Dogo Rangsang Research Journal
ISSN : 2347-7180
UGC Care Group I Journal
Vol-09 Issue-01 No. 01 : 2022

IMAGE DEHAZING FROM REPEATED AVERAGING FILTERS WITH ARTIFICIAL NEURAL NETWORK: A Survey

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Abstract— **In this review, we've looked at the issue of fuzzy image improvement and restoration. With the rapid development of current imaging equipment, haze image improvement has become increasingly important. However, enhancing the contrast of a single foggy image is a difficult task for scientific research and computational applications. Picture dehazing can be divided into two categories: image enhancement and image restoration. Using a priori understanding of the degradation phenomenon, image restoration aims to reconstruct or restore a degraded image. Visual enhancement, on the other hand, refers to the highlighting or sharpening of image elements such as edges, boundaries, or contrast in order to improve the usability of a graphic display for presentation and analysis. In the fields of computer vision, video surveillance, medical imaging, and satellite image processing, image restoration and enhancement techniques are widely employed. The repeated averaging filters using integral pictures with feed forward neural network provide an averaged channel from a single image, allowing for a faster and more efficient removal of halo artefacts.**

***Index Terms*—**Image enhancement, Image Dehazing; Averaging Filter; Feed forward Network

I. Introduction

In today's world, an image is defined as a function of two real variables, such as (x, y) with I as the picture's amplitude (e.g. brightness, contrast) at the coordinate location (x, y), where x and y are two horizontal and vertical coordinates. Image processing is a type of signal processing in which the input is an image and the output is a picture, a characteristic, or a set of parameters connected to the image in imaging research. Analog image processing and digital image processing are two types of image processing.

A numerical representation of an object is a digital image. Pixels are the visual elements that make up the image. Each pixel has its own coordinates and value. A pixel is a representation of the brightness at a specific place in an image. All image processing actions are performed on these pixels. The use of computer algorithms to perform image processing on digital images in order to obtain an improved image or to extract relevant information from it is known as digital image processing. Digital image processing has the advantages of flexibility, adaptability, and data storage and transport. Digital image processing does not necessitate hardware upgrades, and data within the computer can be transferred from one location to another. Memory and processing speed are two of digital image processing's drawbacks. We need to keep digital photographs on a storage device so that we can utilise them again in the future. For storing image data, there are numerous storage devices available. Optical discs, magnetic discs, and floppy discs are examples of these storage devices.

The perception of natural outdoor images is an important aspect of image comprehension. It accurately depicts what the human visual system is capable of and what it sees from it. Visual techniques such as recognition, detection, and surveillance become easier to implement with a deeper knowledge of pictures [1]. In real-world scenarios, the hazy and foggy particles impair atmospheric visibility. Haze, fog, smog, or mist are all possibilities. When light collides with these particles, it scatters in many ways, resulting in images with scattered brightness, faded colour, and low contrast. As the scene light combines with the airlight, the camera obtains irradiance from the scene point [2]. In the case of camera-guided or driverless vehicles, as well as navigation-based technologies, picture visibility is lowered to a dangerous level, resulting in road mismanagement.

Input image

Fig 1: Hazy images

Many important scientific domains have embraced image dehazing, including astronomy, medical sciences, remote sensing, surveillance, online mapping, land-use planning, agronomy, archaeology, and environmental studies. In image processing and computer vision-based applications, haze removal/picture dehazing is a must. After the haze reduction technique has removed the haze, computer vision algorithms can assess the images. Because image analysis at a basic level, such as picture deblurring, sharpening, and enhancement, assumes the input image is in natural brightness, haze in photos has become a big concern. High-quality images are also utilised in high-level image processing, such as target identification, recognition, and surveillance. Haze removal techniques can also aid in-depth image analysis [3] and can be useful in a variety of image analysis domains and applications.

The human brain's most important data to absorb and interpret is visual data. Visual data analysis takes up about a third of the cortical area in the human brain. As a result, picture clarity is critical for a variety of imaging jobs. The light reflected from a subject is frequently scattered by the atmosphere before it reaches the camera in practise. Light scattering is caused by suspended particles, such as mist, dust, and fumes, which deflect light away from its principal path of transmission.

Even in adverse weather, cameras in automobile systems must produce clear images. Dehazing is a must-have feature in consumer devices to gather high-quality photographs since mist and air particles make it difficult to see other vehicles, traffic signs, and people. This process, in particular in the case of distant sensing, results in a significant loss of visual contrast and colour. Such images frequently lack visual vibrancy and appeal, and their poor visibility makes it difficult to do subsequent image processing operations.

Picture dehazing can be split into two categories: image enhancement and image restoration [3]. To address dehazing, image restoration-based approaches create an atmospheric scattering model and then apply the inversing degradation process [4]. Further Image restoration approaches can be divided into two groups: those that consider several photos and those that focus on a single image [5]. Other approaches, such as Retinex [6], homomorphic [7], and wavelet transform [8,] were also introduced. Previously proposed techniques were tested on several photos for haze reduction. However, multiple-based image approaches have run into some issues in online imaging dehazing applications, which necessitate a high-resolution sensor. As a result, numerous studies [2], [9], [10], [11] concentrated on single image dehazing.

In computer vision applications and data collecting, image dehazing improves aesthetic quality, contrast, and the quality of image information. Many computer vision methods, such as remote sensing, intelligent vehicle control, underwater picture dehazing, object recognition, and surveillance, require dehazing.

II. Literature Review

The earliest visibility increases for picture dehazing have been addressed in literature [8], where visibility is improved by dark-object subtraction to reduce dispersed light in numerous images in varied weather circumstances. Schechner et al. [9] developed a haze-free onboard system. To remove the haze through contrast restoration, the suggested system employs a weather estimating technique. It is built on the premise of a flat environment, which makes developing 3D geometrical information-based models difficult in practise and complex. Tan [10] presented a technique for increasing visibility by optimising local contrast in a homogeneous airlight while also producing saturation and halo effect. Fattal [4] presented an optical transmission estimation approach for removing scattering light and restoring contrast in high-visibility images, however it fails in nonhomogeneous and dense foggy environments. He et al. [7] proposed a new method for determining the dark channel prior. The key principle is that there should be at least one dark colour channel comprising pixels with very low intensity values. This information aids in the estimation of haze depth and the restoration of a high-quality dehazed image. Increased sunshine and nonhomogeneous haze in photos may reduce the method's efficiency. Tarel and Hautière [11] proposed an image dehazing strategy based on improved visibility in real-time processing that is less difficult for both colour and grayscale images. Although this approach is based on the maximum contrast assumption and normalised airlight with edges preserved, the restored depth-map is not smooth along the edges.

By adopting Markov random field as two separate layers, Kratz and Nishino [12] focused on the scene washout effect and density in an image. Although the results are promising, the method produces black artefacts at deep spots. Ancuti and Ancuti [13] presented a method for combining two blurry input photos. Saliency, luminance, and chromaticity are three important factors to consider when extracting features. The end effect is nice, but the image has been over-enhanced, and the image's natural colour contrast has not been restored. Meng et al. [14] presented a method for optimising and regularising unknown scene transmission. The outcome created high-quality photographs with natural colours and fine edges; however, the technique does not perform well for images with big sky portions and white areas since the resultant image is excessively amplified to an unnatural level. Tang et al. [15] proposed a machine-learning-based framework for picture dehazing and extracted the combination of the best-selected characteristics. Because the dark channel features are the most important part of image dehazing, the technique concentrated on them. When the haze depth is high, it restores good quality dehazed images but increases noise. Cai et al. [16] proposed a new method for estimating assumptions and priors that employs convolutional neural networks (CNNs). For extracting characteristics responsible for creating haze related features, CNN layers are used. This technique exceeds state-of-the-art procedures in terms of restoring the sky and white patches, but also distorts the image's dark colors.

For image restoration, Bansal et al. [17] discussed a number of single image and multiple image dehazing algorithms. The paper compares various state-of-the-art procedures and discusses their benefits and drawbacks, as well as their future potential. Salazar-Colores et al. [18] suggested a rapid solution for restoring image quality utilising morphological techniques. The peak signal-to-noise ratio (PSNR) and structural similarity index are used to assess performance (SSIM). Due to DCP restrictions, this technique performs well in terms of speed, but it is unable to handle sky regions and white areas. Berman et al. [19] presented a novel approach based on no local prior. The approach concentrates on pixels in a specific cluster, with a few hundred different colour lines representing the cluster's colour. These hazy lines are utilised to restore the image to its original state. It works well on a wide range of photos, however it falls short when it comes to portions with brighter airlight. Li et al. [20] proposed a new approach termed realistic single-image dehazing (RESIDE), which is based on a training set and uses objective and subjective quality judgments. On both synthetic and non-synthetic images, the model is trained. The results are superior than those obtained using state-of-the-art procedures.

- **Overview of Image Restoration and Enhancement**

Image restoration and enhancement procedures are used to enhance the image's look or extract finer information from deteriorated photos. The goal of picture restoration and enhancement is to modify an image so that the final product is more suited to a certain application than the original. Computer vision, video surveillance, satellite and medical image processing and analysis are just some of the applications for these techniques. Filtering the observed image to reduce the effect of degradations is what image restoration is all about.

Sensor noise, random atmospheric turbulence, and other factors may degrade the photos. Random noise degrades images frequently. Noise can arise during the collection, transmission, or processing of images, and it can be reliant on or independent of the image content. The probabilistic features of noise are commonly used to describe it. The extent and accuracy of knowledge of the degradation process, as well as the filter design criterion, determine the effectiveness of picture restoration filters [Jain, 1989]. For image restoration, traditional filters such as mean, median, and so on are commonly utilised. However, these traditional filters have drawbacks, leading to the development of advanced filters like decision-based median filters, switching median filters, wavelet filters, and fuzzy filters [Gonzalez and Woods, 2008].

[Pratt, 2001] The goal of image enhancement is to increase the interpretability or perception of information in images for human viewers or to give better input for other automated image processing approaches. Image enhancement is a technique for improving the depiction of fine features in photographs. Image contrast enhancement is a type of image enhancement operation that entails transforming one image into another in order to improve the look and feel of an image for machine analysis or human perception [Acharya and Ray, 2005]. It's a must-have tool for researchers in a range of domains, including medical imaging, forensics, and atmospheric sciences, among others.

Despite the existence of various fuzzy filters for picture improvement and restoration in the literature, the demand for far better filtering algorithms for improved analysis and decision making persists. Three unique soft computing algorithms based on fuzzy logic have been proposed and implemented to alleviate the disadvantages of existing methods, notably:

- Novel fuzzy-based decision algorithm for high density impulse noise removal.
- Novel fuzzy-based filter for additive noise removal.
- Novel fuzzy logic and histogram-based color image enhancement.

III. IMAGE RESTORATION AND ENHANCEMENT

Picture dehazing can be divided into two categories: image enhancement and image restoration. One of the most important areas of research in the world of digital image processing is picture restoration and enhancement. Using a priori understanding of the degradation phenomenon, image restoration aims to reconstruct or restore a degraded image. Visual enhancement, on the other hand, refers to the highlighting or sharpening of image elements such as edges, boundaries, or contrast in order to improve the usability of a graphic display for presentation and analysis. Image restoration and enhancement techniques are widely utilised in computer vision, video surveillance, medical image processing, and satellite image processing, among other fields.

- **Image Restoration**

Random noise, which can occur during picture acquisition, transmission, or processing, degrades images frequently. Sensor noise, relative object-camera motion, random atmospheric turbulence, and other factors might cause degradation. Noise is commonly described by its probabilistic features, and it might be dependent or independent of image content. During picture transmission, noise develops that is usually unrelated to the image signal. Gaussian noise is a good approximation of the noise that occurs in many real-world situations. Image noise reduction has come to refer to the technique of smoothing out noise that has distorted the image in some way. Image restoration entails filtering the observed image to reduce the impact of degradations, which necessitates prior knowledge of the degradation form. The goal of image restoration is to reduce noise and recover an image that looks as close to the original as feasible.

Deterministic and stochastic processes are the two types of image restoration approaches. Deterministic processes have prior knowledge of the degradation function or point spread function, whereas stochastic processes do not have prior knowledge of the degradation function or point spread function, such as the blind de-convolution approach. Parametric and Nom-parametric methods are the two types of deterministic approaches. Image non-negativity and signal-dependent noise are not always maintained by linear filters. As a result, non-linear and iterative restoration techniques have been developed. Image enhancement differs from image restoration in that the latter is aimed to emphasise characteristics of an image to make it more pleasant to the observer, but may not always generate realistic data from a scientific standpoint. No a priori model of the process that formed the image is used in image enhancement techniques (such as contrast stretching or de-blurring via a closest neighbour procedure).

Image Restoration Model

Most restoration techniques model the degradation process and attempt to apply a reverse procedure to obtain an approximation of an original image.

The process by which the original image is degraded is usually very complex and often unknown. To simplify the calculation, the degradation is often modeled as a linear function which is often referred as point spread function usually known as PSF. Image restoration technique basically employs two different models in the whole process:

- Degradation Model

- Restoration Model

Thus most of restoration techniques firstly degrade the image by passing it through image degradation model. They employ a degraded image into the restoration model to constitute the reverse process of recovering the approximation of an original image.

a) Degradation Model

In the degradation model, degradation function H consists of filters which constitute the point spread functions (PSF) to create a blurred image or degraded image. There are several types of filter which constitute the point spread function for different types of blur like Gaussian filter, motion filter, laplacian filter etc. We can also add random noise n(x, y) to a degraded image for createing a distorted image. The output of a degradation model is a blurred image with an addition of noise which is represented by g(x, y) .The block diagram of such degradation model is shown below in figure 2.

Here,

F(x,y) = Input Image

n(x,y) = Noise

G(x,y) = Degraded Image

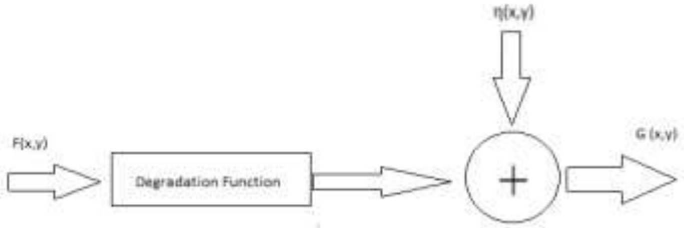

Fig 2: Architecture of Degradation Model

b) Restoration Model

In the restoration model, we apply a degraded image into the restoration function to apply the inverse process of recovering the approximation of original image. In the restoration model, the restoration function consists of different restoration method like blind de-convolution method to remove blur & noise and create a recovered image. The block diagram of original image is shown in the figure 3 below.

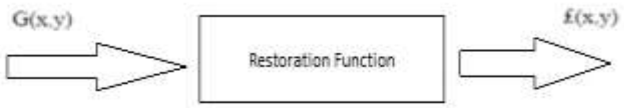

Fig 3: Architecture of Restoration Model

Where,

G(x, y) = Degraded image

£ (x, y) = Original image

- **Image Enhancement**

Sharpening, contrast modification, filtering, interpolation and magnification, pseudo colouring, and other image enhancement techniques are available. The most difficult aspect of picture enhancement is measuring the enhancement criterion. As a result, many picture enhancing approaches are empirical, requiring participatory procedures to achieve satisfying results. Image enhancement, on the other hand, is still quite essential because it is useful in almost all image processing applications. Color picture enhancement may necessitate a colour image's colour balance or colour contrast being improved. Color picture enhancement becomes increasingly challenging not just because of the increased data dimension, but also because of the increased complexity of colour perception [Gonzalez and Woods, 2008].

Image enhancement techniques are employed to improve the image's look or to extract finer information from degraded photos. The main goal of image enhancement is to process an image so that the end result is more suitable for a given application than the original image. A method that works well for one type of image may not be the greatest approach for enhancing another type of image. Color picture enhancement in the RGB colour space is shown to be ineffective since it ruins the original image's colour composition. As a result, HSV colour space is used by the majority of picture improvement techniques, particularly contrast enhancement approaches [Hanmandlu and Jha, 2006].

Methods for image improvement can be divided into two categories: transform domain approaches and spatial domain methods. The approaches in the first category work by changing an image's frequency transform, whereas the techniques in the second group work directly on the pixels. However, even with quick transformation algorithms, computing a two-dimensional (2-D) transform for a huge array (picture) takes a long time and is not suited for real-time processing.

Image enhancement is the process of enhancing the interpretability or perception of information in images for human viewers while also giving 'better' input for other automated image processing processes. The main goal of image enhancement is to change the characteristics of an image to make it more suited for a specific activity and observer. One or more picture characteristics are changed throughout this operation. A task's choice of qualities and how they are updated are unique to that task.

IV. HAZE IMAGING MODEL

The haze imaging model in [4], [12] which shows a hazy image formation and widely used so far, is given as

$$I(x) = J(x)\, t(x) + A\, (1 - t(x)) \tag{1}$$

Where *I* is hazed image, *J* is the haze free image, *x* is a pixel location, *A* is the air light. *I*(*x*) and *J(x)* can be referred to as the intensities of the pixel location in *I*and *J* respectively, where *t*can be referred to as transmission coefficient which describes reflecting probability from an object not scattered and absorbed by air particles. The transmission map is given as

$$t(x) = e^{-\beta d(x)} \tag{2}$$

β is scattering coefficient and *d* is scene depth. The captured image in clear weather is $\beta \approx 0$ and hence $I \approx J$. But when has some value it results in a hazy image. In (4) the first component *J(x)t(x)* is the direct attenuation which is inversely proportional to the scene depth. The second component *A (1 − t(x))* is the air light which is directly proportional to the scene depth. Thus dehazing is all about to recover *J* from *I* after estimation of *A* and *t* from *I*.
From haze imaging (1), transmission *t* is the ratio of two line segments which can be represented mathematically as:

$$t(x) = \frac{\|A - I(x)\|}{\|A - J(x)\|} = \frac{A^c - I^c(x)}{A^c - J^c(x)} \tag{3}$$

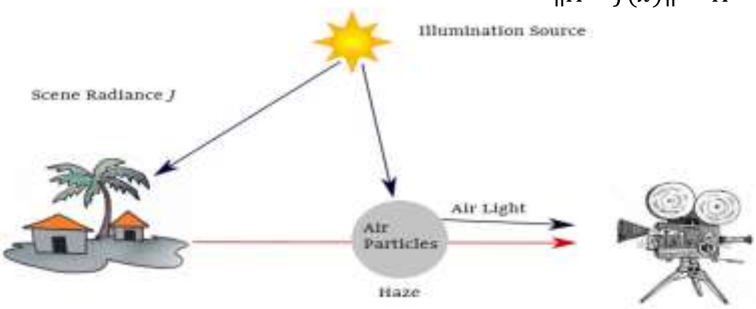

Fig 4: The Haze Imaging Model

- **Dark Channel Theory**

Dark Channel prior [2] suggests that most of the haze-free images have low pixels intensities in at least one color channel expect sky region due to three factors :1) Shadows of buildings, cars and cityscape images: 2) other objects in the image as for instance trees and plants :3) and some dark surfaces such as dark trunks of trees and stones. Noticing this phenomenon suggested that in the presence of haze, the dark pixels values altered by the air light by providing a direct contribution to its values. Therefore dark channels provide a direct clue for estimating the haze transmission. The dark channel is defined as

$$J^{dark}(x) = \min_{c \in \{r,g,b\}} \left(\min_{c \epsilon \Omega\{x\}} (J^c(y)) \right) \tag{4}$$

Where Ω(x) is a local patch centering at x. $J^c$is a color channel of *J*. This scrutiny revealed that J^{dark}tends to low intensity such as zero, and hence $J^{dark}$is demonstrated as a dark channel of *J*. Summarizing our algorithm for recovering *J*, first a dark channel (J^{dark}) is derived from the hazy image, then we applied the repeated averaging filters to normalize the dark channel and estimated the better atmospheric light *A* on the basis of repeated averaging filters from the obtained dark channel. Finally got the haze free image as an output at low computational cost with high visual effects, estimated the dark channel from input image.

V. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks are artificial neural networks where the connections between units do not form a cycle. Artificial neural networks were the first type of artificial neural network invented and are simpler than their counterpart, recurrent neural networks. They are called Artificial because information only travels forward in the network (no loops), first through the input nodes, then through the hidden nodes (if present), and finally through the output nodes.
Feed forward neural networks are primarily used for supervised learning in cases where the data to be learned is neither sequential nor time-dependent. That is, feedforward neural networks compute a function *f* on fixed size input *x* such that f(x) ≈ y for training pairs (x, y). On the other hand, recurrent neural networks learn sequential data, computing *g* on variable length input $X_k = \{x_1, x_2 \ldots \ldots . . x_k\}$such that g($X_k$) ≈ y_k for training pairs (X_n, Y_n) for the all $1 \le k \le n$.

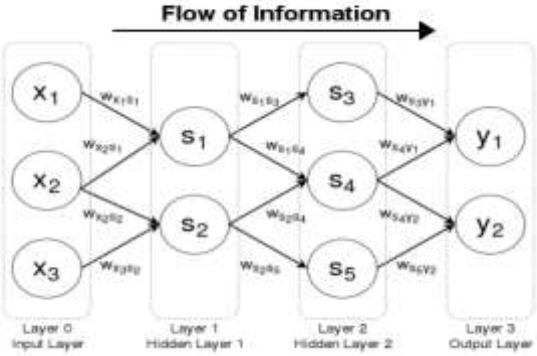

Fig 2: Feed-forward neural networks

VI. CONCLUSION

In image dehazing, the basic concepts of picture restoration and enhancement techniques were applied. The main goal of image restoration is to reduce noise and recover an image that is as near to the original as feasible. The extent and precision of the degradation process knowledge improves the effectiveness of image restoration filters. Image enhancement, on the other hand, aims to improve the image's appearance so that more important information may be collected and used for a given application.

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