A Comprehensive Analysis to Remove Rain from Single Images Using Generative Adversarial Network.

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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APPROVAL

This Project titled "**A Comprehensive Analysis to Remove Rain from Single Images Using Generative Adversarial Network.**", submitted by Fazla Rabbi Talukder and Soumitra Bhowmik to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 21th March 2021.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Md. Reduanul Haque**, **Sr. Lecturer, Department of CSE**, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

"**A Comprehensive Analysis to Remove Rain from Single Images Using Generative Adversarial Network.**", is a research-based project that main goal is to enhance image quality, improving detection performance and more accurate object detection for single image de-raining processes which removing rain-streak and directly generate a pixel-wise image.

Deraining is a process by which we can get a transparent image by removing raindrops from a rainy image. In the rainy time visibility of any device (Camera) decreases and vision property is affected by the rain. For this reason, capturing images on rainy days reduces the resolution of the images. Currently the security control system, traffic system need exalted-quality images. Obtaining a clear vision during rainy time is an urgent requirement for a better image. At present deraining is making a very nice contribution to removing raindrops from any image. Follows different kinds of generative adversarial networks in the draining process. The common deraining mechanism are GAN. Recently generative adversarial networks are popular. GAN models like Attentive GAN, cGAN, DHSGAN, Cycle GAN which acts as a bridge for decreasing the rain drops. In this paper, we proposed a GAN based method that will reduce raindrops from images and also provide better object detection. For experimenting, we use benchmark dataset consisting of both synthetic and realistic rainy images. We gained outputs that are appreciated both qualitatively and extensively. The DHSGAN GAN provides the greatest representation within that technique.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

Introduction

1.1 Introduction

Computer vision systems especially object detection and recognition mainly depend on different atmospheric conditions such as rain, and haze. During the heavy rainy time it is so difficult to detect an object and properly capture them. Raindrops make images blurry and reduce resolution (saturation, contrast). Most of the Vision algorithms are using images for train purposes that are captured in good conditions. Otherwise vision algorithms will not be able to give a proper outcome. Image deraining is a pre-construct technology that provides a derained image from resembling cloudburst ones. Its substance is little bit principal affection from rating images which is practice on computer vision algorithms for ensuring clear photos.

There are maybe three categories of techniques for image deraining. The first one is multiple pictures deraining, the second one is polarizing filter-based draining, and the third one is single image deraining. Among them, the primary 2 techniques aren't suitable for real-world problems like real-life implementation. Moreover, it isn't efficient for getting more information regarding rainy scenes from a single image. For solving this problem, researchers tried variety path for experimentation with an individual deraining image according to further complex data.

This process could be a little bit difficult because we can't get more data from a single image. In past, most of the solutions were dependent on handcrafted priors with lots of limitations. Now generative adversarial network (GANs) is initiated by Good fellow [1] which provides great performance for picture deraining through generative strategy. From a noise distribution input, it is capable to generate denoisy output.

Finally, it's possible to get various rain scenarios through GAN. Different kinds of GAN models are modified for these conditions. Now early demand is how the model is

Performed on a rainy image of the real condition. So the principal object of this paper is to research the success analysis where this model will be suitable for rainy conditions.

In this work, the principal performance are follows:

i. A literature survey is performed on the existing state-of-the-art deraining fetch.
ii. Experiment with the formation of different types of GAN models, like Attentive GAN, cGAN, DHSGAN, Cycle GAN etc.
iii. Analysis of the validity and usefulness by using UCID datasets comprising artificial and actual-earth rainy images.
iv. Getting some recommendations based on upcoming experiment.

The following structure for this paper is: the second part represents a large description based on related work. The third part highlights GAN-based methods for deraining. The fourth part explains the analysis results based on datasets, contention. Lastly, in the fifth part, conclusions are drawn.

1.2 Motivation

With the help of machine learning based generative adversarial networks (GAN) technique, it is very easier away to remove rain streak from a single rainy image. Recently generative adversarial networks are popular. Deraining processes follow different kinds of deep generative adversarial networks (GAN). GAN is common deraining mechanism. GAN models like Attentive GAN, cGAN, DHSGAN, Cycle GAN which acts as a bridge for decreasing the rain drops. It is improve the vision algorithm which enhance image quality. This technique separate an image into two parts for

deraining which reduce the processing system. This technique is applied without the use of any additional post processing for remove rain streak from a single rainy image.

1.3 Objectives

Objective The unpredictable impairments which are called illustrious like radiation, turbulence, and intense atmospheric conditions, like numerous computer vision algorithms performance are impacted by cloudburst, frost, and vaporization which affects tracing, segmentation and detection. The rain is one of the reasons which has deteriorated many computer vision applications such as motive tackle, inquiry the video police, purpose tracking, and remote perception etc. For these weather conditions, many dangerous accidents have occurred daily. For improving this perplexity, deraining the declining picture is essential. Here image deraining is a pre-construct technology that provides a derained image true from resembling cloudburst ones.

The main objective of this project is to enhance the image quality because quality is important for an image performance. Increasing this image performance, we can easily view to all objects without any rainy stick.
Also, we want our model to be able to improving detection performance. It'll be very helpful to accurate object detection and recognition automatically and easily.

1.4 Research Questions

Which machine learning fetch will be used?

Which GAN architecture will be used?

How to defend the problems?

What are the challenges?

1.5 Final Outcome

Our project is based on image derainig. After completing our project, we will get a network. This network will be created using the python language and its libraries. Generative adversarial network (GAN) is the main part of this network. The Generative adversarial network (GAN) will provide us a trained model using large a dataset. Our model will be trained multiple times for removing rain streak out of a single image.

It will provide us a high-resolution and rain-streak-free image. This model will improve the accuracy of object detection and vision strategy.

1.6 Report Layout

In the beginning of this report described the some important of generative adversarial network with their different types of techniques. After that we'll briefly described about

the current and relevant work. In this description, we share some information about different types of GAN techniques. Then we described some limitations about this paper and whole performing procedure. With the help of graph and elaborately discussion, we'll represent it. Lastly our discussion part is how we can be improved this project in future and also some references with short summary will be added.

CHAPTER 2

Background

2.1 Introduction

The machine learning is the demandable topic in this modern era. Machine learning is a self-decision technique which takes step based on previous training pursuit without any help of human being. Machine learning have three types of learning technique. 1st one is Supervised Learning, 2nd one is Unsupervised Learning and 3rd one is Reinforcement Learning. Machine learning (ML) is nearly concerned in our daily life. Self-driving vehicles, web search, image recognition, face detection and artificial intelligence are the best example of machine learning which makes ours daily

Works is easier. Based on sample data or training data, it is capable to build a mathematical model. After creating this model, machine take decision what can it will do.

There are some sub-categories of machine learning. Deep learning is one of them. Artificial neural networks function-inspired deep learning. Artificial neural networks

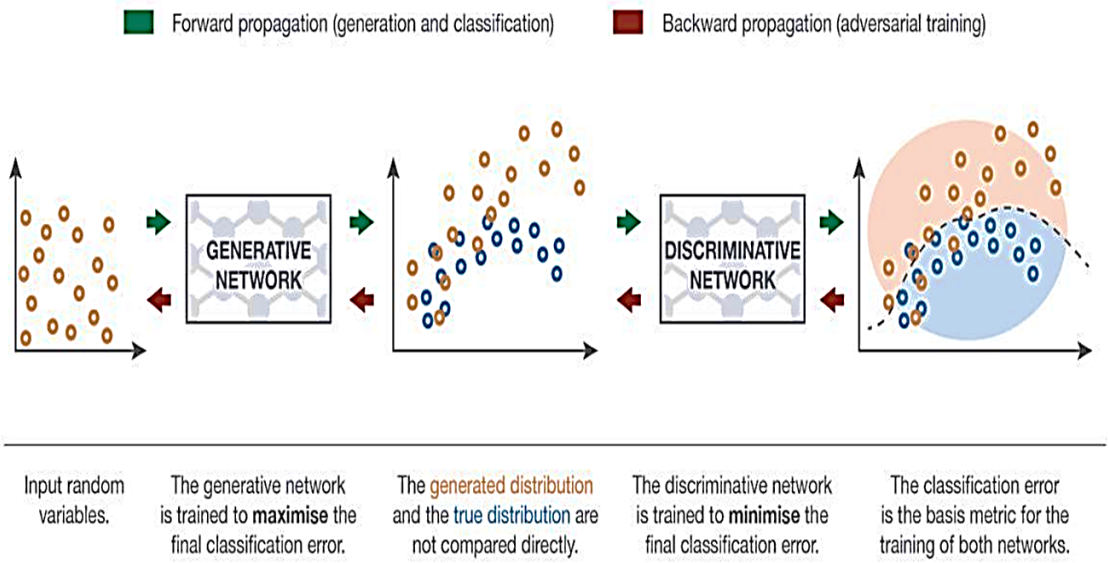


Figure 2.1: Basic Process of GAN

commonly known as ANN. It is inspired by human biological neural networks. Machine learning can be execute by deep learning. ANN plays an important role in deep learning. ANN is an excellent tool for finding patterns in data. Which is difficult for humans to perform on a large-scale dataset.

For the image deraining process, many Kinds of methods are exist. Still, the transmission map is usually used by traditional approaches and a weather sidetracked design also using for similar atmosphere portable part of the rainy scene which decreases the embranchment to modify the rain-free-image. Utilizing rain relevant forms, one or more fundamental systems are checking on. Few times this checking purpose does not show actual results for some cases. The deep learning method used for creating the issue is complicated, then the relevant form is adjusted by the algorithm. At Present Ian Good fellow et al. [17] introduce many kinds of generative adversarial networks (GANs) which are verified to excellently workable in image deraining. The target is to successively

appreciate four state-of-the-art in single picture deraining techniques: Attentive GAN, cGAN, DHSGAN and Cycle GAN.

2.2 Techniques

Based on our project we are introducing some techniques. Using those techniques our model will provide efficient outcome.

2.2.1 Generative Adversarial Network: In diagram figure 1, showing a generic

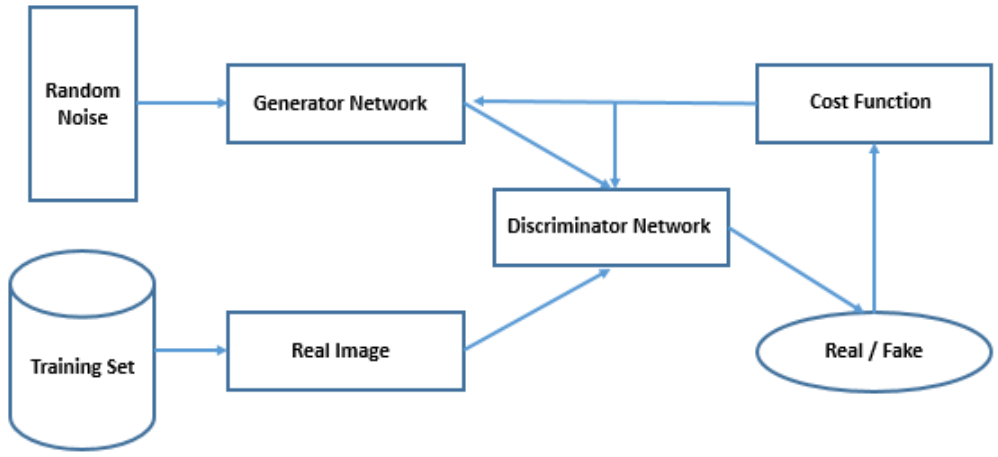


Figure 2.2: Generic Architecture of a GAN

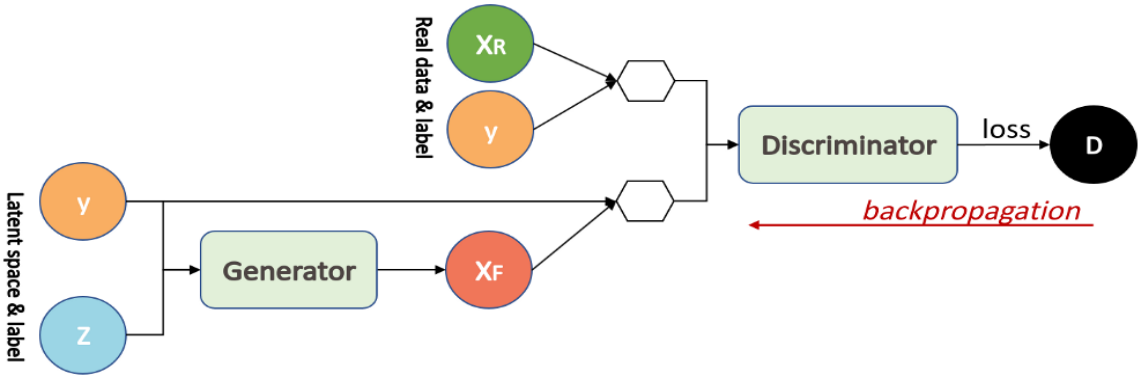
planned stream of a GAN. 2 elements are used for creating this architecture. Here [18] one is a discriminator (D) which makes a difference between the actual picture and the generated picture, the other one is a generator (G) which generates the picture to ignoramus the difference.

G (z) is the distribution of the samples. A probability distribution p_g defines by G. To get a proper knowledge about the generator's distribution p_g we used Generative Adversarial Network.p_r Represents the real data distribution.

$$\frac{min}{G}\frac{max}{D}E_{z\sim p_z} log[D(x)] + E_{z\sim p_z} log[1 - D(G(z))]$$

It's a Generic Architecture of a GAN. Here generator (G) & discriminator (D) are 2 deep neural networks which is the teaching stage by trained session. Here discriminator (D) makes a difference between the actual picture and generated picture and generator (G) is generates the picture to ignoramus the difference.

2.2.2 <u>cGAN:</u> A conditional model is provided by Conditional Generative Adversarial Network (cGAN) [19]. In this model, the discriminator module & the generator module both are adapted with some extra or additional data. Such as knowledge or category labels from many varieties. Optimizing adversarial loss and perceptual loss of function



cGAN

Figure 2.3: cGAN

can generate a clean image or picture from an input image. cGAN also reduces random noise from the image. The loss function equation is,

$$\frac{\min}{G}\frac{\max}{D}E_{I,J}[log(1 - D(I, G(I, z))) + E_{I,J}[logD(I, J]$$

In the above equation, 'J' represents a clean image, 'z' is random noise and the input hazy image represented by 'I'.

2.2.3 <u>Cycle GAN:</u> Cycle GAN [19] is an automatic training process of the image-to-image translation model. In Cycle GAN, Two generators and two discriminators used to learn mapping function without pairing 2 domains images. Cycle GAN makes a better image translation by focusing on high frequency and discriminator.

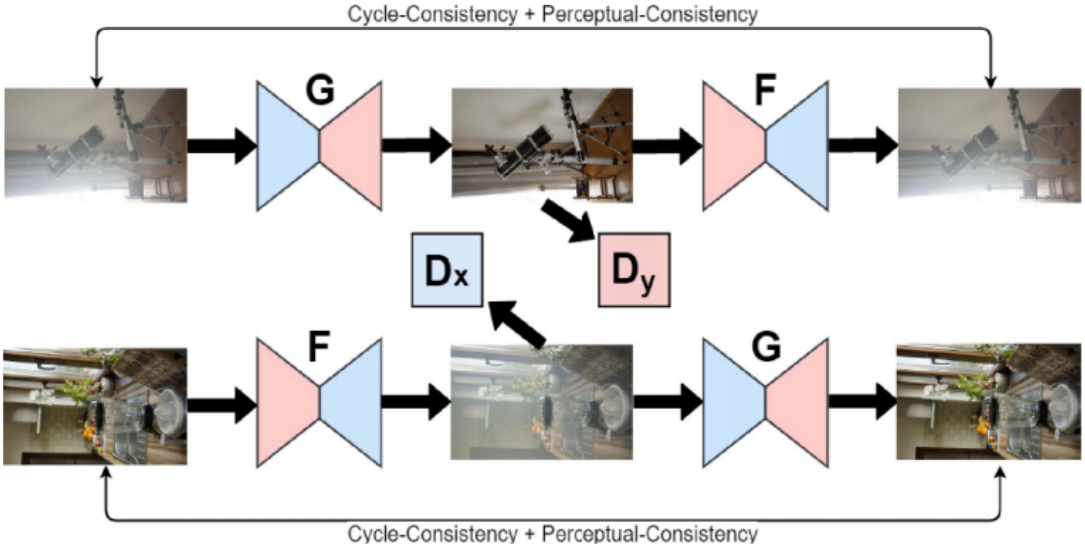


Figure 2.4: Cycle GAN

In the loss function, a penalty term is added to assure that image not change so much after being translated. The process equation is,

$$\mathbf{G^*}=\frac{min}{G,F}\ \frac{max}{D_X,D_Y}L(G, F, D_X, D_Y)$$

In the above equation, G*is the well trained generator G.

2.2.4 <u>Attentive GAN:</u> In Generative Adversarial Networks [20] 2 main elements mentioned within the network.

The networks are Discriminative network & Generative network. The Generative network makes an attempt to provide a picture as equal as potential and clean from raindrops. The Discriminative network can affirm whether or not the picture made by the Generative network appearance is actual.

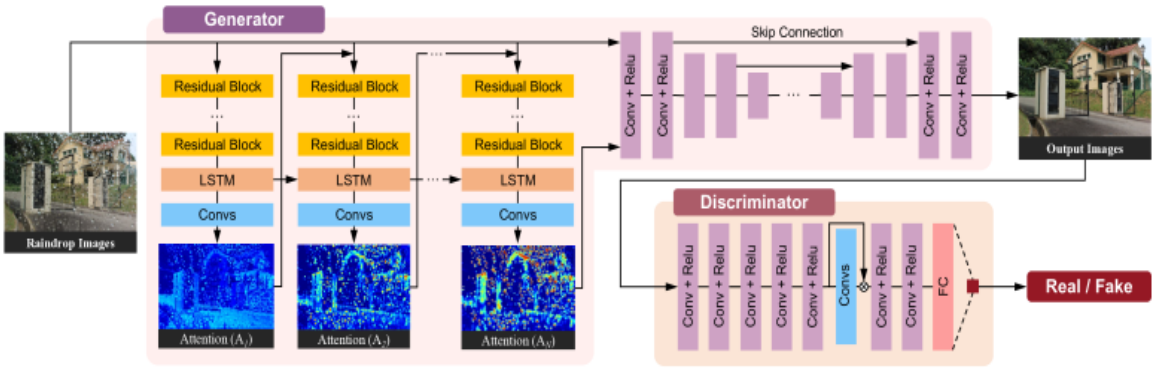


Figure 2.5: Attentive GAN

The Generative Adversarial loss equation is:

$$\frac{min}{G}\frac{max}{D}E_{R\sim Pclean}[\log log\ (D(R))\ ] + E_{I\sim Praindrop}[\log log\ (1\ -\ D(G(I)))\ ]$$

In the equation, D is the Discriminative network, and the Generative network is 'G'. 'I' is the sample that is retrieved from images from raindrops that is the input of the Generative network. 'R' is known as a specimen of natural images.

2.2.5 DHSGAN: De-Haze and Smoke GAN (DHSGAN) [21] provide a De-Hazing architecture. In this architecture, there is no needed any type of post-processing or reversion of an atmospheric model. Using a convolutional network and the final layer

DHSGAN can directly produce a clean image. For realistic clean images, this model is trained by the Generative Adversarial Network. DHSGAN model has 2 sub-modules. 1st

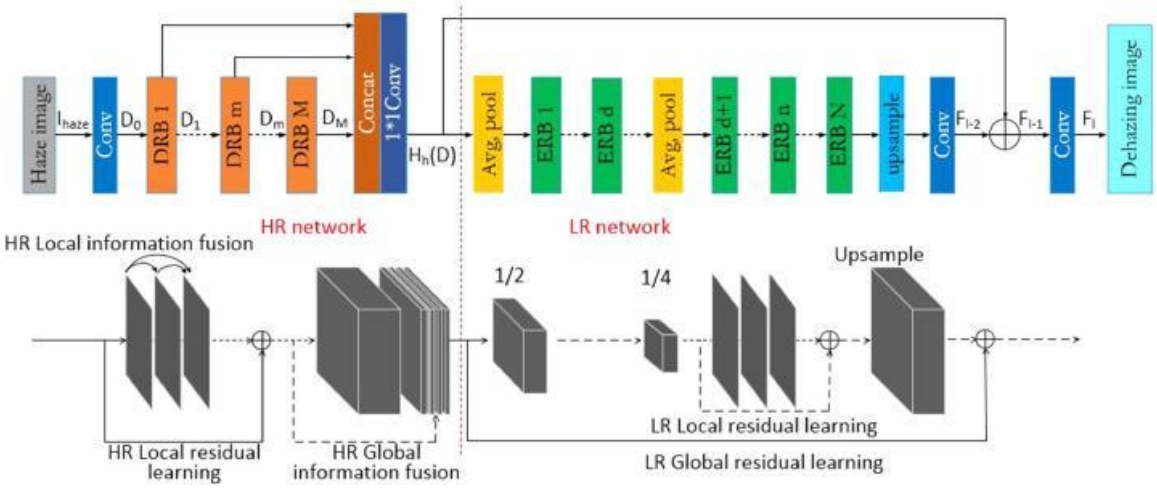


Figure 2.6: DHSGAN

one is the Transmission module and 2nd one is the GAN module. DHSGAN working process equation is,

$$J(X) = G[T\{I(X)\}, I(X)]$$

In the 1st sub-module, a fully convolutional recurrent architecture pre-trained on ImageNet [22] dataset and initialized with VGG19 [23]. The 2nd sub-module (The GAN module) work with 2 CNN architecture.

2.3 Related Works

Raindrop extraction is a challenging issue for the existence of multiform rain amounts in the pictures. A single picture or image deraining processes envisage deraining as a stratum split issue. The subsisting single image deraining [2] is a process where they are planned to meet its particular types of images that are affected by rain.

Bolun Cai et al. [3] propound an end to end process that is known as 'Dehaze Net', for mediocre dispatch enumeration. 'Dehaze Net' accepts a fuzzy picture or image. In 'DehazeNet' a fuzzy picture is used as an input and outputs in its mediocre dispatch sketch. The sketch is used to restore fuzzy-less images through an atmospherically distraction diagram. 'DehazeNet' takes up Convolutional Neural Networks (CNN) basis profound architecture. They conjointly propose a completely unique nonlinear activation methodology in DehazeNet that is named Bilateral corrected linear measure (BReLU), it's capable of boosting the standard of restoring fuzzy less image.

Zheng Wang et al. [4] propound an end to end network which is known as a 'dual-task de-raining network' (DTDN). Under this network, there are two networks: the first one is the Generative Adversarial Network (GAN) and the second one is the Convolutional Neural Network (CNN). Which is used to vanish raindrops by attaching two reciprocally obstructive objectives self adaptively. DTDN GAN is principally dispelled structural raindrops and DTDN CNN is used to restore all of the details from the main images.

Garg and Nayar et al. [5] propose an outlook design using Photometric properties to determine raindrops.

Codruta Orniana Ancuti et al [6] propound a method that is a 'Fusion Based' strategy. By using a white balance and a contrast-enhancing process that can derive from two main fuzzy image inputs. They filter their significant shapes by calculating three measures (weight maps) first one is 'Luminance' second one is 'Chromaticity' and the third one is 'Saliency'. To reduce internal objects initiated by the weight sketch or map. By using a Laplacian pyramid representation they designed multiscale fashion.

Bossu et al. [7] propound a method that uses the histogram orientations to find raindrops.

He Zhang et al [8] attempted to lift the Powerful Generative Modeling. The capabilities of Conditional Generative Adversarial Networks (CGAN) is the derained image. It must be indistinguishable from its resembling ground truth clear image. There is some adversarial loss from GAN. GAN gives an excessive regularization which helps to earn upper outputs. They initiate a brand new loss operation and beaux-arts novelties within The Generator Discriminator Combine for achieving acceptable outputs.

Yu Li et al [9] introduce a method that is known as 'Simple Patch-Based Priors'. This method applies in both layers (Background and Rainy). By the Gaussian mixture models [10] and amount of rain streaks, priors are defined. Using this process, it is possible to remove raindrops or streaks better than other models.

Yu Luo et al [11] propound that they isolate a rain image in two parts. First one is the rain layer and second one is the de-rained image layer. A dictionary learning based algorithm is used for this process.

Bao et al [12] propound a proximal method that is based on dictionary learning problems. This learning method applies in the image recovery fields and face recognition.

Li-Wei Kang et al [13] introduces a framework based on morphological component analysis.The conventional image decomposition technique is not used directly here. In this method, they divide an image into two parts (Low and high-frequency parts) so they use bilateral filters. 'Rain Component' decomposes into high frequency and dictionary learning and sparse coding help to decompose 'non-rain component'. Using this process rain components can be removed from the image.

Kaiming He et al [14] propound an image prior called 'Dark channel prior'. The "Dark channel prior" occurs based on a key observation. Using the haze imaging model and prior, amount of haze can be measured & retrieve good quality haze-free picture.

Narasimhan et al [15] proposed a geometric framework. This framework is used to analyze the chromatic effects. To verify fog and haze a simple color model is used that is atmospheric scattering.

S. G. Narasimhan et al [16] propound physics based models. Using 3 interactive algorithms they remove weather effects.

Patricia L. Suarez et al [17] they introduce an approach that uses stacked conditional GAN. They propound an architecture based on GAN to remove the haze.

2.4 Research Summary

The principal motive of this research is to contribution ours effort in the area of digital image processing system. In A Comprehensive Analysis to remove rain from single image using generative adversarial network is playing vital rules to the development of this modern era. This technique is very applicable to generate a realistic image from a single rainy picture with removing the rainy strike. Our contribution this knowledge is helping to build a method for produce a standard

image which is playing vital rules for object detection, enhance the image quality and also reduce the processing steps.

2.5 Region of the problem

Our research title is "A Comprehensive Analysis to Remove Rain from Single Images Using Generative Adversarial Network". So this approach is only capable for single image and also it can't applicable for any videos. . Our training data set and model only apply for removing rain strike from single image with maintain the image quality and detection power, not apply for multiple images or videos.

2.6 Challenges

The principle challenges have faced during the research are described below -

- For accurate analysis, preprocessing the data.
- Choose the exact programming shelf with accurate libraries.
- For our scenario, choose the proper GAN architecture.
- Testing the accuracy for satisfactory, training enough data.
- Choose accurate activate function with this technique.

CHAPTER 3

Experimental Results and Discussions

3.1 Dataset Description

The realist single image Deraining (UCID) [24] dataset is conduct for researching in this pursuit. Including an experimental and complementing augmentation, the UCID dataset is a deraining benchmark dataset which is comprising of 1338 uncompressed images. A ground truth of a series of query images are attached with uncompressed images. The image set is divided into training & testing set. Its ratio is 8:2. Some sample rainy and ground-truth images from image sets are shown in Figure 2.

3.2 Experimentation

For quantitative evaluation, we used two values (PSNR & SSIM). Table 2 list out the average amount of PSNR and SSIM values of the Derain images for the four GAN-based techniques: Attentive GAN, cGAN, Cycle GAN and DHSGAN. From the tables we can see that cGAN have better performance than the other techniques or methods. The three GAN-based techniques have some visual results that are shown in Figure 3, which also confirms the superiority of cGAN than the other techniques, as it is robust than the other techniques.

(a) (b) (c) (d)

Figure 3.1: Sample Test along with Ground Truth Images from UCID Dataset

Figure 3.2: Qualitative comparison results of different methods after applied on Figure 2(a) image.

Table 2: Average PSNR and SSIM results for the investigated three GAN-Based methods for UCID dataset images.

Metrics	Attentive GAN	Cycle GAN	DHSGAN	cGAN
PSNR	21.93	20.13	21.84	22.06
SSIM	0.85	0.92	0.90	0.89

CHAPTER 4

Future Works & Conclusion

4.1 Future Works

In the modern civilization, technology is improving day by day. Especially machine learning, face recognition, image processing & artificial intelligence are the most featured topics. Our project is based on machine learning. So we want to update our GAN in the future for better performance.

We want to introduce an architecture that will be helpful for object detection and image deraining. In the future, we will update our architecture for better performance. Our architecture will provide a high-resolution image. Using this architecture in rainy time cameras can detect the object clearly.

In the future, we will try to keep our architecture up to date and we add many data set to train our model for high accuracy.

4.2 Conclusions

Rain removal from images for clear vision and analysis is one of the most difficult tasks in computer vision technology. This research reported a comprehensive study on four state-of-the-art that is depends on GAN-based image dehazing methods, such as Attentive GAN, cGAN, DHSGAN, and Cycle GAN. After getting outputs we evaluated those output methods both objectively (based on PSNR & SSIM) and subjectively (based on visual feeling) using the benchmark UCID dataset. Based on the evaluation and analysis, this research found that no single best deraining algorithm under all metrics. Moreover, to deal with the real complicated, varying rains, one might need consider a mixture model of experts. So, it may inspire the authority or community to update or develop a new robust algorithm to account for elevated vision problems on real-world rainy images.

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