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Image Dehazing and Visibility Restoration Method

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***Abstract*— Signifying the necessity of areas concerning obstacle detection, object detection, traffic analysis, etc. in present day situation, the requirement for efficient and robust haze detection, estimation and haze removal has only risen. In this work, proposed a method to estimate, detect and remove the content of haze in an image. In order to achieve the above goal, implemented a laplacian based distribution curve to estimate the transmission map. After determining the haze thickness and removal of the haze content, a gamma correction method is applied to improve the quality of the image post haze removal process. The obtained results show the successful implementation of the haze estimation, removal and improvement in the quality of the image.**

***Index Terms :* gamma correction, haze, laplacian based distribution, transmission map.**

I. Introduction

In present day scenarios the applications involving image processing implementations such as video surveillance systems, object recognition systems, obstacle detection systems depend primarily on the factor of visibility with respect to image. The image visibility criteria play an important role in the image quality assessment with respect to above mentioned applications. The visibility reduction in an image is caused from scattering and absorption of light present in the image to particulate matter and by gases in the atmosphere. This decrease in light from object to observer is computed using the Lambert law of attenuation which is given by eq.1,

$$I(s) = I(o)e^{-b_{ext}s} \quad \ldots\ldots\ldots\ldots (1)$$

Where,

I(s)→ observed intensity at the distance s from the object,

I(o)→ unattenuated intensity at the object

b_{ext^s} → Extinction coefficient which accounts for light extinction. It is due to absorption and scattering by particles and gases.

The light reaching an observer could be from the target or could have been scattered from the line of sight. Alternatively the light could be scattered from the skylight which is represented in eq.2

$$I(s) = I(o)e^{-b_{ext}s} + I_{sky}(1 - e^{-b_{ext}s}) \ldots\ldots\ldots\ldots (2)$$

Where, I_{sky}→ intensity of the horizon sky

The following section shows the effect of visibility in the following image processing applications:

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A. Object recognition systems

Considering the conditions such as illuminations, background, camera parameters and viewpoints in which the scene is captured, the scene complexity is determined which plays an important role in estimating the scene constancy in an image. The features of an image considered under a particular condition will differ if the conditions changes. This occurs due to the reliability on the illumination parameter which differentiates between the background and the foreground object. Thus, when the feature detection reduces the overall recognition rate of the object also reduces.

B. Obstacle detection system

There are two ways in which an obstacle could be detected from an image, one way is to apply illumination to a scene and wait for its reflection or energy which would be received from the image. The second way is to detect a free space or navigable area in an image. Consequently anything which is not navigable is considered an obstacle. Considering the first method where the illumination plays an important factor in the determination of obstacle in an image. The illumination factor is considerably affected by the external weather conditions such as fog, dust, etc. Hence the quality of the image acquisition devices may also play a crucial role in the image assessment pertaining to the visibility criteria.

II. Background

A. Haze estimation

Haze is generally considered an atmospheric phenomenon where the clarity of the sky is reduced with respect to its intensity and contrast. Haze is generally caused by dust, smoke and other dry particles which are formed by farming activity in dry weather, traffic, industry and wildfires.

Haze causes an issue in the area of terrestrial image photography where an object in an image has to be captured after penetrating through a dense atmospheric layer. The effect of haze results in a loss in the contrast which occurs due to scattering of light towards haze particles. The following modules are involved in the estimation of haze as shown in fig. 1 below.

A patch is created which is a predefined region which is used to estimate the darkest region in all three dimensions of the image (i.e. Red, Green and Blue component). Similarly an atmospheric light is assumed which is considered the 0.1 % of brightest pixels in the image. A transmission map is created which estimates the pixel intensity with respect to the brightness of pixel in the image. From this transmission map the radiance of the scene is recovered. Consequently a smoothing filter is applied which at a later stage, the updated radiance will be recovered, producing the final dehazed image.

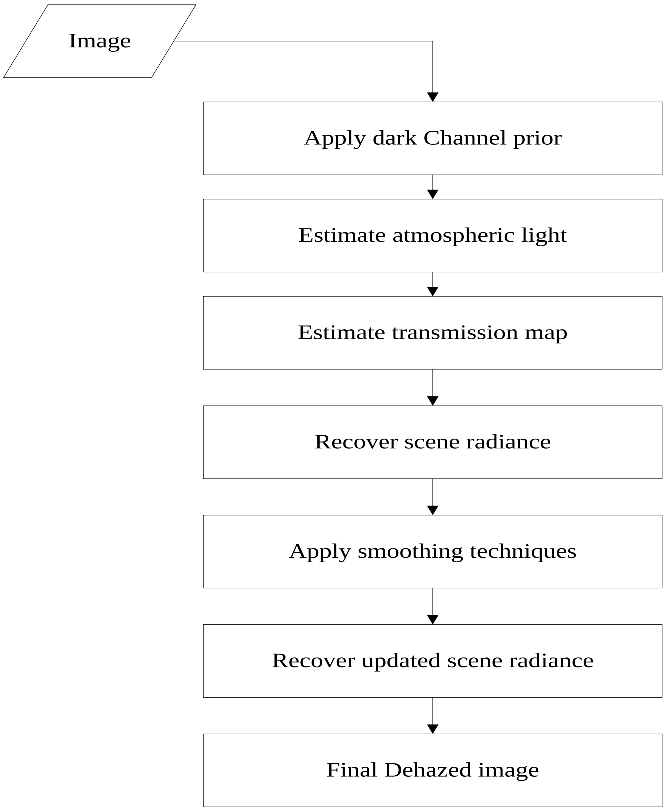

Fig 1: General process flow for estimation, detection and removal of haze content in the image

III. LITERATURE SURVEY AND RELATED WORKS

J. P Tarel et al. [1] proposed an enhancement technique for fog detection in both homogenous and heterogeneous environment. They infer that the generation of fog could arise from local atmospheric veil from constraints. Experimental results demonstrate that the method in [1] produces better results in homogenous fog and heterogeneous fog.

S. C Huang et al. [2] proposed a method based on visibility restoration in a haze image. They propose a novel visibility restoration method that constitutes of three major modules which include depth estimation module, color analysis module and visibility restoration module. The visibility restoration module constitutes the adjusted transmission map and color correlation information for correcting the color distortion in variable scenes captured during inclement weather conditions.

KokKeong Tan and John P. Oakley [3] propose enhancement techniques for color images in poor visibility conditions. The enhancement techniques are difficult to implement in images due to complexity involved in restoring both luminance and chrominance while maintaining good fidelity. Experimental results show that the proposed enhancement technique could enhance the color fidelity along with an improvement in contrast and has better visibility range when compared with other existing image enhancement methods.

Srinivasa G. Narasimhan and Shree K. Nayar [4] propose a physical model for interactive deweathering of physical models. The first interactive algorithm is based on Dichromatic color transfer, the second algorithm for deweathering is based on Depth Heuristics and the third algorithm for image restoration is based on Planar Depth Segments.

J. Kopf et al. [5] proposed a model based photographic enhancement and viewing technique. The work in [5] presents a simple interactive registration process used to align a photograph with such a model. However the process of haze removal in an image was a challenge due to the fact that haze was a function of depth. Since the information of depth was available in geo registered photograph, an excellent haze editing could be achieved from the image.

Yoav Y. Schechner et al. [6] proposed a polarization based vision to remove the effects of haze from passively acquired image. The work in [6] is derived from physics based analysis where if the polarization is low works under a wide range of atmospheric and viewing conditions. The information on the atmospheric particles is also provided in the model. Experimental results show an improvement in the contrast and color correction of the scene.

R. Fattal [7] presented a new method for estimating the optical transmission in hazy scenes in a given single image. The visibility is increased and haze free scene contrast is recovered by eliminating the scattered light which is based on this estimation. Experimental results provide a reliable transmission estimate and also remove the haze layer which could be used for additional applications such as image refocusing and novel view synthesis.

H. Xu et al. [8] proposed a fast dehazing method using Dark Channel prior. This work primarily focuses on physical process of imaging in foggy weather. The dehazing algorithm proposed in [8] focuses on bilateral filtering combined with dark channel prior. Experimental results show that by replacing bilateral filter with soft matting the efficiency with respect to haze removal is considerably improved. Also the visual effect and computing speed has been significantly improved.

S. C Huang et al. [9] proposes a method for enhancement and modification of digital images with respect to histogram and contrast. The brightness of the dimmed image is improved by gamma correction and probability distribution of luminance pixels. Experimental results demonstrate the proposed method improves the quality of the image compared to similar methods with respect to enhancement of an image.

IV. IMPLEMENTATION

The purpose of the system is to basically perform dehazing for a given image with fog content, the haze content is estimated with a help of a transmission estimate, consequently after the estimation and removal of haze in an image, the image is then sent through an image correction process to enhance the quality of the image. The final image is a resultant of a dehazed and enhanced image. The system architecture for the proposed method is shown in Fig.2.

The basic functionality of the proposed system could be described in the following image processing steps. Initially the haze content in the image is estimated through a transmission map which is estimated using the Laplacian distribution function. The hazy image estimation is then sent to a gamma correction block where the image quality is further enhanced.

Initially the image is separated into RGB components, a Contrast Limited Adaptive Histogram Equalization (CLAHE) method of contrast enhancement is applied to the

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individual components of the image. The resulting contrast enhanced image is sent to the haze estimation block where a transmission map is computed in order to determine the atmospheric light for determining the thickness of the haze formation in the image. The image is then normalized; the size of the image is then computed. The size of a patch window is estimated and consequently the transmission map is estimated using Dark Channel Prior (DCP). Parameters such as mean and rho are initialized, a predefined set of iterations are defined for the process. The Laplacian distribution curve is implemented for the haze estimation. The obtained resultant image is subtracted with the original hazy image for the removal of haze content. A restoration function is performed by including a random noise to this function. Finally Gamma correction technique is applied to enhance the quality of the image. The final dehazed and enhanced image is obtained.

V. Simulation Results

This chapter deals with the simulated results obtained from the implementation of the project with respect to haze detection, estimation and visibility restoration methods. The following sections are mentioned as follows. The first section deals with the brief mentioning of the structure and attributes of the database with respect to images. The second section performs an analysis of the outcome of the simulation.

Database

The database considered in this project is a set of images containing haze formation. Four test images are considered in this project which is as shown in table 1 below

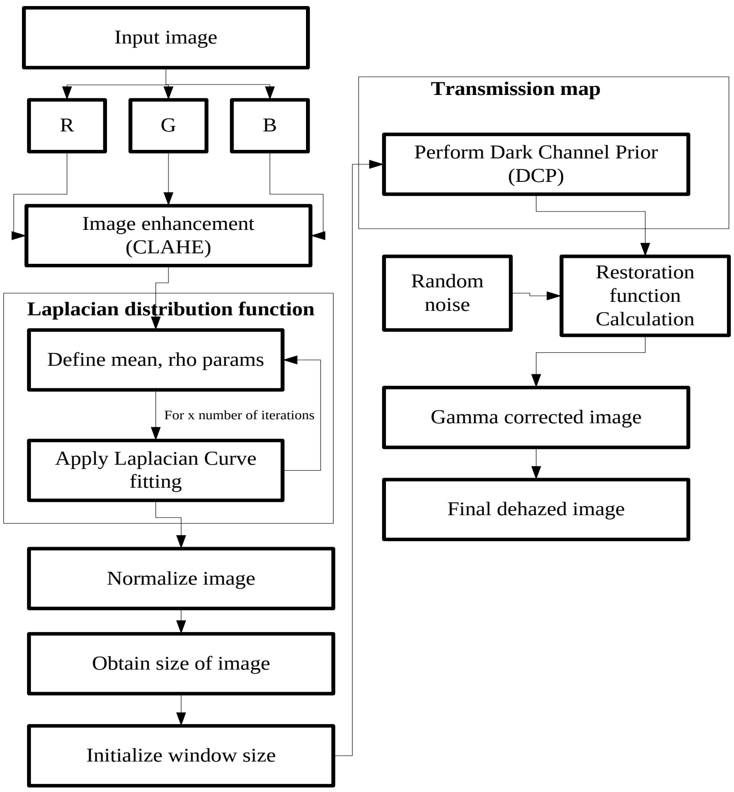

Fig 2: Proposed system architecture

Table 1: Image database

Sl.no	Image	Image format	Image size	Image class	Bytes
1.	Image1	.jpg	400 x 600 x 3	unsigned integer 8 bits	720000
2.	Image2	.jpg	384 x 465 x 3	unsigned integer 8 bits	535680
3.	Image3	.jpg	400 x 600 x 3	unsigned integer 8 bits	720000
4.	Image4	.jpg	768 x 576 x 3	unsigned integer 8 bits	1327104

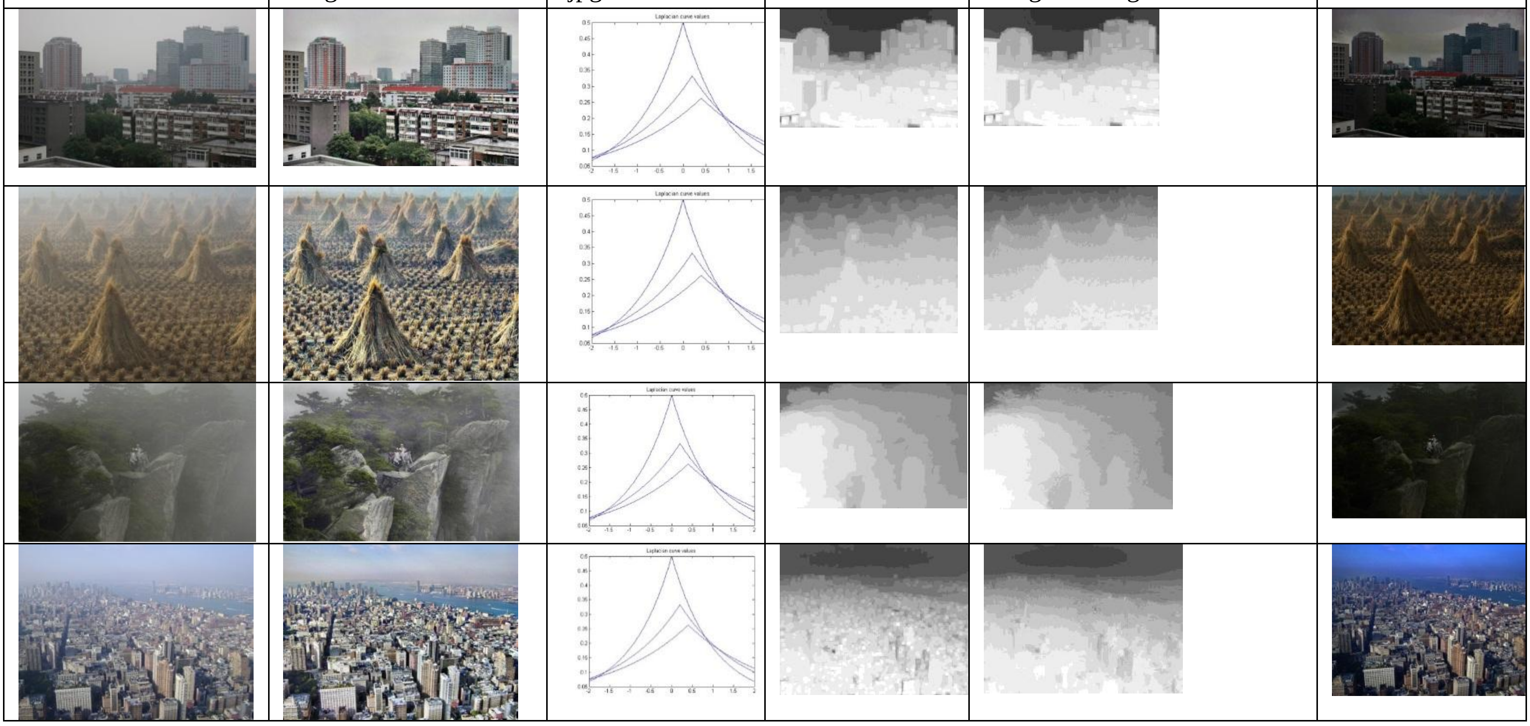

Fig 3: a. Input Image; b. Enhanced image using CLAHE method; c. Laplacian distribution curve; d. and e. Transmission estimates; f. Dehazed and Gamma corrected image

VI. Conclusion

In this work, successfully achieved a good estimation of the transmission map along with estimating the atmospheric radiance using the Dark Channel Prior, the laplacian distribution function is performed for estimating the depth of the haze in a given image. The radiance is estimated by the transmission map obtained post Laplacian function implementation which resulted in better estimation of haze. The obtained haze information is subtracted with the actual hazy image to obtain the haze reduced image. In order to improve the quality of the image, a visibility restoration approach is considered where a gamma correction method is applied. The output is the dehazed image with improved quality with respect to image enhancement consideration.

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