A Survey on Defogging Approaches

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Abstract : Surveillance or monitoring techniques are deployed in various image processing fields. So, the quality of the videos or images are thus critical. Image quality is degraded mainly due to fog or haze. This is because, these cameras or monitoring systems are deployed in environments that are prone to these kind of obstacles. The environments include agricultural field, automated home, surgical field etc. So defogging aims at removing the fog from images, so that it improves the performance of the whole system. There are many approaches and techniques to solve this problem. So, this paper presents a literature survey on defogging techniques.

IndexTerms **- Defogging, Dehazing, Vision-enhancement, Monitoring, Image processing, Survey, Fusion, Image enhancement, Image restoration**

I. INTRODUCTION

Image capturing has world-wide applications. This method is used in several fields to monitor surroundings. From the very basic home automation systems to critical military applications, image capture and monitoring techniques are really popular and effective. The vision can be enhanced by increasing the camera quality. But there exist other kind of barriers. One such barrier is the fog or haze.

Cameras are usually deployed in various environments that are prone to several physical factors, most commonly fog. So enhancing the camera quality alone cannot improve efficiency. So, digital techniques are much more acceptable.

Defogging has gained world-wide popularity due to it's importance in a variety of critical image processing fields. Defogging techniques are used in many applications to remove smoke, fog or haze. There are some mechanical methods. But digital techniques are much more accepted. It is used for removing natural fog from simple surveillance camera images. And it is also used in Minimally Invasive Surgeries (MIS), to remove intra-cavity fog. Thus, defogging is not just an image preprocessing step, but it can be viewed as crucial step in critical applications.

There are many approaches for doing this. Majority of them are based on enhancement and restoration concepts. Some emerging techniques use their combination also. And surprisingly some of them produce some amazing results. These categories are shown in Fig.1.

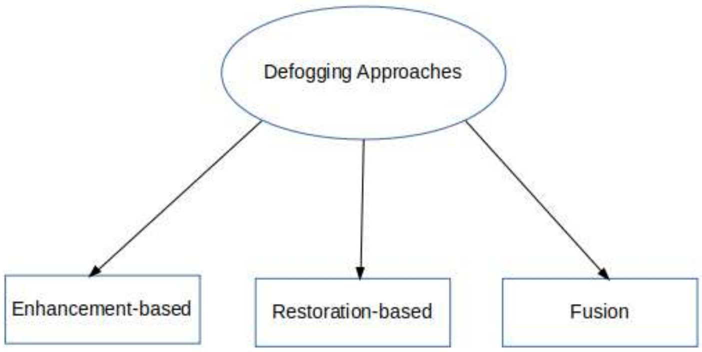

Figure 1:Defogging Approaches

II. RELATED WORKS

Fattal proposed a new method [1] for restoring the hazy-free images from hazy image. In this paper[1], an image degradation model is proposed. This is done because the image quality is degraded due to haze. Here [1], two main terms are considered: one is surface shading and the other one is transmission function. These two quantities are estimated to restore the image. This is advantageous because, in the case of thin fog or in-homogeneous fog it provides high visibility. But this method fails to enhance images with dense fog. If the noise associated with an image is so high, then this method doesn't work.

A scene is visible only when the reflected light from an object enters the camera. But atmospheric particles may absorb and reflect light. This reduces the quality of images. Most of the existing techniques require multiple images to model the attenuation and airlight. Tan and et al. proposed a method[2] that require just one image. The proposed method [2] is based on two assumptions. First, clear-day images or good images always have high contrast. Second, variation of airlight mainly depends on the distance between viewer or camera and object. In this paper [2] , an optical model is proposed. Fog is removed by taking the restored image and selecting the maximum contrast. White balance operation is used to transform the input image into white color. Then the Markov random field was used to model the airlight. Atmospheric light is obtained by the highest intensity of the input image. This method [2] provides good contrast of foggy image. But foggy image also contain regions that are normal or good. This method [2] over-enhances such regions and causes Halo effect. This may also lead to colour distortion.

He and et al. proposed another method [3] for removing haze. This main principle behind this is the dark channel prior theory. Single image is given as input. Dark channel prior is good sign possessed by outdoor images. Most of the outdoor images contain dark pixels in any of the channels. By combining this prior with an imaging model, thickness of fog can be obtained and thus, haze can be removed. The advantage of this method [3] is that it can produce a haze-free image that is an approximation of the corresponding original natural image. But this method [3] fails, if the image contains thin and dense fog. Also it doesn't work well, if the image contains large sky area or white area.

Tarel and et al. proposed an algorithm[4] for visibility restoration. The proposed method [4] is fast and hence it can be used in real-time. This method [4] is applicable to both colour and black and white images. They also proposed a new edge and corner preserving filter [4].The proposed algorithm [4], may be used in real-time with surveillance and remote sensing systems. This method is fast. But there are chances of colour distortion.

Tang and et al. proposed an approach for haze removal [5].This is a learning method [5]. Here, there is a training set of haze-free images. From these haze-free images, the features that are relevant in the context of haze are estimated. Their study [5] reveals that dark channel is one of the most haze-relevant feature. Then, a random forest regression model is learned. Based on this model, haze is removed. This method [5] can be applied to all types of images. But the availability of large data sets and lack of a perfect learning model is still a problem.

Luo and et al. proposed a fusion-based defogging framework [6]. It integrates image restoration and image enhancement techniques. Thus, it shows the advantages of both of the methods. Image enhancement based defogging methods are very fast and they are very simple. They can be implemented without any optimization. On the other hand, image restoration techniques work much better than enhancement based defogging techniques. Here [6], the input image is first restored. Also the input image is enhanced. So there are two images, a restored image and an enhanced image. Their luminances are extracted and they are fused. Finally to balance the chrominance, their respective chrominances are also fused [6].

Fog particles will act as obstacles in the direct transmission of light between camera and object. This deteriorates the quality of the image captured. Tufail and et al. [7] proposed an improved version of dark-channel prior (DCP). This [7] is based on two colour spaces: RGB and YcbCr. Foggy image is in RGB colour space. It is converted into YcbCr space [7]. DCP is computed for both of these. Transmission map ie., amount of light that is not scattered is computed from atmospheric light. Noise is removed with the help of Laplacian filter. Before computing the original fog-free image ,an intermediate image is formed for the two colour spaces[7]. And with the help of that, final image is formed. The fog-free image obtained from this approach [7] has better contrast and less colour distortion compared to other methods. But dense fog is still a challenge.

Ancuti and et al. [8] proposed another fusion strategy that uses single image to find out haze-free image. Two images are derived from the original hazy image. One image is obtained by performing the white-balance operation. The next image is obtained by subtracting the average luminance from original image [8]. Three weight-maps are constructed. They are luminance, chromatic and saliency. The computed maps are applied over the two input images. This fusion strategy [8] gives some good results. They tested this approach [8] over huge data sets also.

Zhao and et al.[9] proposed another method for defogging. This approach [9] also uses single image for defogging. They tried to find out the skylight or atmospheric light, which is basically a constant, through dark channel prior [5]. Since fog is not pure white, a white-balance procedure is done to accurately estimate skylight. Atmospheric veil is calculated by taking the minimum value among R,G and B channels. Then, local minima and maxima are found from which envelopes are calculated. This method [9] doesn't require any extra information like depth information. This method [9] also provides good results also.

There are certain application fields (e.g.: military, security) where degradation of image quality creates serious issues. Guo and et al.[10] proposed a defogging approach for videos. This enables real-time processing. This approach [10] uses deep learning technique. Here a Recurrent Neural Network is used. Here [10] a dehazing algorithm for video image is proposed. Due to impurities and fog particles, the vision may be blocked thus making the images foggy. Atmospheric scattering model is used. First, the video images are converted into YcbCr colour space. There is also a dedicated module for storing the image [10]. So the features related to fog are extracted and they are used to train Recurrent Neural Network. The proposed method [10] is able to find out the scene depth as well as haze free image.

Ren and et al.[11] proposed an approach for video dehazing. The proposed method [11] uses Convolutional Neural Networks. This [11] is a training and testing approach. This approach [11] uses five adjacent frames in the video as input. Output will be transmission maps of the three central frames in the input. This also uses semantic information for best results. In this paper [11], the detailed network architecture is described. NYU Depth dataset [12] is used for training. Atmospheric scattering model is used to find out haze free image. Introduction of semantic information improves the results.

Table 1 Comparison of Methods

Sl.No	Method Used	Advantages	Disadvantages
1	Fattal[1]	• Provides high visibility in the case of thin fog or in-homogeneous fog.	• Fails to enhance images with dense fog. • Fails to enhance noisy images
2	Tan and et al. [2]	• Provides good contrast of foggy image.	• Halo effect. • This may also lead to colour distortion
3	He and et al.[3]	• Approximation of the original natural image is obtained as output	• Problems occur when image contain thin and dense fog. • Also it doesn't work well, if the image contain large sky area
4	Tarel and et al. [4]	• Real-time surveillance • This method is fast.	• Chances of colour distortion.
5	Tang and et al.[5]	• General approach	• Non-availability of large data sets • Lack of a perfect learning model
6	Luo and et al.[6]	• Advantages of enhancement and restoration	• Doesn't works well with heavy fog
7	Tufail and et al. [7]	• Better contrast • Less colour distortion compared to other methods.	• Dense fog is still a challenge.
8	Ancuti and et al. [8]	• Good results. • Tested over huge data sets also.	• In-homogeneous fog create issues
9	Zhao and et al.[9]	• Doesn't require any extra information like depth information. • Provides good results also.	• Heavy fog causes problems

Table 1. provides a comparison of some approaches. It describes advantages and disadvantages of some common approaches.

III. Conclusion

There are several existing defogging approaches. The major principles or concepts behind them are enhancement and restoration of images. The former methods basically enhance the image features to dehaze the image. The later methods apply restoration procedures to restore original non-foggy images from foggy images. Some approaches uses certain patterns in image like dark channels to defog an image. Combination of above mentioned concepts are also utilized. Some methods follow learning approaches also. Dehazing or defogging can be done with the help of a single image or multiple images. Enhancement/restoration methods use both single image and multiple images .Learning based methods need multiple images for training. Fog density is an important problem faced by some of these methods. It is hard to obtain original images from foggy images with thick or dense fog. Noise, colour distortion and lack of data sets also became some challenges. Fusion approaches tends to show high performance.

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