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A Brief Study on Image Restoration with its Types and Enhancement Model

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Abstract

Fog removal also called as visibility restoration alludes to different strategies that aim to reduce or remove the debasement which have occurred even as digital image was being acquired. The debasement may be because of different elements like relative object-camera motion, blur because of camera mis-center, relative environmental turbulence and others. This paper exhibits an audit on the diverse strategies to eliminate haze from images caught in a hazy environment to recuperate a superior and improved quality of haze free images. Fog removal likewise recognized as visibility restoration alludes to different systems that expect to diminish or uproot the debasement that have happened while the digital image was being obtained. The debasement may be a because of different reasons alike relative object-camera movement, distortion because of camera mis-center, relative environmental turbulence and others.

Keywords*: Fog, Histogram Equalization, Clahe*

1. Introduction

The outdoor scenic images are degraded through various reasons, but one of the main reason is bad weather condition [3]. Fog, smoke and haze are a major reason of street accidents. Fog is a gathering of water beads or ice precious stones hung noticeable all around at or close to the earth's surface. The systems of outdoor surveillance effect are limited by fog. Under foggy weather conditions, the color and contrast of the images are definitely corrupted. This debasement level expanded with the separation from the camera to the object. Fog decreases the complexity image level that influences the visual nature of the image. In the PC vision field, visual quality and perceivability level of an image is influenced via air light and attenuation phenomena.

Light beam coming from a scene factor, will get attenuated because of the fact that of scattering through atmospheric particles away. This phenomenon is termed as attenuation, which decreases contrast within the scene. And the light coming from the supply is scattered in the direction of the camera and adds whiteness within the scene. This phenomenon is called air light. Fog influence will also be mathematically realized as an exponential perform of the gap from the scene to the digital camera. Consequently the fog elimination needs depth map estimation.

In order to found depth information for systems using single images as input requires prior assumptions to depth map estimation. Along these lines, numerous methods have been proposed which utilize different images. As of late, numerous single image fog

For enhancing the perceivability level of an image and diminishing mist and clamor different image upgrade techniques are utilized. After upgrade again restores the improved image by rebuilding methods. For enhancing the perceivability level 4 major steps are utilized. The initial step is obtaining procedure of foggy images. The second is an estimation procedure (phenomena, visibility phenomena, visibility). Third is the upgrade procedure (enhance perceivability level, decrease fog or commotion level). The last step is the reclamation procedure (restore improved image).

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Fog in type of cloud is known as stratus cloud. Fog has been noticeable from fog just by its thickness. Fog diminishes perceivability to under 1km while fog decreases perceivability to no less than l km.

Table 1. Visibility and Weather Condition of Fog, Mist, Haze

	Visibility	Weather Condition
FOG	Visibility less than 1Km	Cloudy
MIST	Visibility between 1to 2 Km	Moist
HAZE	Visibility between 2 to 5 Km	Dry

1.1. Types of FOG

The fogs that are composed fully or in most cases of water droplets are regularly categorized consistent with the physical procedure which produces saturation or near-saturation of the air. The foremost varieties of fog are: Radiation fog, Ground fog, Advection fog, Evaporation fog, Arctic sea smoke, Precipitation fog, Upslope fog, Freezing fog, Frozen fog, Artificial fog are a few of most ordinary fog kind.

1) ***Radiation Fog:***

This kind of fog varieties at night time under clear skies with the calm winds when absorbed the heat through means of surface of earth's at the time of day is radiated into space. Because earth's surface continues to the cool, supplied a deep sufficient layer of moist air is present near bottom, humidity will touch a 100% and fog will kind. Radiation fog varies in depth from 3 feet to about 1,000 ft and is consistently discovered at floor degree and in general remains stationary. This fog kind can diminish visibility to the near zero every now and then and create driving hazardous. Valley fog is a radiation fog variety that is general in jap Kentucky mountains. When air along ridge tops and the higher slopes of mountains starts offevolved to cool after sundown, the air turns into dense and heavy and starts offevolved to empty down into valley flooring under. As the air in the valley flooring continues to cool because of radiational cooling, air becomes saturated types of fog. Valley fog will also be most dense at times and create using very hazardous as a decreased visibility outcome. This fog tends kind to dissipate very rapidly once the sun comes up and also starts to fog layer evaporate.

2) ***Advection Fog:***

Advection fog frequently looks, for example, radiation fog and can also be the outcomes of condensation. However, the condensation in this case is induced now not through a reduction in surface temperature, however, instead by means of the horizontal action of heat moist air over a cold surface. This means that advection fog can often times be unique from radiation fog by using its horizontal motion alongside the ground. Sea fogs are continuously advection fogs, considering that the oceans don't radiate warmth within the equal means as land and so in no way cool sufficiently to create radiation fog. Fog varieties at sea when warm air associated with a warm present drift over a cold current and condensation takes position. Oftentimes, such fogs are drawn inland by using low pressure, as mostly happens on the Pacific coast of North America.

3) ***Upslope Fog:***

Upslope fog types when the light winds moist air pushes up a mountainside or hillside to a level where the air becomes condensation and saturated happens. This fog type on the whole varieties a good distance from hill peak or mountain and covers a large subject. Upslope fog occurs in all mountain degrees in North America. This almost always occurs throughout the winter months, when cold air at the back of a cold front drifts westward and encounters the eastward facing Rocky Mountains slopes. Because the cold, moist air rises up the slopes of the mountains, condensation occurs and wide areas of fog type on the cut down the slopes of the mountains. This variety of fog varies when the air temperature is well beneath freezing and is composed thoroughly of tiny ice crystals which can be suspended within the air. Ice fog will handiest be witnessed in the cold Arctic / Polar air. Usually the temperature can be 14 F or less warm in order for the ice fog to occur.

4) ***Freezing Fog:***

Freezing fog happens when water droplets that fog is composed of are "supercooled". Supercooled water droplets remain within the liquid state except they arrive into contact with a surface upon which they may be able to freeze. Therefore, any object freezing fog comes into contact with will grow to be lined with ice. The identical thing occurs with freezing rain or drizzle.

5) ***Evaporation or Mixing Fog:***

This sort of fog types when ample water vapor is delivered to the air by way of evaporation and the moist air mixes with cooler, moderate drier air. The 2 customary types are steam fog and frontal fog. Steam fog forms when cold air strikes over warm water. When the cool air mixes with the nice and cozy moist air over water, the moist air cools until its humidity reaches 100% and fog varieties. This form of fog takes on wisps appearance of smoke increasing off water skin. The other evaporation fog kind is known as front fog. This variety of forms of fog when warm evaporate the raindrops right into a cooler, drier layer of air near ground.

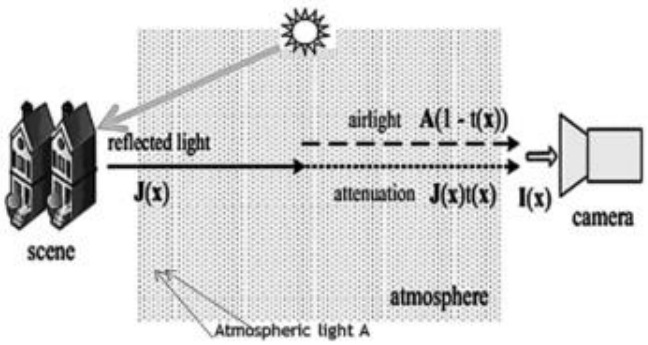
Once sufficient rain has evaporated into the cool layer surface, the humidity of this air reaches 100% and fog forms.

1.2. Effect of FOG

Effect of fog typically is precipitated by way of two scattering phenomena-
1. Attenuation
2. Airlight

Attenuation: The light beam coming from a scene factor gets attenuated given that of scattering via atmospheric particles called attenuation that decreases the contrast of the scene. Fog particles add into 3D GIS (Geographic information system).

Airlight: The light coming from a source is scattered toward camera and give on to the shift in color, it's called airlight. The fog influence is the operate of the distance between scene point and viewer or camera. For that reason, removing of fog requires the estimation of airlight map.



The depth information of any input image is measured in term of airlight, transmission map, depth map or sometime depth information is estimated with the use of scene properties. Initial work in fog removal is founded on the contrast enhancement and restoration based approaches. Under fog, haze and smoke climate conditions, the contrast and color image character degrade in a drastic manner. Thus, a fog elimination algorithm should improve the scene contrast.

Table 2. Properties of Particles [2]

Condition	Particle Type	Radius (μm)
Air	Molecule	10^{-4}
Haze	Aerosol	10^{-2}-1
Fog	Water droplet	1-10
Cloud	Water droplet	1-10
Rain	Water droplet	10^{2}-10^{4}

Fog decreases visibility and distinction level of an image. To improve the exceptional of images more than a few enhancement methods are used. A step-by-step image processing is applied over an image. Firstly acquires the image of the real world and convert into a system readable form, measurement of the effect of noise on the image. There are different noise kind which affects the image. Accordingly, Image enhancement method for bettering the excellence of an image is needed then. After bettering the great of an image again restore that image.
At present technology for fog removal are of two types-

• Fog correction
• Fog removal

The Fog correction is founded on correction of contrast degree. The color correction process is utilized over HSV color space. The color correction approach generates transmission map and estimates atmospheric mild ensuing a defogging image. Additional utilizing color correction approach enhanced video is created. Fog correction procedure improves the first-class of foggy pixel, but in fog removal process the fog level over an image is found out and removed. Figure 2 suggests a common model for fog removing from the image.

2. Image Acquisition Model

When try to remove the fog for an image or video then the first step is acquiring that input image or video. The image is acquired by the camera. Videos can be considered as sequence of image frames. All the single image fog elimination algorithms may be applied over the video frames also by regularly iterating them over each frame. The

capturing of the image is done through CCD/CMOS sensor camera, *etc.* Sensor plane are used for acquisition. The irradiance received by cameras when applies processing in real time system then use the vertical camera for capturing image is also called on board vision. Authors in used camera to convert 4D light field of a scene from 2D camera.

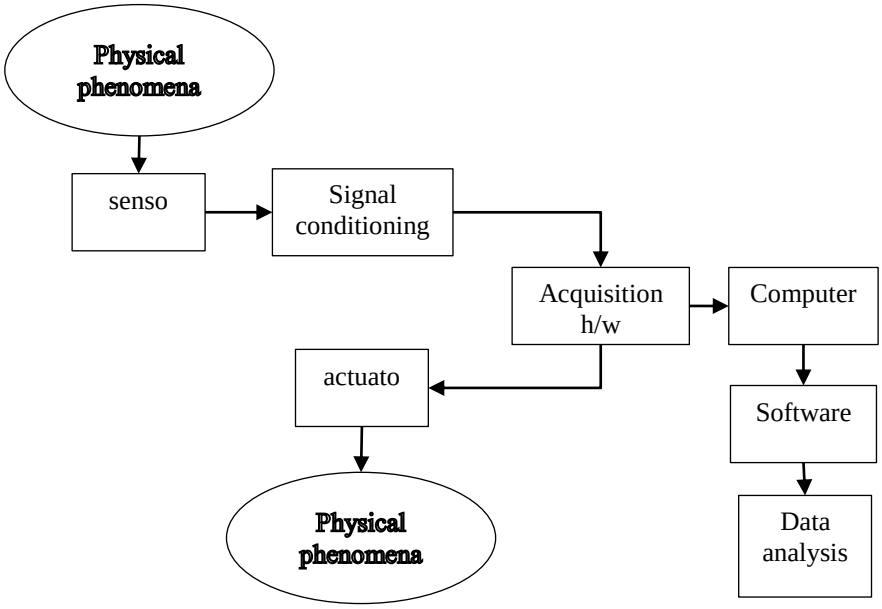


Figure 3. Acquisition Model [2]

Satellites are used when working over optical wireless links. The image may also be captured using polarization filter, which works on different degree of polarization . In the physical model foggy image is described as-

$$I(x) = J(x)\, t(x) + A\,(1 - t(x)) \quad (1)$$

In equation (1), I is the observed depth, J is the scene Radiation, A is international atmospheric light, t is the medium transmission defining the component of light that isn't scattered and reaches the camera.

3. Estimation Based Model

After acquisition process, need to estimate the level of fog or noise in an image. Estimation of airlight, attenuation and depth map is a basic factor which is calculated for enhancing process. Using equation (1) the airlight and balanced the pixel which have maximum brightness among all color channels is found out. An image which is effected by fog. K. He, J. Sun, and X. Tang [10] estimate the direct attenuation J (x) t (x) and air, light A (1-t(x» then estimation transmission for haze elimination process over a single input image. For a refining transmission map using the algorithm of soft matting in the same method. Dark prior channel is another factor which estimates for the enhancing haze channel over an image. Dark prior channel is built on key approach - haze free outside image contain some local patch (non sky patches) which contain some pixels, which have very low intensities in at least one color channel. Utilizing this prior estimate the

thickness of haze and recover it and get hazed free outside image. For calculating dark prior channel-

$$j^{da\,r\,k}(x) = \min \quad (\min (j^{c}(y)))c\epsilon\{r,g,b\}y\epsilon\Omega(x) \tag{2}$$

Equation (2) $j^{da\,r\,k}(x)$ represent the dark channel of image x, If the intensity value of $j^{da\,r\,k}(x)$ is low or zero then haze free outdoor image is obtainedj^{c}. Represent the color channel and n(x) represents local non sky patches in an input haze image. During use of dark prior channel for the haze elimination transmission map is estimated. Assume that local patches are constant for dark prior channel than patch's transmission is t (x) and perform the operation in local patches is

$$\min(I^{c}(y)) = \tilde{t}(x)\min(j^{c}(y))+(1-\tilde{t}(x))A^{c} \tag{3}$$

In equation (3) I^{c} represent the observed strength of color channel and A represent airlift which describe in equation (1). This main operation is performed over 3 color channels independently, then the equation is

$$\min((I^{c}(y))) = \tilde{t}(x)\min((J^{c}(y))) + (1-\tilde{t}(x)) \tag{4}$$

4. Enhancement Based Model

After estimating the factor of noise in term of air light, attenuation, transmission map and depth map be applied enhancement process for bettering the image of distinction stage and visibility excellent of an image. Image enhancement method is split into 2 constituents, founded on pixels. One is spatial domain and a further is frequency domain.

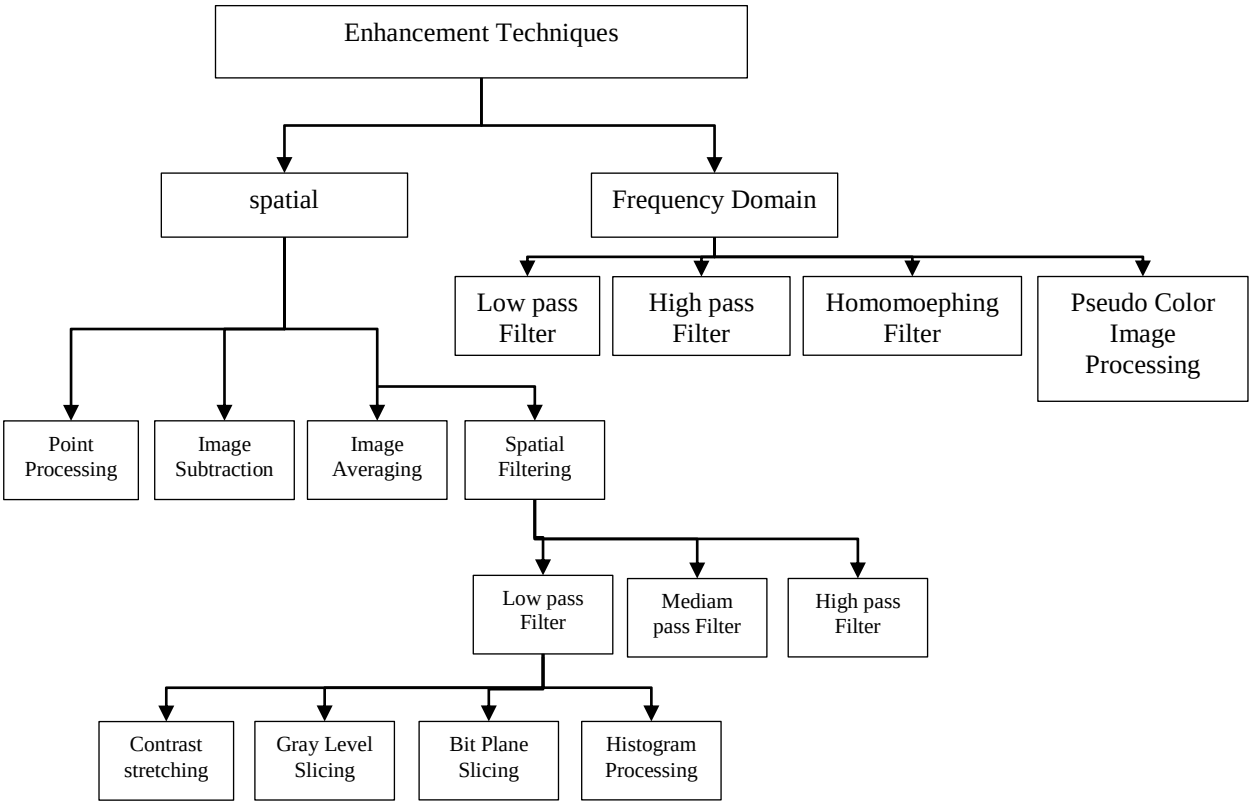


Figure 4. Classification of Enhancement Techniques [2]

In the spatial domain, the process is applied over a pixel of the input image. In image processing spatial domain function is

$$g(x,y)=T[f(x,y)] \quad (5)$$

In equation (9) f (x, y) is the input image and g (x, y) is the output image and T is the operation that over pixels of image f (x, y). In frequency domain used frequency domain filters which are based on Fourier Transform of an image for enhancement process. Contrast enhancement methods are separated into two classes.

4.1. Non Model Based Enhancement Technique

In non model based enhancement techniques, enhancement process is applied over acquired input image or video. In this process, no need to collect extra information about input images. Histogram equalization is the most usual technique is based on non model based enhancement. Many other enhancement based methods like unsharp masking, wavelet, retinex theory, for improving the contrast, brightness of any image. Using retinex algorithm find the balance between the human vision and machine vision, the retinex algorithm classified by 3 ways-

1) Single scale retinex (SSR)

2) Multiscale retinex (MSR)

3) Multi scale retinex with color restoration (MSRCR).

Histogram equalization is a complexity improvement procedure that alters pixel intensities keeping in mind the end goal to acquire new upgraded image with normally expanded neighborhood contrast. Histogram equalization is separated into distinctive sort-

1. Histogram equalization (HE)

2. Adaptive histogram equalization (AHE)

3. Contrast limited adaptive histogram equalization (CLAHE)

4. Brightness preserving bi histogram equalization (BBHE)

5. Quantized bi histogram equalization (QBHE)

6. Dual sub image histogram equalization (DSIHE)

7. Minimum means brightness error Bi-histogram equalization (MMBEBHE)

8. Recursive mean separate histogram equalization (RMSHE)

9. Brightness preserving dynamic histogram equalization (BPDHE)

10. Weighting mean separated sub histogram equalization (WMSH)

Foggy image enhancement histogram equalization techniques commonly used. There are basic 4 methods for HE: possible.

1. Histogram Equalization:

Histogram equalization is a process of improving the contrast globally. This process is the adjustment of intensity which is globally distributed crossways the image [2]. If we consider any gray scale image (x), ni be the quantity of occurrence of gray level i and a probability purpose of incidence of a pixel of level I in the image (x) is:

$$p_x(i) = p(x = i) = ni/n \,.\, 0 < i < L \qquad [2]$$

The conventional histogram equalization algorithm has three flaws [5]:

1. Gray levels of the enhanced image are reduced, a few small prints disappear;
2. Some local areas can be too bright in various enhanced images;
3. Excessive mergers of gray levels create false contours appear in the image. In MATLAB hist eq (X) function used for histogram equalization.

2. Adaptive Histogram Equalization (AHE)

Adaptive Histogram equalization technique is a modified part of the histogram equalization process. In this method enhancement process are applied over a specific region of any image and adjust contrast, according to their neighbor pixels [2]. It is used for the homogenous fog correction image. AHE can apply only on the gray image In adaptive, each pixel is customized by the pixels which are in neighboring region of that pixel. This region is called as contextual region. Input color image than first convert into gray level after that apply 'adapthisteq' function in MATLAB to enhance the image and get the output image.

3. Contrast Limited Adaptive Histogram Equalization (CLAHE)

It is modified part of the AHE. It is In this method enhancement function is applied over all neighborhood pixels and transformation utility is derived. Steps to preform CLAHE over the foggy image:

Step 1:Input Foggy image
Step 2:Obtain all input values Users gives the clip limit and distribution parameter as input. If user not specified the input parameter by default clip limit set to 0.1 and uniform distribution parameter as input.

For better enhancement of the image clip limit set at 0.2 and ‘‘Rayleigh’ distribution parameter used for the bell shaped histogram. CLAHE applied over both types of image gray scale and colored. 'Clip limit' function is used and apply limit over a noisy image. LAB color space is used for RGB true color images
Step 3: Image divides into the region
Step 4:Mapping process applied over the region
Step 5:Generate gray level mapping
Step 6: Interpolate gray level mapping in order to create enhanced image

$$N_{ovg} = \frac{N_{LR-xp} \rightarrow N_{LR-yp}}{N_{0ray}}$$

Where,

$$N_{ovg} = average\ number\ of\ pixels$$

$$N_{gray} = number\ of\ gray\ level\ in\ comtextual\ region$$

$$N_{cR-xp} = number\ of\ pixels\ in\ X\ direction\ of\ contextual\ region$$

$$N_{cR-xp} = number\ of\ pixels\ in\ Y\ direction\ of\ contextual\ region$$

After that calculate the actual clip limit

$$N_{CL} = N_{CLIP} * N_{avg}$$

Step 7: Enhanced foggy image

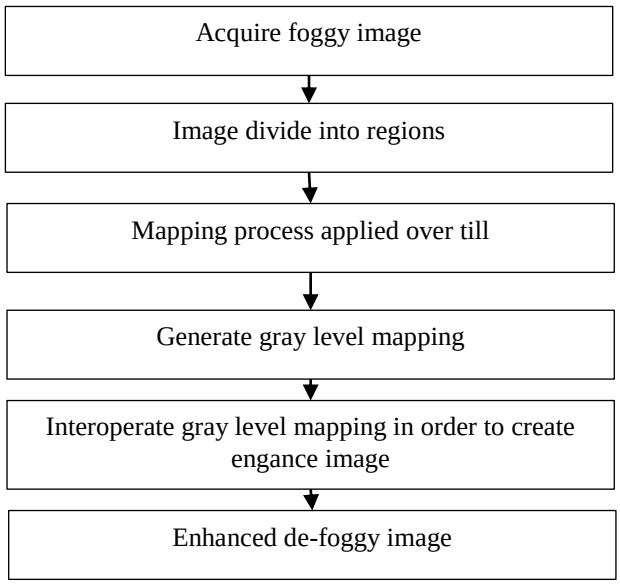


Figure 5. Steps to Perform CLAHE

4. Brightness Preserving Equalization (BBHE)

After HE procedure image brightness is affected which create a problem in some electronic products like television. For removing this drawback BBHE is used.In this method input image is alienated into two sub images and the histogram equalization process is applied separately over 2 sub images.

4.2. Model Based Enhancement Techniques

In model based method physical models are used to forecast the form of image degradation information. It requires extra information about the imaging environment.

Defog

Blur is factor that is responsible for reducing the visibility of images. Defog procedure for making improvements to the greatness of image using depth of the image utilizing blur estimation.

Dehaze

The haze is a term used in image analysis, which is a set of atmospheric outcome that that reduces the contrast of an image. For removing haze a simple and effective method used. This method does not require user interaction; it can be used in practically real time application. This method is also useful when it comes to an offline system.

5. Restoration Model

After enhancement and estimation process again restores the fog free image. For single image haze elimination recovering the scene radiance for restoration. J (x) is the scene radiance is recovered by

$$J(x) = \max(t(x), to) + A \quad (7)$$

Gamma correction and tone mapping are used before restoration of image for improving the high-quality of enhanced image.

(a) (b)

Figure 6. (a) Input Image (b) Restored Image

The multiple restoration method is used for multiple image and single Images-

- Knowledge of the scene depth method uses for multiple input images, but only gray input images.
- Light scattering through atmospheric particles in partially polarized method for color and gray both images.
- Uniform bad weather condition method for color and gray both types of input images.

For single input images-

- Interactive
- Airlight is contrast throughout the image for color and grayImages.
- Cost function based on human visual model.
- Shading and transmission function is locally uncorrelated for colored single image only.
- Method founded on local contrast and spatial regularization for color or grays both images.
- Dark channel prior for single input images.
- Airlift assumes as a contrast percentage for color and gray level images.
- Restoration based on graph based image segmentation.
- Anisotropic diffusion for color or gray single input image.

6. Literature Review

Apurva Kumara *et. al.* [3], proposed a novel and straightforward reclamation based fog removal methodology is proposed. Here, they proposed a methodology which depends on the gamma change technique and middle channel. Transmission guide is refined by the gamma transformation method. At that point acquired transmission guide is smoothed by a middle channel. Subjective and quantitative examination shows that the proposed algorithm performs well in correlation with respective separating. It can deal with color and additionally gray images. Proposed algorithm, because of its velocity and capacity to enhance perceivability, may be utilized as a part of numerous systems, extending from tracking and navigation, reconnaissance, consumer electronics, intelligent vehicles to remote sensing.

GarimaYadav *et. al.*[4], exhibited in their paper audit state-of-art image improvement and reclamation routines for enhancing the quality and perceivability level of an image which give a clear image in bad weather condition. They likewise

look at pervasive methodologies here through usage of the techniques, keeping parameters regular for critical analysis. Many algorithms are developed for improving the visibility, quality of an image in spatial domain but if these methods are applied in frequency domain, then it produces better result and reduce the time to produce the output. When they want to convert the spatial domain input into frequency domain, then use Fast Fourier transforms (FFT) and Discrete Fourier transforms (DFT). When they get the frequency of noise, then we use filtering methods and reduce the noise frequency and produced is enhanced output improved image. At last they give the future extension to working directions here for the readers.

In this reported work [5], the most reduced level channel former are proposed for image fog removal. The utilization of the most reduced level channel is rearranged from the dull channel earlier. It depends on a key observation that fog free power in a color image is typically the minimum value of trichromatic channels. To gauge the transmission model, the dark channel former then executes as a min channel for the most minimal power. Be that as it may, the min channel results in halo artifacts, particularly for neighbours of edge pixels. Rather than the min channel, this work uses the precise O(1) two-sided channel to take care of this issue. Exploratory results demonstrate the elite of the proposed technique.

Chung-Chih Cheng *et. al*. [6], in this paper proposed another transmission model utilizing L0 standard for image fog removal. In the former work, the two-sided channel was utilized to diminish the corona curios. Then again, it is just a local Optimization. Subsequently, we watch a non-zero angle to build up the slope smoothing strategy for global control. The proposed model, then finds critical edges to highlight the prominent parts of an image, Experimental results demonstrates the adequacy of the proposed model for defogging.

In this paper have proposed [7] the estimation method founded on the minimum and maximum bilateral filters. However, the computational cost of the filters is very high. The purpose of this study is to speed up the speed of the proposed approach via making use of the general-purpose computing on image processing models (GPGPU) aiming for the proposed method to be genuinely used in the practical applications. Through the experiments, it's demonstrated that the calculation speed of the method is drastically accelerated enough for practical use. The Authors also have explained Future works as the development of automatic parameter tuning methods, and the development of more high-speed dehazing algorithm, and so on.

This paper aggregates [8] up the status of image fog evacuation techniques. After that, quantitative and subjective evaluation of these techniques are displayed and the difficulties of the current fog evacuation method are abridged. Finally, we proposed some expectations for the future research in the field of image fog removal.

In this paper, we propose [9] the system for recognizing the level of snowfall naturally regardless of the possibility that the greater part of the foundations are secured with snow and the perceivability is low by fogging. When it snows intensely, fog regularly happens all the while. In addition, falling snow grains have low difference in the foundation secured with white snow. To manage these circumstances, the proposed technique makes an information image clear by fog removal. They propose the novel fog removal method which can be connected to the typical scene as well as the overwhelming frigid scene. This technique can remove the impact of fog without relying upon the evaluation of perceivability on the grounds that the level of fog removal is changed powerfully. The level of snowfall is assessed for the amount of falling snow grains, which are removed from the contrast between the present defogged image and the background image made by the three-dimensional middle. Tests directed under different degrees of snowfall have demonstrated the adequacy of the proposed technique.

In this paper [10], a new single image haze elimination procedure established on the Fields of Expert model was discussed. Firstly, the coarse atmospheric transmission map is acquired utilizing the dark channel prior. And after that, the Fields of Experts model is embraced to get the priors from the corrupted image, in order to change the atmospheric transmission map. At last, the scene albedo is restored on the atmosphere scattering model. Experiments show that the algorithm can be an effective recovery of the image scene information. In the future, we will extend our work to the problem of outdoors video dehazing.

In this paper examination [11] of two denoising strategy utilizing versatile wiener channel and fuzzy filter in wavelet area is finished. Wavelet transforms are uniquely utilized for pressure, Denoising, Thresholding, Error reduction, reconstruction, and for image synthesis. Discrete wavelets transform and channels are utilized for image reconstruction as a part of investigations. Execution can be figured on the premise of two parameter, *i.e.* PSNR (peak signal- to-noise ratio) & RMSE (root mean square error). This paper concludes that hybrid filter shows better results in comparison with a filter using alone. This experiment is limited up to Gaussian noise. In future if combinations of different filter will be taken on different noises, then better results can be achieved.

7. Conclusion

Fog removal algorithms have become more useful for a lot of vision applications. It is found that lots of the present existing researchers have uncared for many disorders; *i.e.* no technique is accurate for different kind of circumstances. Fog removal algorithms have ended up more valuable for some vision applications. It is discovered that the majority of the current scientists has dismissed numerous issues; *i.e.* no method is correct for distinctive sort of circumstances. Fog removal algorithms come to be more priceless for many vision applications. It's found that many of the present researchers have neglected many disorders; *i.e.* no technique is better for different kind of circumstances. We will try to restore defog image using gamma transformation and Contrast limited adaptive equalization method. Also, we will work on both gray or color images.We will try to improve gain rate between defog image and foggy image. And also we will calculate peak signal noise ratio for image quality and mean square error for calculating error of an image.

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