatial masking or frequency masking, and both methods are subject to masking. The traditional method: The first method is characterized by changing the pixels of the image for the purpose of inserting the hidden message. This is achieved by changing the color pixel values or spatial arrangement. On the other hand, manipulating high frequencies is another method [1]. The second method of traditional concealment, as mentioned previously, is a change in the frequency of the image for the purpose of hiding the secret message through a change in the values of the contrast or brightness of the image. It is possible to benefit from this technique to protect secret communications by including the message in the images, after which the image that is hidden is sent. It contains the secret message, and thus messages are transmitted without worrying about being exposed to eavesdropping, or for the purpose of protecting copyright and printing, that is, to protect intellectual property, which leads to preventing some malicious parties from unauthorized copying and re-publishing [2]. Another method used in the concealment process is the use of a watermark, which is used as a secret addition to images. It is implemented using a single identifier that is integrated into the images for the purpose of easy tracking. It is considered one of the traditional methods for hiding messages inside images or texts. Messages hidden within images can be discovered through special analysis techniques. By hiding information, therefore, these methods must be used with caution because they are vulnerable to detection, which has led to a recent reduction in the use of these traditional methods [3]. For the purpose of thwarting the process of analyzing information hidden inside images, we use steganography coverless. This approach relies on generative models, which enable us to hide the secret message inside the carrier, and thus there is no change in the carrier. Therefore, the ability to hide a greater amount of information has been enhanced in a secure manner from attacks. Many works based on generative models provide different techniques to hide information without being detected. Liu et al. Providing a technique that creates a hidden image by replacing secret information with the name Generative Adversarial Networks class [4] . Duan and Song provide a technique that transmits data without encoding any information by using generative models to create visually identical pictures to the secret image [5]. In order to greatly increase the hidden capacity, Cao et al. offer a technique that directly generates anime characters based on attribute labels using generative adversarial networks [6]. n a another study, Duan et al. increase security and capacity by creating visually comparable pictures to the secret image using an enhanced Wasserstein GAN model [7].

2. BACKGROUND

Significant advancements have been made in the creation of generative models in recent years. Many fields, including computer vision and natural language processing, are very interested in generative models. Generative models are very useful for hiding information, which is the act of enclosing private information behind a cover object. In particular, a coverless technique to information hiding with generative models is presented in this study. Coverless steganography refers to a technique used to hide messages without using a cover, such as images. Unlike traditional techniques, in which the cover is an important element, with this technique, there is no need for that cover [8]. Recently, with the emergence of generative models, the security of not discovering hidden secret information has increased through a new approach called concealment without cover, meaning this technique works to identify specific locations for secret information and is crammed instead of using traditional methods, which is concealment with cover [9], as it has been widely used, such as images and multimedia. With the development of technology in data sharing as well as cloud computing, steganography methods based on generative models have become characterized by high rates of concealment compared to traditional methods and an increase in security, which is considered the most important characteristic of this approach, which leads to resistance to steganography analysis tools because they do not use cover [10]. This approach requires storing and processing data, which has become possible due to the rapid development of this technology.

3. STEGANGRAPHY

Steganography is one of the methods used to maintain the confidentiality of data, either by making it hidden from view, which is called steganography, or encoding it in a way that is difficult to read, which is called encryption. In both cases, we are able to transfer and share that information only between the people concerned with it. It can be implemented using traditional methods or modern methods such as generative models. It is possible to embed and extract private information from media using steganography. Steganography's objective is to prevent suspicion from being raised about the transmission of a secret message [11]. The basic tenet of this system is that the stego-object (i.e., the object carrying secret signals) must be perceptually indistinguishable to the extent that suspicion is not aroused. Steganalysis makes use

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of the fact that hiding information in digital media alters the carrier's characteristics and distorts the information as images (i.e., the images that don't contain any hidden messages). The foundation for locating the secret message is steganography [12]. An asteganalysis system is created to detect hidden data by examining the various aspects of stego-images and covering a collection of techniques for embedding information using multimedia data, including images, text, audio, video, etc. [13]. Image steganography has sparked a lot of attention since people use images so frequently and because they are one of the most popular forms of media [14].

3.1. IMAGE STEGANOGRAPHY

Image steganography is a method for communication that involves concealing information in an image [15]. Secret message insertion could be used to conceal data by encoding it for each bit in the image or primarily inserting it as a message in the noisy parts that reflect places with less observation, such as those where there is a lot of natural color variation. Additionally, because covert data cover, images have grown to be the may disperse randomly throughout an entire most frequent Steganography cover objects. The present research's subsequent sections will therefore concentrate on concealing information in images [16].

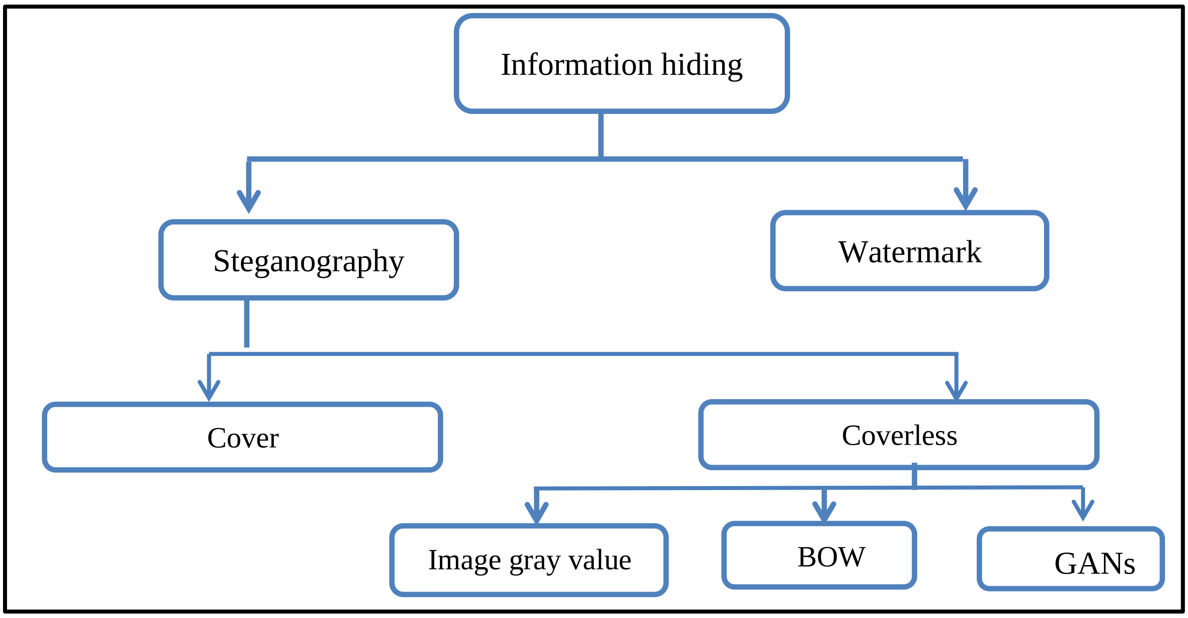

Fig. 1. Classification Of Information hiding techniques

3.2.TRADITIONAL IMAGE STEGANOGRAPHY N

Traditional image steganography involves embedding secret information within an image without altering its visual appearance, thus allowing for covert communication or concealment of sensitive data. This technique utilizes the principle of imperceptibility, ensuring that the embedded information remains undetectable to the human eye. The block diagram of the general traditional image steganography is shown in Figure (2). The approach that is frequently employed in this procedure entails directly encoding the secret data into the carriers. The term "secret data" refers to information where the sender's messages were kept private) [17]. The image that is used to communicate the secret message is referred to as the cover image. When images are used for the purpose of concealment, these images are called stego images, in which we can include the secret information in these images and the cover together, or they are created from the same images. This is on the sending side, but on the receiving side of hidden images, the secret information is extracted through devices that use special decryption algorithms for coding. [18].

3.2.1. LEAST SIGNIFICANT BIT (LSB)

LSB steganography Previously, this technology was one of the most widespread techniques for hiding secret information inside images. The principle of its operation is to use the least important bit in the image pixel values and replace it with the bits of the secret message, so that the secret information is not revealed and the eye cannot perceive it directly inside the image. It has two methods of application, depending on the field. In the spatial or frequency domain, one of the spatial or frequency transforms is used, and then the values of the least important bits in the image are manipulated in order to include the secret message. There are many transforms, including wavelets, etc. [19]. The LSB technique is one of the techniques that is easy to implement and clear to use because it only changes the least significant bit and provides good storage capabilities compared to other transformation techniques. LSB information hiding has limited capabilities in the direction of statistical analysis attacks because it works to analyze and examine whether there is hidden information or not [20].

4. COVER IMAGE STEGANOGRAPHY

Hiding through cover is one of the ways to hide secret data inside digital images without the human eye being able to perceive that secret data because that data will be merged with the pixels of the cover image, so the cover image will be observed as if it were the original image. Due to the great diversity of digital media and the great repetition of these images, there has been a widespread demand for hiding images in all fields, such as combating crimes and the military field, as well as electronic commercial transactions, and electronic development has contributed to the development of this technology [21]. One of the most important benefits of hiding secret photos is the ability to transfer confidential data without detection by unauthorized persons. This feature is important for the security of governments, in addition to the possibility of hiding them in the cover photo and not revealing that identity in communications, for example, during voting processes, for the purpose of not revealing their identities [22].

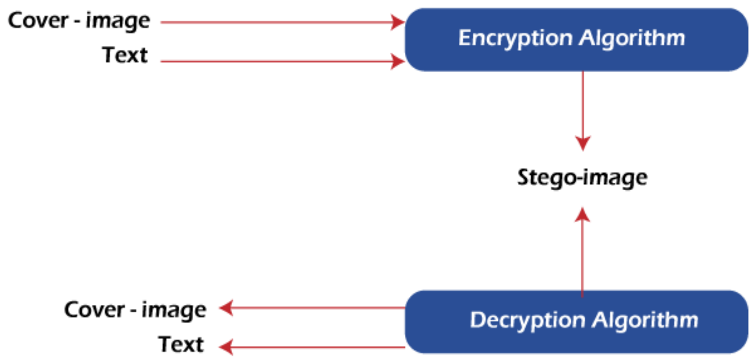

Fig. 2. Traditional Image Steganography[23]

5.COVERLESS IMAGE STEGANOGRAPHY (CIS)

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Coverless steganography is an image steganography framework for hiding secret data by searching for acceptable images that contain these data. These images are considered stego-images. While the carrier is still utilized in coverless image steganography, it is not altered. The hidden information is represented by its own attributes, including pixel brightness value, color, texture, edge, contour, and high-level semantics. The carrier is passed without going through the standard steganography method's construction of the camouflage carrier (the secret information) [24]. In terms of resistance to well-known attacks, including brightness change, rescaling, JPEG compression, and contrast enhancement, enhancing the privacy of information's security of the CIS framework outperforms earlier steganography techniques. Due to the fact that it is invisible and cannot be read, the CIS has a lot of development potential. The fundamental concept of coverless image steganography is to examine the carrier's qualities and map them to the secret information in accordance with predetermined rules based on the attributes' properties. The secret information can be directly represented by the carrier in this way. The stego cover is directly generated or acquired using the secret information. Despite the fact that an image just consists of pixels, the information they hold is very different. The image can express more than the image itself, which is not available in the text, according to previous research on the subject [25].

5.1 Three Challenges Faces CIS:

A. Capacity

It is the first parameter that reflects the most information that can be effectively buried and retrieved. Compared with watermarks, which only need little embedding of copyright information, since steganography is used for communication transmission, high embedding capacity is necessary [26]. Capacity, sometimes expressed in bits per pixel, refers to the typical number of bits hidden within each pixel of the cover image. The number of hidden messages that can be sent through the medium increases with the number of bits that can be hidden in the cover image.

B. Robustness

The second parameter evaluates the extent to which steganography technology resists attempts to remove or change hidden information, because when a hidden image is communicated through trusted systems, an active observer can see the image and change it in an attempt to eliminate any hidden information [27].

C. Security

To hide information because the technology must be able to withstand steganography analysis tools [28]. Steganography is considered secure if the precision value of the classifier is a random guess, making it difficult for an attacker to decrypt the secret message from the shell medium, and security depends on the secret key and knowledge of the algorithm [29].

6.METHODS OF INFORMATION HIDING THAT IS BASED ON DEEP LEARNING

Information can be hidden through unsupervised deep learning via auto encoders, where a neural network equipped with auto encoders is used for the purpose of encrypting and decrypting the required data. The auto encoder part is responsible for the input data for the purpose of representing it in an encoded form containing important information about the original data. The decoding part undertakes the task of reconstructing the original information before encrypting it. By using this method of data hiding, it has become possible to extract hidden information and combine it with various other information carriers, such as images, a framework for a coverless image information steganography strategy based on generative models was first presented in the method in . The hidden image of the generative model database is used to generate regular, independent images with a set of associations. The produced image is then delivered to

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the recipient and entered into the model database to produce a second image identical to the secret image. The parameters and data set are the same for the sender and receiver. Sending the typical standard image, unrelated to the secret image, to achieve the same result as sending the secret image [30]. Another technique for hiding using graphs, where the secret message is included in the design of the graph and is implemented by convolutional neural networks [31]. An autoencoder is a type of artificial neural network used to learn efficient encodings for unlabeled data and is a very useful tool for network embedding. The encoding is validated and refined by attempting to reconstruct the input from the encoding. Autoencoder is an unsupervised learning method [32]. Using autoencoders is one of the methods used to reduce noise for learning text embeddings. It learns the representation (encoding) of effective data by training the neural network to ignore the noise signal [33]. Generative Adversarial Networks are another deep learning-based technique for hiding information. Discriminative and Generative Neural Network play a game-theoretic framework. The Generator aims to generate realistic data samples, while the Discriminator aims to distinguish between real and generated data. By taking advantage of autoencoders within generative adversarial networks, scientists were able to generate realistic data in addition to making a clear meaning of that data through these networks. Therefore, generative adversarial networks became an important field in hiding secret data coverless [34]. This article provides a brief, high-level overview of coverless information hiding and offers solutions to typical challenges, such as the need for separated cover samples and real-world applicability. The advent of deep learning (DL) based models has shown an encouraging performance with typical meta-problems, such as steganography, security, capacity, and model complexity, faced by traditional CIH methods. These have been corroborated by applications in real-world scenarios. So, this new kind of hidden communication framework appears to be not only of academic interest but also of practical importance. Methods for information hiding that are based on deep learning shown in table 1 below:

Table1. -The Coverless Image Steganography that Based on Deep Learning

Ref.	Method	Result	Challenges
[35]	The two generative models, F and G, that make up the approach are used to create the cover image and reconstruct the secret image, respectively. In this paper, many different metrics were used, such as the extent of embedding, its resilience to attacks, and finally the quality of the images, for the purpose of evaluating the method used.	One of the most important results of the research paper is that it achieved a number of metrics, that recorded high image quality in exchange for higher inclusion of confidential data. On the other hand, it withstands many attacks, the most important of which are compression and cropping that affect the images.	One of the disadvantages of the research paper is that it does not withstand certain types of attacks because it was limited to a specific type of quality metrics, in addition to the large amount of data required for the purpose of training these models.
[36]	The paper uses a deep learning model called WGAN-GP to generate visually identical images to hide secret information without using a cover image.	In addition to the security provided by generative models in the data-hiding process, the research paper touched on improving the quality of images.	The method proposed in this research paper is limited to a specific type of data and has not been applied to other types, which results in weak security and lack of accuracy of the data.
[27]	The method proposed in this research clarifies two courses of action, which are as follows, in order to create a synthetic image for the first generative model F, a secret image is first integrated into a public image. This process creates an encrypted image. The quality of the encrypted images produced at this stage is enhanced by the addition of an extraction module and adversarial loss. The secret picture is extracted	The proposed method was able to achieve better results in terms of security, robustness, and reconstruction ability compared to existing methods.	There are no ways to measure the experimental results such as the accuracy of the proposed method

	from the reconstructed synthetic image during the decryption stage, which uses a second generative model G to reconstruct the synthetic images from the encrypted images.		
[37]	A method based on the creation of anime characters is suggested. Using generative adversarial networks (GANs), the secret information is first transformed into an attribute label set of the anime characters. Then, the label set is used as a driver to directly generate anime characters.	Hidden capacity improved by nearly 60 times and Good performance in image quality and robustness	The paper does not provide a detailed analysis of the security of the proposed method against steganalysis attacks.
[38]	WGAN-GP (Wagner Neural network and improved GAN model)	Generated image gets closer to secret image with more iterations and Generated image visually identical to secret image	There are no ways to measure the experimental results such as the accuracy of the proposed method
[39]	The two parties agree in advance on a special sequential approach, after which the cover is divided into several small parts, and then we assign each MSB in the image and confidential data.	more hiding capacity, a reduction in the Bit Error Rate (BER) of the distorted stego image, and a limitation on the distortion of the image to enhance its quality.	The proposed method not be suitable for all types of images and be effective against certain types of attacks.
[40]	First, a fractional image is created and we consider it as a cover image. The secret information is merged with that image with modifications to the fractional values. This modification is then exploited to form a new image containing the secret information.The original fractal image is used as a reference to extract the secret information from the new fractal image.	The results show that the proposed algorithm has the following advantages: High embedding capacity Good imperceptibility Strong robustness against various attacks	The generalizability of the proposed algorithm to other datasets and scenarios is not clear. Additionally, the paper does not compare the proposed algorithm with state-of-the-art methods in the field.
[41]	The proposed method uses an image sampler based on the generative adversarial network to ensure that the distribution of the synthesized image is the same as the distribution of a real image under an ideal condition, so that a hidden analysis method based on statistics can be resisted.	The proposed method can be used in various applications such as secure communication, digital watermarking, and copyright protection but does not provide any specific numerical results or experiments.	Limited concealment ability as well as no specific security level

7.CONCLUSION

Continuing progress in the development of traditional steganography analysis methods degrades the performance of public classified communications systems and makes them vulnerable to detection and hacking. Steganography is the practice of hiding a message within a medium, such as a digital image, audio file, or other types of media. It serves as an important means of confidential communication with a wide range of applications. According to the range of applications, information hiding can be divided into communication security, copy restriction, fingerprint protection, ownership protection, and some other fields. On the one hand, the ubiquity of the network and the rapid development of computer communication make information transmission more and more convenient and vast, and they also let the carrier medium of steganography have higher concealment. On the other hand, as a product and application of ideal mathematical technology, especially the application of digital technology, steganography emerges accordingly. It is crucial to develop new methods to protect private digital content. Using neural network models to achieve coverless communication is a new concept of information security. The experimental results of the mentioned methods show that the coverless steganography system has good performance in the experimental environment in which the most intuitive and original features of steganography are described, and the application of steganography is analysed. The idea of coverless steganography is to hide the edges that carry information or to extract the basic properties of the information and represent it. In other words, although the image itself does not contain secret information, the behaviour and nature of the algorithm used still contain the property of hiding information.

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