Literature Survey on Digital Watermarking Techniques'

M.tech. Scholar Rina Khande, Assistant Professor & Head Ashish Tiwari
Computer science , Vindhya Institute of Technology & Science Indore (M.P) Country
Rinakhande09@gmail.com, ashishtiwari205@gmail.com

Abstract - Digital image watermarking is the technology that is used in information security applications like digital image content protection and copyright protection. In this paper, a brief review of literature on digital image watermarking is presented. Watermarking algorithms can be classified based on different criterions. Depending upon the specific application, watermarking algorithm should satisfy certain requirements .This paper presents a review on different digital watermarking techniques and their properties. The main reason for development of digital watermarking research is to protect intellectual properties of the digital world. Since the recent technology makes it easy copying the digital contents without any restrictions and editing without any prohibitive professional efforts. In the absence of protecting techniques, it difficult to rely on digital storage & communication systems for secure medical, business, and military applications.

Keywords- Digital Watermarking,DWT-DCT, watermark technology

I INTRODUCTION

Digital watermarking is considered a potential technology to solve various challenges in the digital age. In addition to copyright protection, other potential uses of digital watermarking include content authentication, distribution tracking, and tamper recovery. In short, digital watermarking is perceived as a very relevant and widespread field in the field of digital content protection. The imperceptible watermark technology in digital image protection

Since data and multimedia resources such as images, audio and video are mainly stored in digital formats, a foolproof mechanism for protecting valuable digital content is also important. There are two ways to achieve content protection: data encryption and watermarking. In data encryption, data is encrypted before transmission, and the decryption key is provided only to legitimate recipients. Encryption protects data during transmission. However, once the data arrives at the destination and is decrypted, it is no longer protected from unauthorized reuse. as a result, there is an urgent need for an another technology that can shield content even after decryption. Watermarking technology integrates watermarks that are inseparable from managed resources. Therefore, even after the content is decrypted and can be viewed in the public domain (such as the Internet), watermarking can protect the content. In this regard, the watermark mechanism can complement data encryption. Given the fact that digital data is extremely vulnerable to unauthorized modification, watermarking can provide a higher level of security for a person's valuable intellectual property (IP). In fact, the growing awareness of copyright protection of content has led to active research in digital watermarking [4,5,7].

Another area closely related to watermarking is data hiding. The term steganography refers to the process of using cover images to hide messages or data. The main purpose of data stored used in steganography is to use cover images to hide and transmit secret messages. Therefore, although both steganography and watermarking belong to the science of hidden information, they have different goals. Steganography can be considered as the art of conveying information without attracting attention. However, in the watermark, data is attached to the host data to protect or prove the ownership of the host data. However, the host or external data in steganography is only a carrier of important information, so it is not important. They are carefully designed so that the existence of other information remains hidden and unknown to the public.

In general, watermarking is a data protection mechanism having certain similarities to data encryption and steganography. Notable difference is that watermarking does not restrict contact to data, while encryption makes data unintelligible to public who tries to access them. Moreover once encrypted data is decrypted, the data is vulnerable to the danger of open availability and illegal redistribution. On the other hand a Watermark is integrated permanently to reside in host data [1]. And whenever ownership of the data is questioned, the hidden ownership watermark information can be extracted to prove the rights.

II OVERVIEW OF DIGITAL WATERMARKING

The main proposal is to use digital watermarking as a copyright protection mechanism to detect and limit the

utilization rate by avoiding illegal copying of digital resources [3,5].These technologies allow us to add copyright notices or some sort of authentication information to digital media to protect valuable content. Watermarking is a process of subtly integrating identification information into digital data while preserving the recovery of hidden information. This protects digital images from illegal copying and redistribution. To introduce a watermark, information such as the owner's trademark or identification code can be embedded in the digital image to be protected. The host image with the watermark embedded is now called the watermark image. Such watermark images can be published without worrying about ownership disputes, because as long as there is doubt about the ownership of the image, the hidden watermark can be retrieved. Therefore, if you want to ensure that the image I is watermarked with the known watermark w, the embedded watermark (w') must be restored from that watermark image and compared with w. If the comparison shows that they are the same, the watermark image is considered valid. For example, if the test of watermark similarity sim (w, w ') is equal to zero, it means that they are not the same and a value close to 1 indicates the similarity.

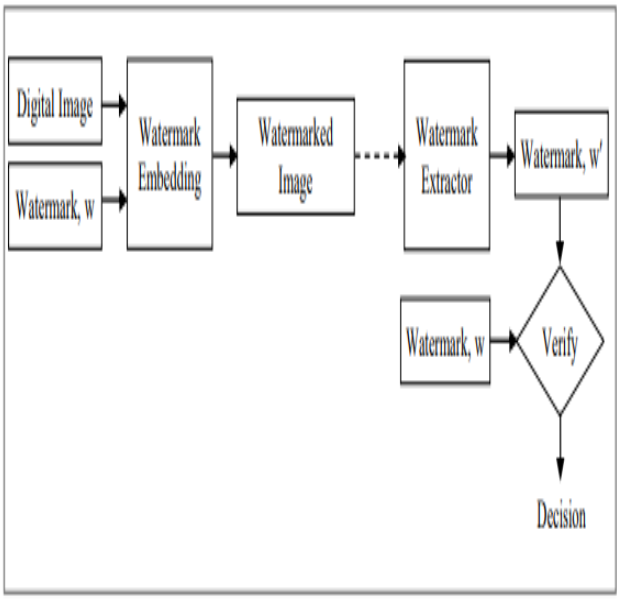

Fig.1 Typical digital watermarking systems

General Framework: All watermark systems basically consist of an embedding step and an extraction step. The embedded retrieves the main image and identification data to generate a watermarked image. The extractor is the recovery part that obtains the watermark image and registers the existence of the hidden watermark. When the watermarked data is modified or manipulated, the extraction work becomes difficult. However, retrieving the watermark in all unfavorable conditions is an ideal feature of the watermark scheme. Figure 1 shows the basic blocks in a typical watermark system. The watermark embedding step is the most prominent process in which the watermark signal is integrated with the host image. It is important that the embedding process does not reduce the quality of host images and render them unusable by introducing distortion. The algorithm must also be able to maintain the embedded watermark without being deleted or deleted without suffering from signal processing attacks.

A useful watermarking scheme has to meet certain essential requirements such as robustness, imperceptibility and more [6,7].

In case of images, watermarking techniques are classified based on two working domains. Spatial Domain in which pixels of one or two randomly selected subsets of an image are modified based on perceptual analysis of the original image and Frequency Domain in which values of certain frequencies change.

Spatial domain: A watermarking method based on the spatial domain scatters information to be embedded to make the information more secure so that it is very difficult to detect. It uses minor change of the value of pixels. This approach has an advantage which is it is strong for cropping and translation. Various approaches for spatial domain techniques have been proposed so far which are checksum techniques, two-dimensional spatial watermark, spread spectrum approach are some of them.

Checksum Technique

In this approach [1], a watermark is formed from the checksum value of the seven most significant bits of all pixels. A checksum is the modulo-2 addition of a sequence of fixed-length binary words which is a type of hash function. This technique randomly chooses the locations of the pixels that are to contain one bit of the checksum. The pixel locations of the checksum together with the checksum value form the watermark which must be kept secret. To verify the watermark, the checksum of a test image is obtained and compared to the watermark. The advantages of this technique are mentioned below:

• Embedding watermark only changes half of the pixels that covered by it, as a result it not only reduces visual distortion but also increases security.

• An image may hold many watermark as long as they do not overlap. The drawback of this technique is that it is fragile, therefore any change to either the image data or the embedded checksum can cause the verification procedure to fail.

Basic M-sequence approach
In this approach, the watermark is formed based on using a modified m-sequence. A linear feedback shift register with n stages can form pseudo-random binary sequences with maximum period of 2n-1 [2]. Two types of sequences may be formed from an m-sequence: unipolar and bipolar. The advantages of this technique are that The watermark is robust to small amounts of noise, in the image. Successive watermarks treat the previously watermarked image as a new. An attacker can deduce watermark if 2n consecutive bits in it are known.The drawback of this method is that it does not protect the DC value of the pixels covered by an individual block.

Secure Spread Spectrum Watermarking for Multimedia: This approach inserts a watermark into the spectral components of the data using the techniques which are analogous to spread spectrum communication, therefore hiding a narrow band signal in a wideband channel The advantages of this approach are as

• The watermark is difficult to remove for an attacker even when several individuals combine together with independently watermarked copies of the data.

• It is robust to common signal and geometric distortions such as digital-to-analog and analog-to digital conversion, re-sampling, and requantization, including dithering and recompression and rotation, translation, cropping and scaling.

Frequency domain
In frequency domain, DCT, FFT and DWT [3],[4] methods are used for data transformation. Wavelet transform decompose an image into a set of band limited components that can be reassembled to reconstruct the original image without error. Linear programming optimized the Wavelet domain watermarking method. In Object based image watermarking technique, a watermark that embeds in distributed of an original data is very difficult to delete.

A Wavelet-Based Watermarking Algorithm for Ownership Verification of Digital Image This approach first inserts the watermark into the middlefrequency range. Filter banks can be saved for the watermark embedding and the middle-frequency band to insert the watermark is chosen the coefficient in that band of the image is replace by the watermark. The advantages of this approach:

• This technique achieves both spatial and frequency localization.

• It is both perceptual invisibility and robustness to compression.

• It is robustness to noise, image processing techniques, median filter, geometric transform.

Hierarchical Watermarking Depending on Local Constraints In this approach, the watermark is embedded according to two keys [5]. The first key is used to embed a code bit in a block of pixels. The second bit is used to generate the whole sequence of code bits. The watermark is embedded in spatial domain by adding or subtracting a random digital pattern to the given image signal depends on the local energy distribution. The embedding depth level depends on the spectral density distribution of DCT coefficients and on the JPEG quantization table and inserts the watermark in the low frequency component. The depth label consists of a set of bits that are embedded locally in a rectangular set of blocks and it is repeated over the entire image. After detecting individual bits, the retrieve label is verified by performing a XOR operation to the watermark code.

Hybrid Watermarking
In this method, watermark can be embedded into both spatial and frequency domain. A Hybrid Watermark for Tamper Detection in Digital Image – A hybrid image authentication watermark can be obtained as a combination of fragile and a robust watermark. The fragile watermark has the advantages that it has good localization and security properties. The hybrid watermark can be used to precisely identify changes as well as distinguish malicious tamper from simple operations. The authentication can be done without accessing any information about the original image. Effective Hybrid Digital Watermarking Scheme Using Direct Sequence-Spread Spectrum Method – in this scheme, a watermark image is produced using the personal ID of copyrighter which is inserted into the original images and the watermark image is detected. It is an extension of the spread-spectrum watermarking scheme which combine key with logo method. Binary image is used as watermark image, and the degradation of image quality between original image and watermarked image is applied to confirm required invisibility in watermark system and watermark robustness is applied to protect a attack from the outside are analyzed using the values of PSNR of the watermark image. Discrete Cosine Transform the DCT [3] transforms a signal from a spatial representation into a frequency representation. Lower frequency are more obvious in an image than higher frequency so if we transform an image into its frequency component and throw away a lot of higher frequency coefficients, we can reduce the amount of data needed to describe the image without sacrificing too much image quality. The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension. Audio Watermarking Comparing with the

development of digital video and image watermarking, digital audio watermarking provides a special challenging issue because Data hiding is not audible otherwise it will mask the original audio signal that can be easily tampered with and removed, The human auditory system (HAS) operates over a wide dynamic range between 20 Hz to 20 kHz, therefore it is difficult to embed outside this rage, There is a limited area of embedding the data. Audio watermarking techniques [6] mainly focus on four characteristics, which are (1) low bit coding, (2) phase coding, (3) spread spectrum-based coding and (4) echo hiding.

III LITERATURE SURVEY

DWT digital signage technology is proposed, which incorporates signatures on images to prove owner identity and limit unauthorized copying. The basis of the technology is the use of situational models and fuzzy inference filters to integrate the waters with greater entropy coefficients of the thick DWT sub band (Hsieh 2010). In semi-sensitive liquids, the liquid is incorporated into it and is easily supported by predefined processing, but is strong in predefined processing. This is an approved watershed. Semi-sensitive files are more powerful than soft files and are less sensitive to traditional user changes such as JPEG compression. These technique distinguish among malicious operations (such as adding or removing important elements of an image) and global process that preserve the semantic contented of image. Compared to digital signatures and fragile watermarks, the advantage of using semi-fragile watermarks is to characterize manipulation distortions and design methods that are robust to certain types of treatments.

Hilkiya Joseph et.al.- a The success of internet technology transform the world of technology and fashioned our life such a lot easier. The matter of duplication and unauthorized use of information become a great threat within the field of technology. To beat these problems, techniques like digital watermarking, steganography and cryptography were introduced. The approach of embedding a secret data associated with the digital signal inside the signal itself is digital watermarking. For embedding and detecting the watermark different techniques are used; spatial domain techniques like Least Significant Bit (LSB) and Patch Work Algorithm, then the frequency domain techniques such as Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Discrete Fourier Transform (DFT) are some of them. Combination of DCT & DWT technique for digital watermarking is proposed here. The proposed methodology is implemented in MATLAB 2017a simulator and result is analysed using evaluation parameters like Peak Signal to Noise Ratio (PSNR) & Mean Square Error (MSE). PSNR value obtained for the case of watermarking using DWT is 27.46 and MSE value is 17.45. The value of PSNR for watermarking using DCT is 41.4 and for MSE the value is 0.67. The PSNR and MSE values obtained for watermarking using LSB technique is 50.55 and 0.58. The proposed method improves the watermarked image quality and the MSE & PSNR value obtained is 0.52 and 51.017 respectively[1]

Guiliang Gong et.al (2019) to solve the problem of blurred natural blurry images, the Anti-Blur GAN network is proposed. The proposed method separates the clear part and the obscure part of the image, and uses the former to control the excess. Compared to the most advanced conflict networks with deblurring functions (i.e. Deblur GAN), through new communication networks and various abuses, this method is may find better results with artificial local indistinct images and natural local blurred imagery. art The network can be used for local restoration and local image translation.[2]

Heunseung Lim et al. (2020) this paper presents a technique based on image breakage, which uses deblurring based on norm0 norms and fusion drawing based on norm2 standard for remote image processing. To restore the complexion of dull skin, the first method uses Richardson-Lucy deconvolution treatment results and a fusion mask to restore the appearance. Next, we examined the intensity of the dark and dynamic channels in the remote sensing image, and used the previous values and black channel values to carry out the development based on channel0 standards. Although consumption based on the ℓ0 standard results in significant recovery results, the loss of the degraded area does not overcome. On the other hand, the sary2 standard image mixing method can maintain sharp edges and structural details at the same time. Through testing, we have proven that compared to today's advanced educational methods, this method can provide better discounts without causing too much frustration and unnecessary art.[3]

Ryo Tanikawa et al. (2018) in this paper we nearby a new way to recreate images from pairs of images with noisy and vague art. These images are obtained from dissimilar time-lapse cameras, or refurbish images are of higher excellence. Some tips on restitution using multiple imagery. Most of this technique solves difficulty of improvement when it comes to eliminating noise and inconveniences. But, this method does not easily tolerate the elimination of noise and inconveniences. This paper offers a new way to recreate images from pairs of images with noisy and vague art. We make a weighted average of 2 images to have an image for the restoration process. By mixing blurry images, you can effectively prevent noise

and blurry artifacts while maintaining the necessary image information. Then, we proposed a effortless reinstatement process and got a high eminence updated image. The outcome show that this technique can get a higher quality image, eliminate noise and save edges.[4]

Jin Liu et al (2018) Due to the poor quality of the blurry image, a good correction period can improve the quality of the blurry response. Expectable logarithmic patch likelihood (EPLL) is a patch-based control before processing smaller image adjustments, which have proven to be effective and can achieve blurred image performance. However, in the EPLL way, the auxiliary parameters must be large, which results in difficulty in numbers. To avoid such problems, we are developing an improved Lagrangian method to adapt to the EPLL blur algorithm. Experimental results show that planned technique can recover image quality and is better than existing deblurring algorithms.[5]

Wang Manwei et al. (2019) Due to overload, defocus and other factors on remote sensors, dirty image collection may be blurred and the system may be blurred. Therefore, blurred processing of far-sighted images is the biggest problem with remote sensing. To improve the image quality of remote sensing, remote sensing blur algorithm based on dark channels is suggested. First, make an estimate of the kernel depending on the dark channel beforehand, and then make an image processing using the estimated kernel blur to achieve a clearer image retrieval. International filters are provided to maintain the detail of the image and improve the edges to achieve the desired result during clear image restoration. Experimental results show that the high-level noise level (PSNR) at the target rating index in this method was improved by about 5%. 1.5 dB, and the structural uniformity (SSIM) increased by about 0.04. Evaluate with obtainable image blur algorithm, this technique can evaluate blurry information, so that return image blur retains its edges and eliminates its effects.[6]

Liu Sheng et al. (2019) the vision-based object classification system is a key model for building and dismantling the processing industry. Image blur is critical, as the image is very blurry due to vibration, and often the system is unable to report solids, leaving the belt useless. This paper presents a new method of resolving blindness, which illustrates the functioning of new penalties as a common reference to full-scale energy work. Common language is based on pre-existing intervals and solved as part of the problem of mathematical improvement made of dark channels in introductory images. This technique not only retains the structural information of image, but also prevents the smoothness of the final restoration process. With a blurry and natural-looking image, this method is superior to other frequently used methods. Although the number of iterations is small, the speed of promotion and product quality are very good. We have used this method to restore the defective image and achieve exceptional results with efficiency and reliability.[7]

Fangfang Dong et.al (2018) Image blur is a major difficulty in image dispensation. Blur spot blind is a more difficult difficulty because the actual image needs to be restored, but the type of blur is not known. The general modification method proposed by Tony Chan et al. [1] It is used when the image is not blurry and changes shape, but often affects the process. To avoid this influence, we offer a new and innovative way of changing the blind based on the differences in this article. In addition, in image editing, we added visual aids to keep the edges sharp. The first two algorithms were developed to solve the model. Experimental calculations show that our method can obtain clear images, have no effect on processes, and can accurately estimate vague unknown bases.[8]

Blurry photos of **Zhao Hongtian and others. (2020),** is a very unpleasant problem, including the assessment of fabozy cabo and blind deconvolution. However, previous deblurring process still could not properly solve the triangular neck or noise and could not prevent artifact from the restored image, because if it had not been used before the natural image could not provide secure access from insufficient information. Final evaluation and image development. In this work, we see that the blur procedure will change allotment of image gradients and try to apply knowledge before leading the blur. To facilitate the design of the model, we have proposed lightweight for image gradient distribution in order to solve the model restoration model. We also focus on considering how to improve the model and develop algorithms based on priorities and image structure: First, calculate the image structure based on the overall model change and strategy. we balance, or then estimate the solid edge based on model. It is possible to eliminate strong edges (structures) that may have a negative impact on fuzzy projections. Next, we follow another repetitive system to achieve high-level virus values by evaluating the flash kernel from the thick system and then restoring the hidden image guided by the clear image prepared. Finally, we propose multiple precursors based on setting as an irreversible deconvolution method to restore the hidden image. In addition, we have examined the success of knowledge-based celebrities in photo publishing or have proven that they can support clearer images than blurry images and can successfully block sound art. Numerous experiments have proven the superiority of this method in the latest algorithms in terms of quality and size.[9]

The process by **Amreen Kazi et.al (2019)** to restore an image from overcrowding and noise is called image recovery. Over the past year, image recovery algorithms have used patch-based processing methods. In image processing, image production plays an important role. The worldview will experience a variety of damage at different stages (such as image capture, recording, storage, transmission or reproduction). Various functions such as blur and contrast will reduce the quality of the image. The role of the automatic image quality control system is to make reliable decisions in real time with minimal human intervention. In general, in terms of quality measurement, images are classified as subject-oriented or targeted techniques. This is an expensive process of self-reliance and then evaluation. This process is time consuming and leads to a long process. In addition, it depends on the perspective. Compared to the subject index, the image quality indicators are faster and can produce immediate results without manual input. Here the grinding is applied to a blurred image. Here, resize the image, and then perform the partitioning on the RGB channel. This post explores the blur of travel and Gausian blogs. Use repetitive image recovery techniques. MatLAB is used in testing to achieve realistic images. This ideology is very effective and has produced progressive results in denoising, deblurring and division.[10]

Yang Haoyuan et al. (2018) Natural imagery suffers from the deterioration of the efficiency of the image structure, and blur is the main source. Most existing methods aim to evaluate the fuzzy kernel by optimizing other methods across multiple spaces. However, in the proper implementation of the project we have to deal with the ambiguity caused by the behavior of the conveyor belt. In this case, we know the destructive model and its path. In this article, we will show you how to adapt to blurry images. The heuristic algorithm is used to improve the model parameters, and the latent image is blurred by deconvolution based on and1 constraint norms. The simulation results show that this method is not only suitable for ambiguous models, but also able to deal with atmospheric turbulence models and defocus models. The comparison results show that this method is better than the other methods. In addition, it can effectively deal with blur in real-world situations.[11]

In this article, **Suphongsa Khetkeeree et al. (2019)** Repetitive algorithm for blurred images. The algorithm is based on a complementary filter pair. The modified Tikhonov control is used to control the intensification of the fuzzy process. In our experiments, several sizes of Gaussian blur are used to create the damaged image. The highest signal-to-noise ratio (PSNR) is used to measure image quality. The results show that the algorithm is superior to the traditional Lucy-Richardson algorithm, and control filters are used for visual analysis and quality indicators. It can work well with kernel blur of all sizes and can be applied to opaque seeds. Moreover, the relaxation and artifacts at the border are not obvious[12]

IV CONCLUSION

The literature review presents the fact that there are large numbers of innovative and inventive watermarking approaches are available. Now research should be directed towards multi-objective watermarking schemes. Most of the proposed watermarking schemes are based on Human Visual System (HVS) using Just Noticeable Distortion (JND) for the selection of watermark positions. Further, the review reveals the fact that even though abundant information on watermarking schemes are published, a performance evaluation of various schemes is absent. Future work is also planned to perform a comparative performance evaluation of existing watermarking schemes. Digital audio and video watermarking techniques rely on the perceptual properties of a human auditory system (HAS) and human visual system (HVS) respectively. The HVS is less sensitive as compared to the HAS.

REFERENCES

1. Hilkiya Joseph and Bindhu K Rajan Image Security Enhancement using DCT & DWT Watermarking Technique Hilkiya Joseph and Bindhu K Rajan International Conference on Communication and Signal Processing, July 28 - 30, 2020, India
2. Guiliang Gong Kai Zhang Local Blurred Natural Image Restoration Based on Self-Reference Deblurring Generative Adversarial Networks 2019 IEEE International Conference on Signal and Image Processing Applications (ICSIPA) Year: 2019 ISBN: 978-1-7281-3377-5 DOI: 10.1109/ IEEE Kuala Lumpur, Malaysia, Malaysia
3. Heunseung Lim Soohwan Yu Kwanwoo Park Doochun Seo Joonki Paik Texture-Aware Deblurring for Remote Sensing Images Using ℓ0-Based Deblurring and ℓ2-Based Fusion IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing Year: 2020 DOI: 10.1109/IEEE
4. Ryo Tanikawa Takanori Fujisawa Masaaki Ikehara Image restoration based on weighted average of multiple blurred and noisy images 2018 International Workshop on Advanced Image Technology (IWAIT) Year: 2018 ISBN: 978-1-

5386-2615-3 DOI: 10.1109/IEEE Chiang Mai, Thailand

5. Jin Liu An Augmented Lagrangian Method for the Patch-based Gaussian Mixture Model In Image Deblurring 2018 IEEE 3rd International Conference on Signal and Image Processing (ICSIP) Year: 2018 ISBN: 978-1-5386-6396-7 DOI: 10.1109/ IEEE Shenzhen, China
6. Wang Manwei Zhu Fuzhen Zhu Bing Bai Yuyang An improved remote sensing image blind deblurring algorithm 2019 3rd International Conference on Electronic Information Technology and Computer Engineering (EITCE) Year: 2019 ISBN: 978-1-7281-3584-7 DOI: 10.1109/IEEE Xiamen, China, China
7. Sheng Liu Yuan Feng Shaobo Zhang Hongzhang Song Shengyong Chen L0 Sparse Regularization-Based Image Blind Deblurring Approach for Solid Waste Image Restoration IEEE Transactions on Industrial Electronics Year: 2019 DOI: 10.1109/ IEEE
8. Fangfang Dong A Fractional-order Differential Based Variational Model for Image Blind Deblurring 2018 IEEE 3rd International Conference on Signal and Image Processing (ICSIP) Year: 2018 ISBN: 978-1-5386-6396-7 DOI: 10.1109/IEEE Shenzhen, China
9. Hongtian Zhao Hua Yang Hang Su Shibao Zheng Natural Image Deblurring Based on Ringing Artifacts Removal via Knowledge-Driven Gradient Distribution Priors IEEE Access Year: 2020 DOI: 10.1109/ IEEE
10. Amreen Kazi S.D. Sawarkar D.J. Pete Image Restoration using Blind Deconvolution 2019 IEEE Pune Section International Conference (PuneCon) Year: 2019 | ISBN: 978-1-7281-1924-3 DOI: 10.1109/IEEE Pune, India, India
11. Haoyuan Yang Xiuqin Su Chunwu Ju Shaobo Wu Efficient Self-Adaptive Image Deblurring Based on Model Parameter Optimization 2018 IEEE 3rd International Conference on Image, Vision and Computing (ICIVC) Year: 2018 ISBN: 978-1-5386-4991-6 DOI: 10.1109/IEEE Chongqing, China
12. Suphongsa Khetkeeree Sompong Liangrocapart Iterative Image Deblurring Algorithm using Complementary Pair of Filters 2019 7th International Electrical Engineering Congress (iEECON) Year: 019 ISBN: 978-1-7281-0729-5 DOI: 10.1109/IEEE Hua Hin, Thailand, Thailand