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# An Extensive Survey on Image Defogging Techniques

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**Abstract**

In this research paper we have studied and analyzed the context relevant to the image defogging in order to overcome the trouble facing in the same context. A review work has been developed with the contribution of other researchers in field of image defogging. In the previous work various researchers have proposed different methods to recover the image from defog trouble and depth from a single image. As the atmospheric visualization model may used away for defogging. Researchers have cast the problem into a relaxed factorial Markov random field but still it would be improved up to a appropriate level. This would lead us to have the satisfactory outcomes and formulation would be efficiently solved using our techniques. The utility of our method is very essential for the depth and recovery the real image. This can provide good output compared against other techniques discussed in the literature.

**Keywords**

Image Defogging, Dehazing and Fog, Clouds and Smoke Light Scattering.

## 1. Introduction

Along with defog, the latter usually implying that the air is dry, there are other hygroscopic and non hygroscopic objects which will be the topic of this field. The distinction between the humid phenomena can be made through the droplet size and concentration. As a rule of thumb, the higher the concentration and the bigger the particles are, the more they will scatter light, and hence the visual range will drop. Although water absorbs certain wavelengths, it does not absorb all light, though some particles, especially black smoke particles are able to absorb visible light independent from wavelength. This will of course result in a strongly decreased visual range. These particles would need further classification. It is also noteworthy that clouds are not the same as fog; the visual effects are of different magnitude as are the constituents in terms of size, size distribution and number. To visualize the droplet size, one should have a look at fig1, it shows the differences in particle sizes of cloud, fog and haze drawn to the same scale.

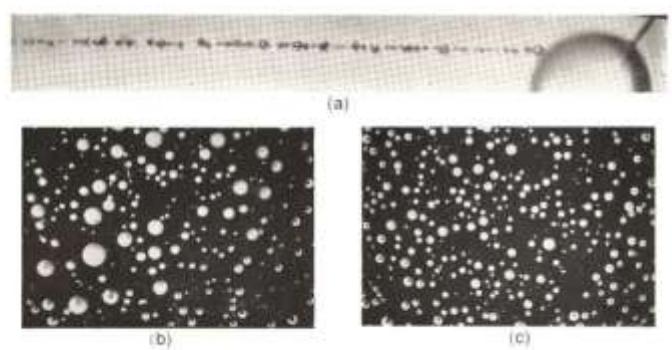


Fig1: Images of Cloud, Fog and Haze droplet.

These photographs show certain types of clouds and fogs shown in fig1 are a coastal fog with larger droplets than the cloud and also a larger range of radii. Clouds also are not always of the same type, since they may have different origins and altitudes. Common mean radii of clouds depend on their type:

Though all these particles and cloud types, even rain could be described by the power-law size distribution function, described in the earlier subsection. This shall just show the large variety of particles in the air and their constitution and origin, respectively. It is therefore a complex problem to find a defogging algorithm that can handle all kinds of haze, clouds, fog and smoke, respectively.

Such that, for example the outline of a person seen through a wall of fog, is horizontally or otherwise distorted and that the actual outline cannot be seen. There is no scientific data that shows this phenomenon. All photographs that show objects through thick fog either show clear outlines of that object or no object due to light extinction. It is more a stylistic device of painters than a real world effect. This can also be shown by light beams, for example that of a flashlight seen in fog or smoke, although the light appears weaker along the path as it travels through the medium, the boundaries of the cone or beam are not diffuse but indeed sharp. This is a fortunate characteristic and therefore does not need further regard from the defogging method.

*Light Scattering*

As a rule of thumb, it can be said that, the larger a particle is, the better it scatters light. This phenomenon is illustrated by figure 2, the figures show the scattering pattern of a light beam scattered by 3 different sizes of particles (a) shows the symmetric scattering pattern of a particle smaller than one-tenth of the wavelength of the incident light beam.(b) and (c) show the scattering patterns of larger particles, note that the complexity ofthe pattern grows with the particle size. The similarity of all scattering patterns ofparticles larger than one-tenth of the wavelength of the light is that most photons are scattered in forward direction, this effect is increased also with particle size.

In addition to removal of atmospheric veils, image defogging techniques have potential applications in many other domains, for instance, distance measurement. Traditional distance measurement techniques, such as laser ranger and infrared ranger, work poorly in bad weathers due to the absorption and scattering by atmospheric medium. Though, most dehazing methods must first reliably estimate the haze transmittance, which correlates with the distance to an object, before removing haze. The same distance estimation techniques can also be employed as a supplement of traditional distance measurement techniques in non-ideal weather conditions. Moreover, the frameworks for defogging methods may be generalized for other image restoration problems, such as color DE mosaicking, white balancing, and color image interpolation. The demand for superior visual quality along with other versatile applications makes image defogging an important field.

Fig2: Image affected in fog environment

**2. System Characteristics**

In this scenario where air molecules maybe in a concentration of $N_L = 2.687 \times 10^{19} cm^{-3}$ (Loschmidt's No.), the average spacing available to each molecule is $\frac{1}{N_L} cm^3$.

Therefore the average spacing between air molecule centers is

$$S = \sqrt[3]{\frac{1}{NL}} \approx 3.3 \times 10^{-7} cm \approx 33\text{Å} \quad (1)$$

That is about nine times the diameter. The mean free path $\bar{l}$, usually used to express the average distance a molecule travels between collisions is given by

$$\bar{l} = \frac{1}{\sqrt{2}\pi d^2 N_L} \quad (2)$$

*The* diameter for air molecules.

Though to show that a photon will in most cases collide with an air molecule or haze particle in distances common for visual ranges, one can use the effective collision area of a photon with an air molecule instead. A photon, not having a radius, causes the effective collision area to be just $A = \pi r^2$. With *r is* the radius of an air molecule, one will get for the mean free path:

$$\bar{l} = \frac{1}{\sqrt{2}\pi r^2 N_L} \approx 2.4 \times 10^{-5} cm \approx 2400\,\text{Å} \quad (3)$$

This shows that the distance traveled by a photon through air is, although considerablylonger than that of an air molecule, extremely small compared to visual ranges. This is the system scenario to take a closer look at the scattering process itself.

**3. Denoising Methods**

*Contrast-Limited Adaptive Histogram Equalization* Contrast-limited adaptive histogram equalization locally enhances the image contrast. CLAHE operates on 8×8 regions in the image, known tiles, than the entire image. Every tile's contrast is enhanced, in order that the histogram of the output region approximately matches a flat histogram. The neighboring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The enhanced contrast, especially in homogeneous areas, is limited to pass up amplifying noise or unwelcome structures, such as object textures, that might be present in the image. The parameter calculating this limitation was optimized on 40 images, varying together the scene & the fog properties. For Color & Contrast Enhancement the Contrast limited adaptive histogram equalization algorithm. This algorithm is not based on Koschmieder's law (1) and this is only capable to remove a fog of constant thickness on an image. This is not visibility enhancement algorithms.

*Free-Space Segmentation (FSS)*

To be able to enhance the visibility in the rest of the scene, an estimate of the depth d (u, v) of each pixel is needed. In [4], a parameterized 3D model of the road scene was proposed with a reduced number of geometric parameters. Even if these models are relevant for most road scenes and even if the parameters of the selected model are optimized to achieve best enhancement without black pixel in the resulting image, the proposed model is not generic enough to handle all traffic configurations.

With no-black-pixel constraint (NBPC). This algorithm which relies on a local regularization is analyzed. The distance d(u, v) being unknown, the goal of the visibility enhancement in a single image can be set as inferring the intensity of the atmospheric veil

$$\mathrm{V(u,v) = Is(1 - e^{-kd\,(u,v)})}$$

Most of the time, the intensity of the sky $\mathrm{I_s}$ corresponds to the maximum intensity in the image, and thus $\mathrm{I_s}$ can be set to one without loss of generality, assuming the input image is normalized.

*Dark Channel Prior (DCP)*

An algorithm for local visibility enhancement named Dark Channel Prior was proposed. For gray level images, the DCP algorithm consists first in applying morphological erosion or opening with a structuring element of size$s_v$, which removes all white objects with a size smaller than$s_v$. Then, the atmospheric veil $\mathrm{V(u, v)}$ has been set as a percentage p of the opening result. This first step can thus be seen as a particular case of the NBPC algorithm using a morphological operator as filter and with $\mathrm{f} = 0$.

*No-black-pixel constraint and the planar assumption (NBPC+PA)*

On the one hand, the visibility enhancement with FSS performs a segmentation to split the image into three regions: the sky, the objects out of the road plane, and the free-space in the road plane. Various enhancement processes are performed depending on the region. The difficulty with an approach based on segmentation is to manage correctly the transition between regions.

**4. Literature Review**

Mutimbu, L. and Robles-Kelly A. [1]investigated a method to recover the albedo and depth from a single image. To this end, Authors depart from the scattering theory in the atmospheric vision model used elsewhere for defogging and dehazing. Authors view the image as a relaxed factorial Markov random field (FMRF) of albedo and depth layers. This may lead to a formulation which, for each of the layers in the FMRF, that is akin to relaxation labelling problems. Researchers may obtain sparse representations for the graph Laplacian and Hessian matrices involved. This employs that global minima for each of the layers may be estimated efficiently via sparse Cholesky factorisation methods. Authors illustrate the utility of their method for depth and albedo recovery making use of real world data and compare against other techniques elsewhere in the literature.

Yeejin Lee, Gibson, K.B. and Zucheul Lee [2] presented a new approach to estimate fog-free images from stereo foggy images. Authors investigate a new way to estimate transmission by computing the scattering coefficient and depth information of a scene. The most existing visibility restoration algorithms estimate transmission independently on scattering coefficient and object distance. In the proposed method, the natural color of a foggy image is recovered using depth information from a stereo image pair even though prior knowledge or multiple images taken at different times are not required. Furthermore, Authors explore a new way to measure the scattering coefficient by using a stereo image pair from an image processing perspective. Experimental results verify that the proposed method outperforms the conventional defogging methods.

Jie Chen and Lap-PuiChau [3] worked on the dark channel prior is a simple yet efficient way to estimate the scene depth information using one single foggy image. The prior fails for pixels with low color saturation. Based on the observation that areas with dramatic color changes tend to belong to similar depth, the window variation mechanism has been proposed in this research work based on the neighborhood scene complexity and color saturation rate to achieve an ideal compromise between depth resolution and precision. The proposed technique greatly alleviates the intrinsic drawbacks of the original dark channel prior. Results show the proposed technique produces more accurate depth estimation in most of the scenes than the original prior.

Dubok Park and HanseokKo [4] described the images captured under foggy conditions often have poor contrast and color. This is mainly due to air-light which degrades image quality exponentially with fog depth between the scene and the camera. In this research work, Authors restore fog-degraded images by first estimating depth using the physical model characterizing the RGB channels in a single monocular image. The fog properties are then removed by subtracting the estimated irradiance, that is empirically related to the scene depth information obtained, starting the total irradiance received by the sensor. Efficient restoration of color and contrast of images taken under foggy conditions are demonstrated. In the experiments, Authors validate the effectiveness of their method via representative performance measurements.

Jing-lei Zhang, Bin Gaoand Xiu-ping Gu [5] presented a new traffic image enhancement method based on the vanishing point detection. The basic principle of the technique is atmosphere scattering model. Loss points are used to estimate the depth of field. The main feature of vanishing points algorithm is that extract the corner points from the edges, that is based on the Curvelet transform. Five image sharpness evaluation functions are combined to evaluate the effect of the method. The outcomes on an open foggy traffic images set, which includes 359 color images. By using this method image contrast increased by 29.79% compare with histogram equalization and 52.06% compare with Multi-scale Retinex enhancement methods.

Kratz, L. and Nishino, K. [6] described in their research work that the atmospheric conditions induced by suspended particles, these are fog and haze, severely degrade image quality. Restoring the true scene colors (clear day image) from a single image of a weather-degraded scene remains a challenging task due to the inherent ambiguity between scene albedo and depth. In this research work, Authors introduce a novel probabilistic method that fully leverages natural statistics of both the albedo and depth of the scene to resolve this ambiguity. Their key idea is to model the image with a factorial Markov random field in which the scene depth and albedo are the two statistically independent latent layers. Authors exploit natural image and depth statistics as priors on these hidden layers and factorize a single foggy image via a canonical Expectation Maximization algorithm with alternating minimization. Experimental outcome shows that the proposed method achieves more accurate restoration compared to state-of-the-art methods that focus on only recovering scene albedo or depth individually.

## 5. Problem Identification

Photograph of outdoor are often veiled since of undesired atmospheric phenomena like fog, fume, etc. When travelling through atmospheric medium, lights are absorbed and scattered by water droplets, dust, and other particles. The interactions of lights with aerosols degrade image quality, in form of reduced contrast, diluted color saturation, and loss of details. These degradation effects are not only visually unpleasant but also detrimental in many computer vision applications like surveillance, object recognition and classification. Those automatic systems usually assume the clear visibility of input images. In case of bad atmospheric conditions where this assumption does not hold, their performances may severely decline. For defogging has been studied as a critical problem for removing the weather effects from degraded images.

## 6. Proposed Methodology

The potential safety benefits of a Fog Vision Enhancement System, based on the proposed visibility enhancement algorithm, have been analyzed on a scenario of accident in fog. Some improvements are possible. The metric used to compute the distance between the restored image and the image without fog can be refined by focusing only on the roadway or by using a model of human vision as propose. The image rendering as well as the visibility enhancement algorithms studied are all based on Koschmieder's law. Stray light and shadowing effect may be introduced to improve the fog model at the cost of an increased number of parameters. This opens new perspectives of research. After analyzing different image defogging techniques the visibility enhancement algorithm performs better than the original algorithm on road images where a uniform fog is added following Koschmieder's law. The proposed algorithm would demonstrate its ability to improve visibility in such difficult heterogeneous situations.

Efficient defogging of image can be done with the below defined techniques:

1. By utilization of contrast and colour adjustment techniques

2. By utilization of unsharp mask filtering technique

3. Some DE blurring technique

4. By using noise removal/filtering techniques.

## 7. Conclusion

In this research review paper we studied many defogging methods that have been described by authors in their research work, most presented algorithms give enough visibility improvements, but problem still remains. The calculation time duration per image is very long for real-time applications. The researchers have chosen the method that had the potential for speed improvements but not reached up to appropriate stage. The development of fast computer technology as well as electronic video sensors defogging method is very essential. Real-time image defogging is rather new to this subject and thus still in the process of development.

An advanced defogging algorithm would be designed with new improvements that can make possible to defog the image in real-time utilizing just the CPU.

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