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An Improved Technique for Automatic Haziness Removal for Enhancement of Intelligent Transportation System

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Abstract

Image restoration is the process for image refinement to extract valuable information from the image. The haze causes various visualization problems in the image causing different variations. In this paper, an improved algorithm for haze removal from the pointed camera has been discussed. The present implementation uses Genetic Algorithm method. The proposed techniques have been validated against the previous techniques for haze removal from the pointed camera. Various parameters viz. peak signal to noise ratio (PSNR) and mean square error (MSE) have been compared for validation of the proposed method with the existing method.

Keywords: Haze removal, colour space model, median Filter, Genetic algorithm.

1. INTRODUCTION

Haze removal

The presence of haze significantly degrades the quality of an image captured at night. Similar to daytime haze, the appearance of nighttime haze is due to tiny particles floating in the air that adversely scatters the line of sight of lights rays entering the imaging sensor. In particular, light rays are scattered-out to directions other than the line of sight, while other light rays are scattered-in to the line of sight. The scattering-out process causes the scene reflection to be attenuated. The scattering-in process creates the appearance of a particles-veil that washes out the visibility of the scene [1].

Images that capture outdoors scenes contain haze, fog and other atmospheric absorption due to availability of particles in atmosphere that cause dispersion of light. Light dispersal from these particles get absorb in images through camera that can rise to degradation in quality of mage. While this, effect may be desirable in an artistic setting, it is sometimes necessary to undo this degradation. For example, many computer vision algorithms rely on the statement that the input image is accurately the scene radiance, i.e. there is no disturbance from haze.
Figure1 (a) shows hazy image and figure1 (b) shows the image after automatic haze removal.

(a) *(b)*

Figure 1: (a) Hazy image (b) Image after automatic haze removal [6]

In the middle of current haze removal research, haze estimation methods can be divided into two broad categories of either relying on additional data or using a prior assumption. Methods that rely on additional information include: taking multiple images of the same scene using different degrees of polarization, multiple images taken during different weather conditions and methods that require user supplied depth information or a three dimensional model.

Dark channel prior

The dark channel prior is based on the statistics observation on outdoor haze-free images. In most of the non-sky patches, at least one color channel has some pixels whose intensity is very low and close to zero. Equivalently, the minimum intensity in such a patch is close to zero. To formally describe these observations, the concept of a dark channel has been used. Equation (1) describes J^{dark} the dark channel of J where J^{c} a color channel of J and Ω (x) is a local patch centered at x. The intensity of J^{dark} is low and tends to be zero, if J is a haze-free outdoor image. By using equation (1), for an arbitrary image J, its dark channel J^{dark} can be calculated [8].

$$J^{dark}(x) = \min_{\{c \in r,g,b\}}\left(\min_{y \in \Omega(x)}\left(J^{c}(y)\right)\right) \quad (1)$$

Haze removal using dark channel prior

In the process of haze removal using dark channel prior various steps have been carried out that are illustrated in different sections.

Estimating transmission

In the process of estimation of transmission in hazy images assumption has been made that the atmospheric light A is given. An automatic method to estimate A is proposed. In equation (2), normalize the haze imaging equation (1) by A. In this process of normalization, all color channels that are available in hazy image has been normalized independently. Another assumption has been made that transmission in a local patch Ώ(x) is constant. This transmission has been denotes as t(x). By using equation (3), dark channel can be easily computed [1].

$$\frac{I^c(x)}{A^c} = t(x)\,\frac{J^c(x)}{A^c} + 1 - t(x) \tag{2}$$

$$I(x) = J(x)t(x) + A(1 - t(x)) \tag{3}$$

Soft matting

Haze imaging equation (3) has a similar form as the image matting equation. A transmission map is exactly an alpha map. Equation (4) represents image matting equation where F and B are foreground and background colors respectively. Therefore, in this process one can apply a closed-form framework of matting to refine the transmission [3].

$$I = F\alpha + B(1 - \alpha) \tag{4}$$

Estimating the atmospheric light

In the process of estimation of atmospheric light available in hazy image, assumption has been made that the atmospheric light A is known. In this section, a novel method has been proposed to estimate A. In the past research's, the color of the most haze-opaque region is used as A or as A's initial guess. However, little attention has been paid to the detection of the "most haze-opaque" region. In proposed work, dark channel prior approach has been used to compute atmospheric light, which is more robust than the brightest pixels in the hazy image. This is true only when the weather is overcast and the sunlight can be ignored. In this case, the atmospheric light is the only illumination source of the scene.

The dark channel of a hazy image approximates the haze denseness available in the image, that's why in this research dark channel can be used to detect the most haze-opaque region and improve the atmospheric light estimation. Firstly 0.1 percent brightest pixels have been selected available in the dark channel. These pixels are usually most haze-opaque. Among these pixels, the pixels with highest intensity in the input image I are selected as the atmospheric light. These pixels are in the red rectangle. Note that these pixels may not be brightest ones in the whole input image.

This method works well even when pixels at infinite distance do not exist in the image. Our method manages to detect the most haze-opaque regions. However, it is not close to zero here, so the colors of these regions may be different from A. Fortunately, t is small in these most haze-opaque regions, so the influence of sunlight is weak. Therefore, these regions can still provide a good approximation of A [8].

Patch size

A key parameter in our algorithm is the patch size. On one hand, the dark channel prior becomes better for a larger patch size because the probability that a patch contains a dark pixel is increased. It is illustrated that the larger the patch size, the darker the dark channel. Consequently, is less accurate for a small patch and the recovered scene radiance is oversaturated. On the other hand, the assumption that the transmission is constant in a patch becomes less appropriate. If the patch size is too large, halos near depth edges may become stronger.

2. RELATED WORK

Khodary and Aly (2014) [1] presented algorithm and implementation that helps the driver by providing an electronic view that improves visibility through haze removal. **Makarau *et al.* (2014) [2]** introduced a new haze removal method. Fog thickness estimation per band is created, permitting multispectral picture de-inception. Frightfully predictable de-inception is accomplished on other multi-and hyper phantom information, for example, AVNIR, Landsat 7, RapidEye, and AVIRIS. The conclusion and conceivable further improvements of the technique are given toward the finish of this paper. **Wu *et al.* (2014) [4]** presented various challenges and expectations of image haze removal. Authors exhibit the murkiness evacuating comes about utilizing a few delegate fog expulsion techniques took after by quality appraisals on the dimness evacuation strategies utilizing a few markers. **Pan *et al.* (2015) [7]** proposed a haze imaging model, generally utilized as a part of managing awful climate, which is depicted on the RGB shading channels. This paper introducing test comes about demonstrate that the proposing strategy can accomplish engaging de-right of passage impacts for both remote detecting pictures and open air pictures. **Li and Zheng (2015) [9]** presented a new edge-preserving decomposition based method to reckon transmission map for a haze image. The exploratory results on various sorts of pictures including murkiness pictures, submerged pictures and typical pictures without cloudiness will demonstrate the execution of the presenting calculation.

3. METHODOLOGY

Image haziness removal is a process for removal of noises available in the image due to luminance and atmospheric light distributions. In this process, quality of the image degrades due to absorption of atmospheric light particles. In this process, dark channel prior approach has been implemented on the image for estimation of dark channel available in the hazy image. In this process, dark channel prior approach has been implemented on the image to compute darkness available in the image.

Dark channel prior

Dark channel prior approach has been used to move a patch over the image that computes minimum values of intensity from the image. These values have been used for estimation of darkness available in the image where J^c a color channel of J and Ω

(x) is a local patch centered at x. The intensity of J^{dark} is low and tends to be zero, if J is a haze-free outdoor image and J^{dark} denotes dark channel of image J. Various factors are responsible for low intensity available in the various parts of the image. After computation of image dark channel, atmospheric transmission available in the image has been computed using estimation of atmospheric light channel available in the true color space in the image.

Estimation of transmission

With the transmission map, extraction of scene radiance has been done. The attenuation term J(x), t(x) can be very close to zero when the transmission t(x) is close to zero. The directly recovered scene radiance J is prone to noise. Therefore restrict the transmission t(x) to a lower bound t0, which means that a small certain amount of haze are preserved in very dense haze regions.

Equation (5) is the recovering formula for hazy images. The key of single image dehazing, based on the haze imaging model, is estimating A and t where A is the global atmospheric light and t is the medium transmission telling the part of light that is not scattered and reaches the camera. By using equation (5), final scene radiance J(x) can be recovered [9].

$$J(x) = \frac{I(x) - A}{\max(t(x), t_0)} + A \tag{5}$$

Typical value of t0 is 0.1.Since the scene radiance is usually not as bright as the atmospheric light; the image after haze removal looks dim. So, we increase the exposure of J(x) for display. After these steps, atmospheric light has been estimated available in the image. High intensity particles available in the image have been treated as atmospheric particles available in the image so that extraction of these pixels with dark channel prior pixels can be done [9].

Soft matting and colour analysis module

After transmission map extraction from the image, the weightage variable w has been used for computation of best soft matted image. These parameters computes small objects haze available in the image from transmission map. Particles of dust and sand available in the atmosphere, which cause sand–storms absorb specific portion of color spectrum. This leads to changes in their color distribution intensity during capturing image. To overcome this phenomena, average color pixel intensity of the all the RGB regions of image has been computed for distribution of the gray world image process [4].

Average of the all the colors have been divided by image that contains haziness and atmospheric light image. On the basis of this division, value of color spectrum, adjustment parameters has been measured that can be used for avoiding color shifting in enhanced image. Figure 3.1 represents flow of the proposed work that must be carried out for processing of hazy image to create haze free image.

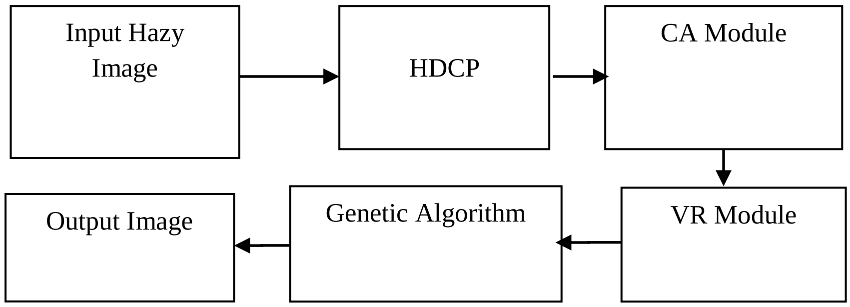

Figure 2: Flow of proposed work

After this process, radiance has been measured from the image. To capture a high quality haze free image, hybrid dark channel prior (HDCP) and colour analysis module have been combined at different atmospheric level values for computation of radiance scene from the image.

Genetic algorithm

Genetic algorithm (GA) is a nature inspired approach that work on the principal of previous generation genes. The genes of the previous classes have been used for development of new child production that cause properties of base class as well as new classes. In this image de-hazing process, GA has been used for evaluation of best image on the basis of image pixels fitness. In this process, image has been used for window size of 3*3 that computes the center pixel values. On the basis of pixel value, fitness for all the pixels in particular region has been measured for computation of best fit pixel and other pixels undergoes process of crossover and mutation process for generation of new pixels.

The new pixels, that have been generated, have been selected on the basis of selection criteria, replaced with previous pixel that has low fitness value. The crossover and mutation operators that have been used for generation of new generation evolved fitness for each new generated child. On the basis of fitness, this child's have been selected for replacement. Various steps that undergo the process of genetic optimization have been explained below.

Initial population

In the proposed work, genetic algorithm has been implemented by initializing all the pixel values of the image. Images have been divided into 3 * 3 matrixes. These pixel values have been selected as initial population of the image and on the basis of initial population, selection has been done so that best pixel from a region can be evaluated. Selection has been done on the basis of fitness function.

Selection population

In selection procedure, image region undergoes this process that computes fitness for each pixel available in the region on the basis of fitness function.

Crossover

After selection of the image pixels from the region, the best selected pixels have been used for generation of new pixels by using two pixels at a time. In the process of crossover, two parents have been evolved to generate a new offspring. Using two different pixels values, a new pixel value has been generated that has been used for replacement on the basis of fitness.

In this process, two-point crossover has been used that contain properties from both parents and generate a new pixel on the basis of these parents. If one parent binary value is represented as 11001011 and other is represented as 11011111, then after two point crossover the new offspring has been evaluated as 11011111.

Mutation

After process of crossover, new offspring's has been generated using mutation process. New pixels have been generated by using bit inversion approach. In this process, a single pixel has been selected from population and that has been used to generate new offspring by inversion of the binary bits of pixel value.

The new offspring generated from single parent eventually having better properties than than of parent class. If a binary stream of a pixel value has been given by 1**1**001001, then using bit stream inversion that has been converted to 10001001

Selection and replacement

After process of generation of new offspring's, selection of the offspring's has been done on the basis of fitness. Numerous generations has been evolved on the basis of stopping criteria of the optimization process. From these generations, best chromosomes have been selected on the basis of fitness evaluation that has been used for replacement with previous population. This provides best enhanced images that contain less distortion than that is available in original image.

4. RESULTS

Image enhancement is the procedure for removal of various noises and other extra contents available in the images. These images have been enhanced by using various operators. In this paper, haze removal from the single image has been done. In this process, hybrid dark channel prior approach has been used for removal of haze with combination of nature inspired genetic approach.

Figure 3 represents dataset which consists of Foggy Road Image Database (FRIDA) images that have been used in the proposed work for image restoration process.

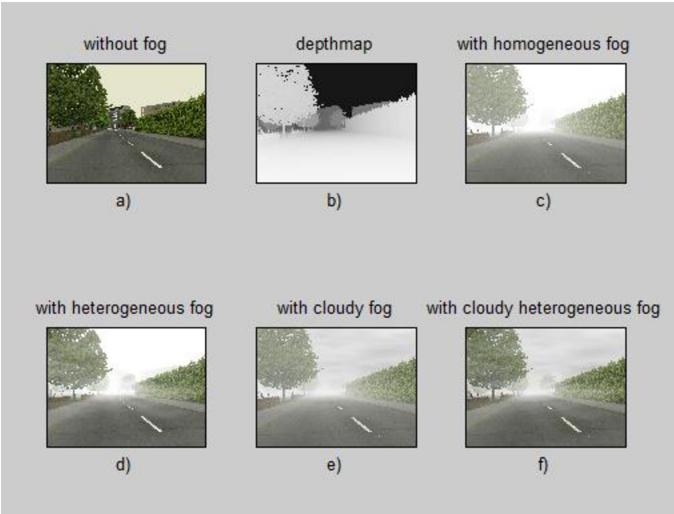

Figure 3: FRIDA haze image dataset

In this dataset various road images have been captured that has been used for simulation process. In this figure a) original road image captured without any fog b) depth map of the original image c) image that contain homogenous fog d) image that contain heterogeneous fog e) image that have cloudy and homogenous fog f) represents image that contain image with cloudy vision and heterogeneous fog.

In the experimental setup, various images have been used for image restoration using proposed module. In this module, image has been captured and darkness and transmission map has been measure for the image. After this, to prove proposed approach of image restoration is effective, comparative study has been done on the basis of performance evaluation parameters. Figure 4 shows image, that has been captured from the environment contain haze, has been refined using hybrid approach.

Input Image

Dark Image

Transmission Image

Haze Free Image

Figure 4: Images extracted using proposed model

Peak signal to noise ratio (PSNR)

PSNR analysis uses a standard mathematical model to measure an objective difference between two images. It estimates the quality of a reconstructed image with respect to an original image. The basic idea is to compute a single number that reflects the quality of the reconstructed image. Reconstructed images with higher PSNR are judged better. By using equation (6), PSNR value can be calculated [4].

$$PSNR = 10.\log_{10}\left(\frac{MAX_I^2}{MAE}\right) \quad (6)$$

Mean square error (MSE)

In statistics, the mean square error (MSE) / normalized error is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. By using equation (7), mean square error can be calculated [4].

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (7)$$

Table 1 represents value of PSNR for different image that contain homogenous fog in the entire image. PSNR represents similarity between ground truth images and enhanced images.

Table 1: PSNR value for image restoration using cloudy heterogeneous fog images

Image	HDCP Technique	Proposed Technique
U080-000001	32.46	57.43
U080-000002	31.02	56.25
U080-000003	31.07	56.67
U080-000004	32.56	57.86
U080-000005	33.27	57.96
U080-000006	31.72	56.78
U080-000007	31.84	57.26
U080-000008	30.68	56.18
U080-000009	30.36	56.06
U080-000010	31.28	57.32
U080-000011	31.59	57.34
U080-000012	32.59	58.13
U080-000013	31.02	57.42
U080-000014	31.43	57.14
U080-000015	31.09	56.61
U080-000016	30.66	56.50
U080-000017	32.67	58.23
U080-000018	31.31	56.57

Figure 5 represents comparison between proposed approach and Hybrid dark channel prior (HDCP) approach on the behalf of PSNR that has been computed for homogenous fog images. On the basis of graph, it can be said that proposed approach provides better PSNR than that of previous approach.

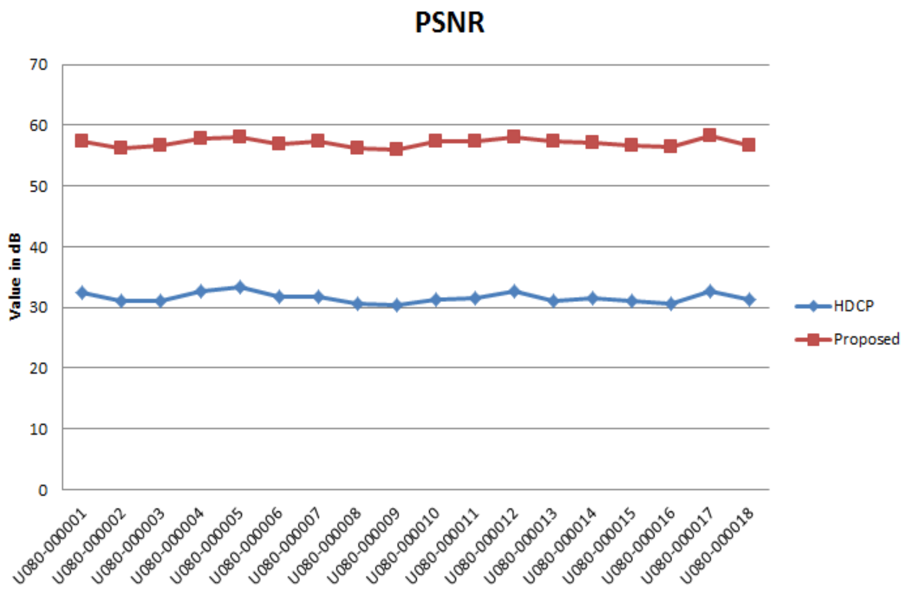

Figure 5: PSNR using various image restoration approaches

Table 2 represents values of mean square error under different images of homogenous fog that has been de-hazed using proposed approach. Comparative analysis has been done on the basis of MSE between proposed approach and hybrid dark channel prior (HDCP) approach.

Table 2: MSE for image restoration using cloudy heterogeneous fog images

Image	HDCP Technique	Proposed Technique
U080-000001	6.07	0.34
U080-000002	7.16	0.39
U080-000003	7.12	0.37
U080-000004	6.0	0.32
U080-000005	5.52	0.32
U080-000006	6.61	0.36
U080-000007	6.52	0.34
U080-000008	7.44	0.39
U080-000009	7.73	0.40
U080-000010	6.95	0.34
U080-000011	6.70	0.34

U080-000012	5.97	0.31
U080-000013	7.16	0.34
U080-000014	6.83	0.35
U080-000015	7.11	0.37
U080-000016	7.47	0.38
U080-000017	5.92	0.31
U080-000018	6.92	0.37

Figure 6 represents comparison between proposed approach and previous approach of haze removal. By analyzing figure 6, it can be said that MSE based on proposed approach provides better results than that of HDCP model.

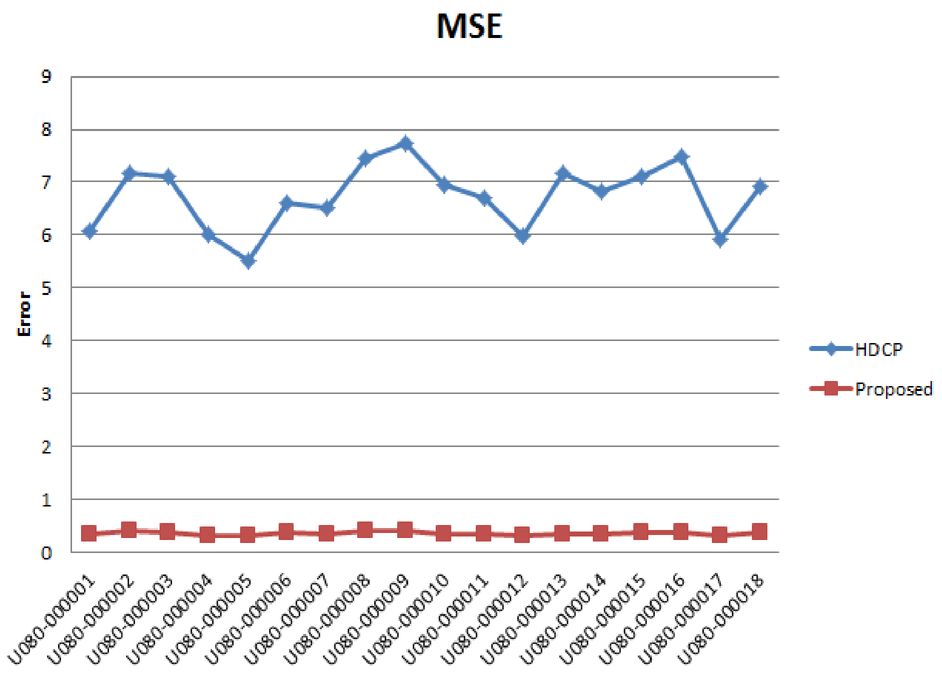

Figure 6: MSE using various image compression approaches

5. CONCLUSION

The images that have been captured from the pointed camera in different areas have been degraded due to absorption of luminance effects of light, sand particle absorption. These images that can cause problem in feature evaluation and scene visualization from a particular image for meaning full usage. In this paper hybrid HDCP and GA based approach has been proposed that has been used for image enhancement process for computation of different haze free components of the image using estimation of dark channel and transmission map. GA is used for better visualization of the image so that proper features can be evaluated. In the proposed work, desired approach provides much better result than that of previous approaches.

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