

Survey in Image and Audio Steganography by using the Deep Learning Methods

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Abstract *Steganography is the practice of secretly encoding information into another medium (called a cover media) such that its existence cannot be identified. Steganography is the method that is utilized to successfully do this task. Through the use of digital image steganography, one is able to achieve the capacity of secure communication, which is vital in the bulk of the applications that are now being created. The use of steganography is applicable in a wide variety of advantageous settings. Its ascent to the forefront of current security systems may be attributed to a confluence of factors, including a phenomenal rise in processing power and a heightened awareness among individuals of the need of safeguarding their personal information. When it comes to the creation of a steganographic method, the most significant challenge that must be surmounted is finding the optimal balance between quality and quantity. The method is distinguished from linked systems like encryption and watermarking by its ability to embed information, as well as by the fact that it cannot be seen by the human eye. This article presents a thorough examination and analysis of some contemporary steganographic methods that are regarded as state-of-the-art approaches. In addition, we have included an in-depth discussion of the most important steganographic technologies now available. Recent steganographic techniques that are based on deep learning have been enhanced, which has enabled the resolution of issues that were previously present.*

Keywords— *Image Steganography, Deep Learning, GAN, Audio Steganography.*

1. INTRODUCTION

Due to the rapid advancement in communication technology that has occurred over the past several years, it has become increasingly vital to increase the information security. Because of the necessity, more sophisticated methods of data security are now readily available to a wider audience. Through the use of numerous communication technologies, such as the internet and a variety of other types of local area networks, individuals now have the ability to quickly exchange and receive information.

The possibility that information may be snatched up by those who are not authorized to do so is among the most serious difficulties connected with the transfer of data. The protection of sensitive data is the necessary first step in the process of moving it to a safe place; thus, information security is of the utmost importance for the successful completion of the process without any interruptions. Information security is the protecting of data from manipulation by hackers or other users who are not authorized to access the data. This might include other users who try to access the data. It provides a high level of protection against the data's being altered in any way. Cryptography, information concealment (including steganography and digital watermarking), and similar techniques are only a few examples of how the security of data transmissions over the internet may be improved in a number of different ways [1, 2].

The study of secret communication as well as the creation of matching mathematical tools is what cryptography is all about. Cryptography allows two parties to share information through a method that isn't totally dependable without having to worry about the information being intercepted or used in any manner by a hostile third party. This is because the information is

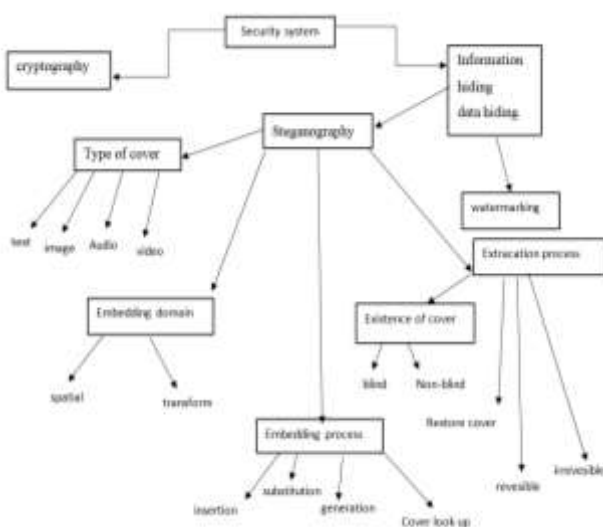
encrypted before it is sent. It's possible that a wired telephone connection, an internet network, or a wireless access point will serve as this media. [2, 3] Keys are the basic way by which asymmetric and symmetric cryptography approaches may be differentiated from one another.

Steganography is a method as well as an embedding science that is used to disguise information such that only the creator and the intended recipient can decipher it. receiver understands that it is present [3, 4]. Steganography is a collection of techniques and procedures for encoding confidential information into a digital cover file (image, audio, video, etc.) in such a way that unauthorized persons are unable to access it. Steganography is also known as "stealth photography." On the other hand, steganalysis is utilized in order to determine whether or not cover files include sensitive data that has been encrypted. When an adversary discovers that a steganographic system exists or decodes a concealed message, the system is said to have been cracked [5]. The Least Significant Bits (LSB) technique is a straightforward approach utilized in spatial domain steganography for the purpose of concealing information within a cover picture. This approach is used in the research that is being presented here. This is done in a sequential manner, with the bits that make up the secret message being instantly placed into the bit cover image plane that has the fewest significant bits. It is important that the image on the cover does not change aesthetically in any way, regardless of what happens to the contents within. For instance, when using LSB replacement in bitmaps with a width of twenty-four bits [6,] there is no discernible reduction in the image's quality. The LSB approach offers a high degree of invisibility due to the fact that it hides information using just one bit per pixel, but its capacity for concealing data is somewhat limited. This is due to the fact that the

representation of each image only has to employ a single bit. Recovering the LSBs exposes that the picture includes sensitive data, which can be easily retrieved as a secret message [7, 8], hence it is not a safe method. This is the reason why it is not secure. The fact that it is feasible to know that it includes private information just by glancing at the picture is another reason why it is unsafe. As a result of the fact that the Internet is an open and public communications network, the problem of information security has become increasingly significant. Encryption of the data being transmitted is often thought to be sufficient to ensure the safety of the communication process; but, in practise, this has not always been the case. Researchers have concentrated more on ways that hide communications rather than methods that encrypt them, despite the fact that contemporary encoding methods are constantly developing and improving. Therefore, the examination of secure communications entails not only encrypting information but also masking their presence, the basis of which is in the concealment of information. This system contains technologies such as mobile subscriber temporary determiners, which are utilised in digital telephones to supply operators with some degree of secrecy location, and spreading the radio's spectrum, which has generally been utilised in strategic military systems to avoid the presence of transmitters. Additionally, this system contains technologies such as spreading the radio's spectrum, which has generally been utilised in strategic military systems to avoid the presence of transmitters. Steganography is an essential method that may be used to conceal information. Steganography, on the other hand, is concerned with concealing the presence of the communications, whereas cryptography is concerned with protecting the substance of the messages [3].

On the other hand, we offer an explanation that is both straightforward and succinct about the basics of cryptography, watermarking, and steganography primitives.

Figure (1) : show the categorization of several types of information security System



2. Image Steganalysis Based on Deep Learning

The effectiveness of deep learning algorithms has been proved to be exceptional across a broad range of application areas. Researchers that specialize in picture steganography and steganalysis have shown an interest in investigating the feasibility of using deep learning algorithms to a variety of crucial areas of multimedia security. It's astonishing how successful steganography can be when it's built with generative adversarial networks (GANs), especially when it comes to deep learning. If a training set is used as the method's input, it will learn how to produce new data that have the same statistics as the training set. For instance, a GAN that has been trained on images is able to produce new pictures that look at least superficially legitimate to human observers. These newly generated pictures exhibit a huge variety of properties that are realistic. Initially, GANs were conceived of as generative models that could be applied to unsupervised learning. Nevertheless, it has been demonstrated that they are beneficial for learning in all three of the aforementioned modes: semi-supervised learning, wholly supervised learning, and reinforcement learning. A Steg analyzer that is built on deep learning enables us, without a shadow of a doubt, to automatically produce random pictures and classification stages inside a one-of-a-kind network architecture that exceeds any prior feature selection. It has spawned several effective strategies that are based on GAN, which has led to tremendous development and has attracted the attention of a significant number of scholars. After all, the most recent breakthrough in deep-learning steganography is still confronted with a great deal of resistance. For this reason, methods of deep learning should be applied in order to do research on these issues. The graphic that follows illustrates numerous problems that are related with the deep learning-based algorithms that are now accessible.

2.1 GAN-Based Steganography

GANs, or generative adversarial networks, have only recently been developed, but they have opened the door to many new ways to accomplish image steganography. Researchers came up with the idea of steganographic generative adversarial networks (SGANs). This was done so that GAN-based techniques could be applied to steganographic algorithms. It comprises two distinct varieties of neural networks: a generator network (G) and a discriminator network (D). The generator creates false images to trick the discriminator, while the discriminator works to differentiate between real and fake data samples. Both parties are working to achieve their respective goals. By pitting them against one another in practice and doing so repeatedly, we can improve the Generator and the Discriminator. First, Volkhonskiy et al.

introduces a brand-new adversarial training framework to construct an image similar cover image container that is a part of deep convolutional generative adversarial networks (GANs). Using this strategy, we can generate cover images that are more secure and can deceive any step analyzer. However, the images generated using this technique will readily attract attention.

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3. RELATED WORKS:-

This section presents the efforts that have already been accomplished on the subject of steganography by making use of various systems. Several diverse methods, some of which are related to the ongoing research and are described in the lines that follow, can be connected to the transmission of information in a covert manner:

According to Roshidi Din and Alaa Jabbar Qasim in [Steganography analysis techniques applied to audio and image files] (2019), there is a strong connection between the two types of steganography aims to conceal information in a way that is invisible to the human senses. However, there are very weak techniques that have already been breached. For example, LSB is one of the simplest to implement, but it provides very little security and robustness because the hidden data is straightforward to extract. Conversely, made hiding and Spread Spectrum are two of the most secure aural steganography methods; likewise, PMM and Discrete Cosine Transform offer higher levels of security than other methods. [16].

Ye Dengpan et al. [Heard More Than Heard: An Audio Steganography Method Based on GAN] (2019) In this article, we present a novel method for producing automatically generated audio steganography. The suggested model comprises three parts that work together to create the embedding, extracting, and discriminating processes. During the adversarial training, we considered the external detector and used a steganalyzer as the discriminator. By conducting three separate trials, we successfully demonstrated the efficacy of our approach [11].

Abraham Ayegba Alfal et al . [A Comparative Study of Methods for Hiding Large Size Audio File in Smaller Image Carriers] (2019) This paper corroborated numerous researches in image steganography that utilized at least two methods such as spatial domain (pixel value variation) and transform domain (DWT). The undercover exchanges between parties for image encompass pixel MSBs and LSBs as usual practice in order to minimize risks on channels. The effectiveness of image steganography depends on the exploitation of HVS weaknesses in spotting insignificant alterations of the cover image pixels by inadvertent receivers. This paper established that colour images with LSB have greater propensity of enhancing undercover broadcast of audio file with lesser likelihoods of being discovered by HVS/unwanted clients during transmission. However, this is attained upon preprocessing of standard grayscale and RGB colour images including noise removal, smoothing, enhancement, and resizing. Similarly, the audio sound file is contiguously reduced with DWT compression to simply embedding process in cover image. The process of hiding the preprocessed voice notes involved bits substitution method, which replaced the MSBs and LSBs of image cover medium

with those of voice notes. This paper recommends for further study a method for secret broadcast of large size audio data inside image covers by combining MSBs and LSBs in hiding slices of audio file into the cover image[31].

Jiaohua Qin et al . [Coverless Image Steganography Based on Generative Adversarial Network] (2020) used to protect photographs. In this investigation, a GAN generates the cover image and confidential information. At this stage, the personal data is incorporated into the composite image at any place you choose. On the basis of this, a performance index of a steganography system based on deep learning is given, making it convenient for direct comparison with the conventional steganography algorithm. The experimental findings demonstrate that our models have a large payload, and this is because our models make use of a variety of convolution approaches[9].

LANG CHEN et al . [Learning to Generate Steganographic Cover for Audio Steganography Using GAN] (2021) In this work, we proposed employing the generative adversarial network to build better steganographic cover audio to hide audio. It is possible that embedding messages on steganographic cover audio could produce more secure stego audio, which can withstand steganalysis based on deep learning. The suggested method uses a training architecture comprising three primary modules: a generator, a discriminator, and a deep learning-based step analyzer that can be purchased off the shelf. We purposefully conceived of the network architecture of the generator and the discriminator. We offer an efficient training approach for adversarial training among the three modules in the proposed framework [10].

Hariom Dudhwal, Asst. [Audio Steganography Based on LSB Method] (2021) This investigation analyzes the various ways of audio steganography based on LSB. Due to the sensitivity of the Human Auditory System (HAS), extracting the information that is hidden in audio recordings can be a challenging undertaking. On the other hand, listeners rarely pick up on a few generic ambient aberrations in the recording. Researchers use these features by transmitting secret information through audio signals as carriers to conceal the information. This study presents an evaluation of a Least Significant Bit (LSB) technique. The goal of this technique is to tackle the low security and capacity difficulties that are associated with conventionally utilized LSB techniques. The LSB-based approach consists of three primary stages: the preprocessing stage, the embedding and extraction stage, and the message validation stage. The primary objective of the first stage is to strengthen the safety of concealed messages [12].

Ilham Firman Ashari [The Evaluation of Image Messages in MP3 Audio Steganography Using Modified Low-Bit Encoding] (2021) The test is carried out based on an objective assessment by paying attention to aspects of imperceptibility, recovery, fidelity, robustness, and payload. The results of imperceptibility testing by looking at the image histogram curve of the image before and after insertion with the same results and there is no difference, means that the image quality before and after insertion is the same. Audio files before and after insertion by looking at the comparison between the methods LBE + 1, LBE + 2, LBE + 3 do not look very significant differences. Based on testing on the fidelity

aspect, we can see optimal PSNR and SNR values on LBE + 2, by looking at the capacity of the inserted picture message and image quality. PSNR LBE + 2 values range from 50-60 dB with SNR different about 0.01% from LBE + 1. The test results based on the aspect of robustness show that the proposed method is not resistant to attacks with changes in bit rate and channel mode. Testing of the recovery aspect gives the result that the proposed method already supports the 100% recovery aspect, meaning that the quality and size of the image (.jpg, png, BMP, and. gif). Before insertion and after extraction will be the same. And finally, the test results on the payload aspect, there is an increase in message capacity with LBE + 2 around 12.5% of LBE + 1, and using LBE + 3 will increase the maximum size around 25% of LBE + 1 and about 14% of LBE + 2. The insertion and extraction time for LBE + 3 is slower compared to the others. This research can be developed further by using a more secure encryption algorithm, for example using RC4 or AES. In addition, it can use several variations of other message objects such as audio and video[33].

Muhammad Harith Noor Azam¹ et al [A New Method to Estimate Peak Signal to Noise Ratio for Least Significant Bit Modification Audio Steganography] (2022) This paper proposes a new method to estimate the PSNR value of any LSB embedding level to cater to the trade-off between imperceptibility and robustness. PSNR values' pattern from embedding at a different level of LSB, which affect the robustness features, can be used to estimate the PSNR specifically for the imperceptibility feature of audio steganography. The estimated PSNR value generated based on the new method has an average of 99.9% accuracy compared to the actual embedding result at a different level of LSB throughout different embedding levels. The proposed method obtained higher accuracy when compared to Mazdak Method and only needed one actual PSNR value compared to Mazdak Method, which needs two actual PSNR values to operate. However, the focus of the proposed method is only on LSB modification. Hence, it is not suitable and accurate to implement the frequency domain in audio steganography. To conclude, this method can be used as a utilisation tool to refrain from the repetition of embedding processes in finding the feasible solution to cater for the trade-off problem between imperceptibility and robustness features and further reducing the computational complexity of unnecessary repetitive embedding processes. Furthermore, the efficiency of an audio steganography method can be improved as any bad cover audio can be avoided from being produced. Future work that can be considered includes creating a steganography method based on this new estimation method to obtain a method with balanced features in terms of imperceptibility and robustness[32].

Muatamed Hajeret al [IDENTIFYING OPTIMAL MESSAGE EMBEDDING LOCATION IN AUDIO STEGANOGRAPHY USING GENERATIVE ADVERSARIAL NETWORKS] (2022) The main objective of this research is to improving the data protection by identifying the data embedding location in the audio. Generative Adversarial Network-based Audio Steganography Framework (GAN-ASF) is presented in this study, and it can automatically learn to provide better cover audio for message embedding. The suggested framework's training architecture comprises a generator, a discriminator, and a steganalyzer learned using deep learning. The Least Significant Bit Matching (LSBM) message embedding technique encrypts the secret message into the steganographic cover audio, which is

then forwarded to a trained steganalyzer for misinterpretation as cover audio. After performing the training, stenographic cover audio has been generated for encoding the secret message [34].

Chandan Kumar et al. [Latest Trends in Deep Learning Techniques for Image Steganography] (2023) In the realm of picture steganography, the purpose of this study is to offer a high-level overview of the different deep learning algorithms that are being applied or that may possibly be used for best outcomes. This is a concise overview of various current deep learning-based image steganography algorithms, along with a comparison of those approaches. In spite of the fact that a significant amount of research has been carried out in recent years, with some really encouraging results, there is still a significant distance to travel. For instance, certain algorithms, when analysed theoretically, produce better results than other available choices; nevertheless, putting them into practise is challenging and yields inferior outcomes. A fantastic method for further refining the performance of these algorithms is to include newly developed deep learning models in their code. In addition, there are several forms of deep learning learning models, such as autoencoder-based models, reinforcement learning models, etc. It has been demonstrated that it is possible to conceal images using methods such as learning, attentiveness, and convolutional neural networks. [35].

Table(1) : Shows a comparison of previous readings

No.	name Author	Search Name	the year	the method used	the accuracy
1	Roshidi Din and Alaa Jabbar Qasim	Steganography analysis techniques applied to audio and image files	2019	techniques LSB , Temporal domain and Frequency domain and Spatial domain and Transformation domain and Masking and filtering.	the performance of PMM has been measured through various metric techniques such as Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Root Mean Square Error (RMSE) and Structural Similarity Index (SSI), and a measurement has also been made with stegoanalysis techniques such as RS , SP , Chi-square resulting in a high safety measure and prove
2	Dengpan et al. Ye	Heard More Than Heard: An Audio Steganography Method Based on GAN	2019	a generative adversarial network (GAN)	the proposed scheme could produce high fidelity steganographic audio which contains secret audio. Besides, the additional experiments verify the robustness and security of our algorithm.
3	Abraham Ayegba Alfa et al	A Comparative Study of Methods for Hiding Large Size Audio File in Smaller Image Carriers	2019	the audio file is compressed to appropriate size before embedding it into two distinct image files (grayscale and RGB color) at binary level using both Most Significant Bits (MSBs) and Least	RGB colour cover image with LSB is better than when put side-by-side with the grayscale cover image with MSB.

				Significant Bits (LSBs) methods	
4	Jiaohua Qin et al	Coverless Image Steganography Based on Generative Adversarial Network	2020	a generative adversarial network (GAN)	steganography GAN is an efficient method which generates highly similar images
5	LANG CHEN et al	Learning to Generate Steganographic Cover for Audio Steganography Using GAN	2021	a generative adversarial network (GAN) and LSBM	proposed method enjoys preferable undetectability performance when the embedding rate is 0.1 bps Lower Detection Accuracy Indicates Better Undetectability Performance.
6	Hariom Dudhwal, Asst	Audio Steganography Based on LSB Method	2021	LSB Method	The method is successfully tested on various 32 bit & 16 bit stereo wave files with different payloads. The SNR dB values comes out be in the range 139 dB to 142 dB for 32 bit and 67 dB to 85 dB for 16 bit stereo files. The Bit Error Rate (BER) comes out be in the range 0.23 to 0.32 percent for 32 bit and 0.018 to 0.028 percent for 16 bit files
7	Ilham Firman Ashari	The Evaluation of Image Messages in MP3 Audio Steganography Using Modified Low-Bit Encoding	2021	the AES or RC4 encryption algorithm and the LSB method	The test results on the fidelity aspect obtained PSNR results from the image message on average above 30 dB for image sizes > 50 kB
8	Muhammad Harith Noor Azam et al	A New Method to Estimate Peak Signal to Noise Ratio for Least Significant Bit Modification Audio Steganography	2022	Audio steganography is implemented based on three main features: capacity, robustness, and imperceptibility, but simultaneously implementing them is still a challenge. Embedding data at the Least Significant Bit (LSB)	the proposed method has 99.9% of accuracy in estimating PSNR values at different levels.
9	Chandan Kumar et al	Latest Trends in Deep Learning Techniques for Image Steganography	2023	a generative adversarial network (GAN)	Various deep learning algorithms provide a better, more efficient approach to achieving the desired results
10	Muata med Hajer et al	IDENTIFYING OPTIMAL MESSAGE EMBEDDING LOCATION IN AUDIO STEGANOGRAPHY USING GENERATIVE ADVERSARIAL NETWORKS	2022	Generative Adversarial Network-based Audio Steganography Framework (GAN-ASF) And LSB Method	The test results GAN-ASF achieves a performance ratio of 94.5 %, accuracy ratio of 96.2 %, an error rate of 15.7 %, SNR 24.3 %, and an efficiency ratio of 94.8 %

Because of the unpredictability that is built into the training technique. When it comes to training models with GANs, there are a few usual roadblocks to look out for. The following is a summary of some of the most typical issues that researchers could face when training GANs models.

1. Unstable progress towards achieving a convergent state that is stable for the model parameters. Convergence is the most significant theoretical and practical challenge associated with GANs.
2. When training a GANs network, a key challenge that many GANs models encounter is called "mode collapse." Mode collapse happens when the generator creates a limited fraction of the potential distribution of samples from an actual dataset. This might lead to unexpected results.
3. Reduced gradient: When the gradient completely disappears while the network is being trained. The discriminator network is performing incredibly well; however, the generator network is struggling to learn as a result of the gradient being removed. As a direct consequence of this, overfitting problems manifest themselves whenever there is an imbalance between the generating networks and the discriminator networks.

Figure (2) shows comparison between steganography, steganalysis and GAN structures

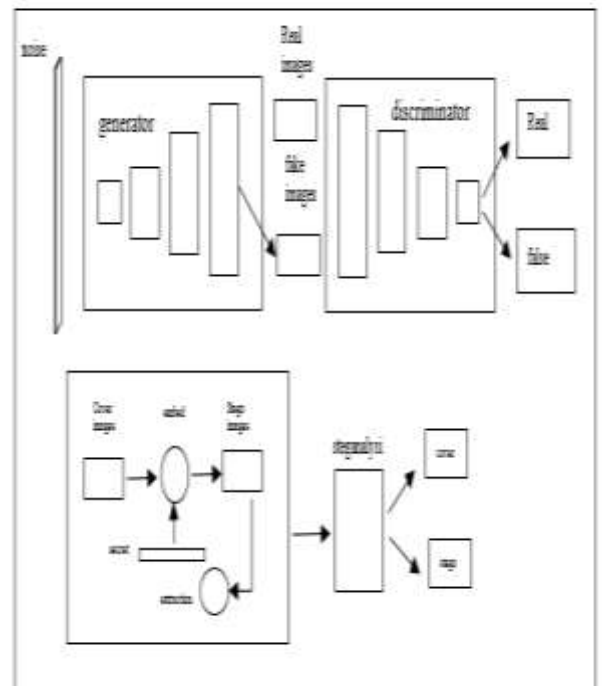
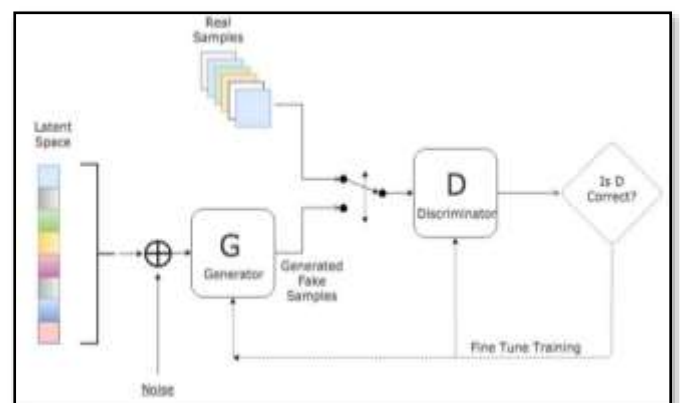


Figure (3) shows Global concept of a GAN



4. Difficulties in GANs Caused by Steganography Frameworks for Deep Learning

GANs have the potential to yield astonishing outcomes, but it may be challenging to train a stable network.

4.1 Applications of GAN :-

1- Art :-

GANs are used to generate realistic paintings such as the works of Vincent Van Gogh or Rembrandt.

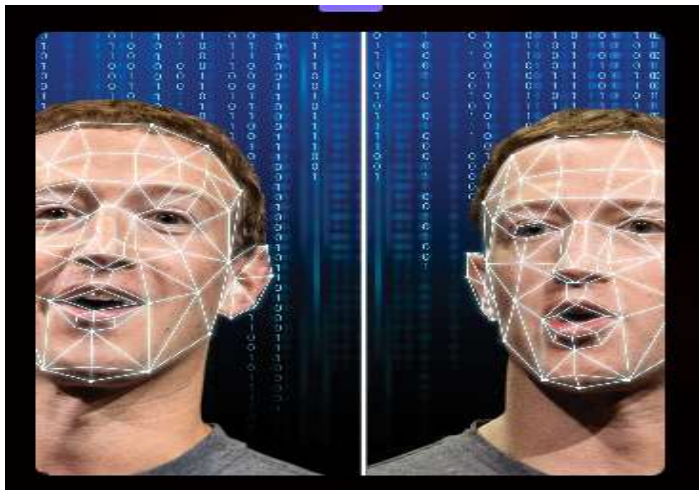
Figure (4) shows Art by using Gan



2- Entertainment :-

GANs can create DeepFakes or generate fictional characters like Shrek or Harry Pottle .

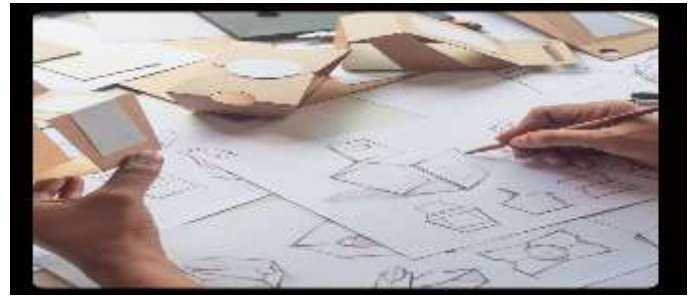
Figure (5) shows DeepFakes by using Gan



3- Product Design :-

GAN-generated images can be used in product design, allowing companies to visualize how products might perform in different environments.

Figure (6) shows Product Design by using Gan



5. Directions for Future Studies

Deep learning-based steganography and steganalysis algorithms provide solutions to a number of problems that, if tackled with more traditional methods, would be impossible to solve. Nevertheless, as was said before, there are still a number of issues that are not being dealt with in an appropriate manner. We have published a detailed survey that focuses on the most urgent difficulties in the field of steganography in the hopes that it would be useful to academics who are interested in building a deep learning framework for steganography and steganographic analysis systems. In addition, we presented an overview of the deep learning architecture for picture steganography and steganalysis. This included a discussion of pixel selection, payload capacity, and embedding techniques, all of which are essential topics for further research. As a result, it is to everyone's advantage to examine these challenges as soon as possible utilising methods of machine learning. In addition, we discussed recent developments in deep learning that might open the door to workable solutions and presented a list of potential future research directions pertaining to this subject area.

- 1) Do more research into deep learning models and systems that are supported by theory, such as RNNs and Bayesian neural networks. Make use of these technologies in the conflict between steganography and steganalysis that you will be utilising deep learning to resolve.
- 2) Conduct research into the clipping and compression methods utilised in the existing Deep Learning framework for steganographic analysis with enormous parameter and size ranges. Make use of these discoveries to construct a.
- 3) steganographic analysis framework that is efficient despite its small size and brevity The basis for steganography analysis may now be constructed automatically using deep learning. This was previously impossible. When developing a framework for deep learning steganographic analysis, it is imperative that the human factor not be taken into account at any point.
- 4) The embedding rates and levels of security provided by the least distortion embedding framework and the deep learning steganography framework are roughly equivalent.

6. Conclusion

The purpose of this study was to provide a comprehensive overview of the present state of the art about the use of deep learning (DL) steganography to image and audio etc. Examine recurring and one-of-a-kind problems, the strategies that researchers have used to try to solve them, and the ways that have been used to solve them; determine some of the questionable future approaches, both in terms of the applications they have and the improvements they offer to everyday practice. We also discussed some of the most important challenges and aspects of image steganography, demonstrating how these challenges might be transformed into lucrative new research fields. When using techniques of deep learning to steganalysis and picture steganalysis, it has been established that considerable progress may be achieved by taking into consideration all of the benefits and downsides of existing frameworks and This research demonstrates how valuable Generative adversarial network-based deep learning algorithms are for audio and image steganography. Recently, generative adversarial networks, which are utilized for steganography and steganalysis, have exhibited results that are rather astounding This is true for both steganalysis and image steganalysis.

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