Haze Removal-using Colour Attenuation Prior

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***Abstract*——*Removing haze is always a problem when we are doing it with a single image .Now in this paper we are bringing a new simple method for haze removal called color attenuation prior. Here first of all we create a depth map, from a previously created linear model. From this we next find the transmission map so as to retrieve the depth information clearly. From this we can find the scene radiance easily and haze removal is done efficiently.*

Keywords— *Dehazing procedure, Defogging Image restoring procedure, Depth restoration procedure.*

I. INTRODUCTION

Usually the outdoor images taken are diminished in clarity as it is being scattered by the haze, fog and smoke particles. The automatic systems available now are not working properly as they are dependent on definition of input images and we are having degraded images, thus techniques to improve dehazing should be introduced to sought out this problem. We have many methods for dehazing actually, these methods can be classified in to two broad categories: Multiple image processing and single image processing. Usually we don't get multiple images thus the single image processing have been mostly attracted nowadays. It actually introduced an automated method to increase the contrast of image and helped in developing a cost function in framework of Markov Random Field. The second is method used to increase scene visibility and then recover a hazeless or haze free image contrasts. Previously dehazing was done with single image and then it developed to be working for multiple images. However haze removal is actually challenging as it is dependant on the depth information of the haze. If the input is single image then the case is under constrained. So many methods have been brought up using multiple images. Taking images at different degrees of polarization helps to remove haze using polarization methods. For depth information we actually require information from user input or from 3D models.

Now we see that haze removal using single image is more established and we use strong priors for this. Great progress is seen in dehazing a single image using physical model. By assuming that local contrast of haze free image is more than hazy image, Tan came up with a new method for maximizing local contrast based on Markov Random Field (MRF).It produces over saturated image .Next Fattal proposed a system to remove haze in a image by using the process of Independent component Analysis (ICA). It is time consuming and cannot be used for grayscale images. It has difficulty to deal with dense hazy images also. Now next based on dark-object subtraction technique and based on a large number of experiments on haze less images. He et al. discovered the Dark channel prior algorithm (DCP). In non sky patches we may see at least one color with very low intensity which is almost equal to zero. In this method we retrieve the haze free image by making use of scattering model. This method is very useful, but the problem is that it cannot be used for sky patches and it is computationally very intensive. Many other methods are now used to overcome this. When many methods were proposed for haze removal from single image, it is actually a very computationally intensive problem. The application of such method is very difficult practically. To overcome all these problems we have method introduced in this paper called the Haze removal using color attenuation prior. This is a very simple and efficient method to dehaze image faster with less complexity.

II. LITERATURE SURVEY

There are many researches taken place in the field of image processing for dehazing images. Wang et al. (2010) has explored haze removal depends on depth information. In this dark channel prior is applied to a selected region. Its demerit is that it cannot dehaze sky patches.

Yu, et al. (2011) brought another defogging method, which did dehazing of a single image by scattering model. Here, Weighted Least Squares (WLS) was optimized for edge-preserving smoothing, that to get the edges in the image. This does not require prior information.

Shual et al. (2012) brought a method to lower the problems in dark channel prior which did median filtering on dark channel. Thus a media function was made and more accurate filtering is applied. Here the mean square errors are reduced and fog free image is easily obtained.

Cheng et al. (2012) brought new method lowest channel prior which is simplified method of dark channel prior. Here transmission model is found and minimum filtering is done for lowest intensity. This method also uses trilateral filter based on the raised cosines function .Thus cost and efficiency of defogging is much more improved by this method.

Xu, et al. (2012) proposed a model on physical process of imaging in foggy weather. Here fast haze removal with trilateral filtering in dark priors is done. First the Atmospheric scattering model is found, then the transmission map if found to which trilateral filtering is applied. Thus dim images are not formed as a better transmission map formula is used.

Sahu ,et al. (2012) recommended a model for haze removal with color preservation. Firstly the image is converted from RGB to YrCr. Then key observation and intensity of image is computed.

Matlin, el al. (2012) discussed a method in which noise information is also included. An algorithm Black Matching and 3D filtering was used for dehazing. After pre-processing the algorithm is divided into two parts, Haze estimation and haze restoration. Last is the restoration step.

Kang, et al. (2012) proposed a method for rain removal of single image. The image is converted into low frequency and high frequency parts by trilateral filter. Then by using sparse coding and dictionary learning the high frequency parts are converted into rain and non rain component.

Yuk, et al. (2012) proposed a method for defogging videos. This method can efficiently defog the surveillance videos in heavy snowy weather. In this method dark channel prior or soft matting is used for estimation map. Then background/foreground algorithm is used to process the background frame.

Hitam, et al (2013) recommended a new method called mixture Contrast Limited Adaptive Histogram Equalization (CLAHE) color model that was brought for enhancement of under water image.

Selichi Serikawand Lu (2014) has discussed about under water image processing. Due to frequently attenuation of light in under water the image processing is very complicated in this case. There have been many methods for renovating and improving under water images.

S Serikawa and Lu (2014) proposed a easy prior based on distinction in attenuation among diverse channels. This was done by Balancing the inconsistency in attenuation and do join tri lateral filtering for filtering the transmission map.

III. PROPOSED METHOD

It is actually challenging to remove haze from image in computer. Human brain can far more easily detect the hazy areas without need of any additional information. So then we conducted a study on hazy images to make a prior for single hazy image. By our studies we found that brightness and saturation of our input hazy image vary with the concentration of haze. In a natural image for this study we see that the haze free regions have saturation more, the brightness here is actually moderate and the difference between the saturation and brightness is nearly zero. When haze comes in to play in the hazy image we see that the saturation decreases and the color of the haze decreases, the brightness increases here and thus the difference increases here .Here it is actually difficult to find the color of the scene, and the difference value is also higher here. From this we understood that the three properties: brightness saturation and difference vary greatly for images. The figure 1 shows the haze removal in proposed method.

Fig 1: Color attenuation prior

A. Demerits of existing system

The He et al. found Dark Channel Prior (DCP) that in non sky images there will be at least one color channel that has some pixels whose intensities are low and somewhat equal to zero. In this method the dehazing is done using atmospheric scattering model. It is efficient model. This system cannot handle sky images and is comparatively computationally intensive. Dark channel prior is actually used as a statistic for outdoor image haze removal.

B. System implementation

The colour attenuation prior method is very efficient for removing haze from single image. We first create a linear model to find the depth information and learn the parameters. Now we create a depth map from this. With the information from the depth map we can easily estimate the transmission and then restore the scene radiance by making use of atmospheric scattering model, thus we can remove the haze from our image. This method outdates all other algorithms for dehazing when comparing dehazing efficiency. Here we mainly make use of five modules for image dehazing and they are: Estimation of the depth information, Estimation of the transmission map, Estimation of atmospheric light, Scene radiance recovery and Experimental result analysis. In first module we have: When the haze dense is high the influence of the airlight will also increase. So this helps us to estimate the difference between the brightness and saturation so as to find the concentration of haze in the image. The difference found here increases as the concentration of the haze increases. Here there are two mechanisms (the direct attenuation and airlight) for dehazing under hazy weather. The direct attenuation caused reduction in the reflected light lead to low intensity of brightness. For understanding this we study the atmospheric scattering model. The intensity of the pixel present in the image decrease in multiplicative manner. So we see that brightness decrease with direct attenuation. The white or gray light, which is formed by the scattering of environmental light increases brightness and reduces saturation. As the concentration of the haze increases with the change of scene depth we can make a assumption that depth of the image is positively related to the concentration of the haze. So the depth map is created from the linear model. Now in the next module we have: we find the values of the pixels within the depth map, it is drawn from standard uniform distribution. Secondly we generate the random atmospheric light which has a coefficient value that is between 0.85 and 1.0 atmospheric light. The important advantage of this model is that it has edge preserving property. In the next module we have: The white objects that are seen a image have high value of brightness and low value of saturation so the system that is being proposed here tend to focus on the image object with white colour as distant but this may lead to inaccurate calculations of depth at times. To overcome this problem we have a solution that is to consider each pixel in the neighbourhood. Following the assumption that the image depth is locally constant we process the raw depth map here. The restored depth maps have dark colours in haze less regions and have light colours in the dense haze regions. We use guided filter imaging for smoothening the image. In the next module we have: we know about the depth of the image and the atmospheric light with that we can estimate the medium transmission and recover scene radiance. The scattering coefficient β, which is regarded as constant in homogenous regions actually represents the ability of unit volume of atmosphere to scatter light in all direction. β determines the intensity of the restored maps that the transmission maps with different β . We see that if we have small β, it leads to small transmission and corresponding resulting image still have hazy regions in the distant regions. If we have a too large β it may lead to over estimation of transmission. Therefore we actually prefer a moderate β. Usually we make use of β=1.0.In the last module we have to find mean square error peak signal to noise ratio and normalised cross correlation of image to check about the accuracy and efficiency of our result. Figure 2 shows the System architecture that is implemented here.

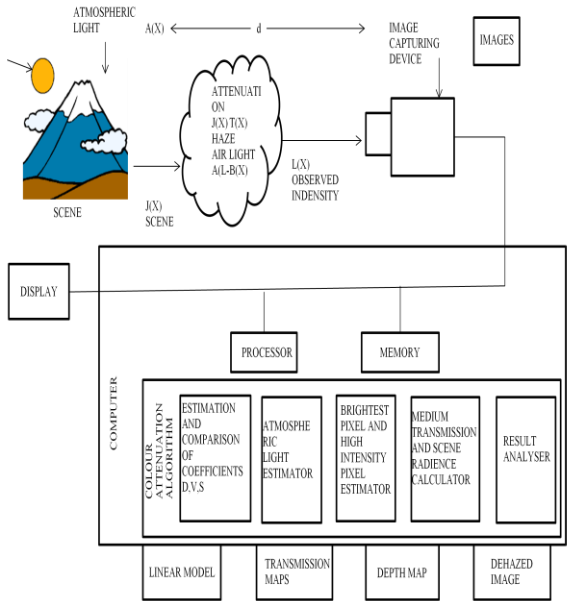

Fig 2: System Architecture of Proposed system

IV. ATMOSPHERIC SCATTERING MODEL

McCartnet proposed a scattering model to describe the hazy image which was expressed as follows:

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

$t(x) = e^{-\beta d(x)}$,

where I,J,K are 3-dimensional vectors in RGB, x is the position of pixel, β is the scattering coefficient which considered to be in homogenous condition ,also I is the hazy image, J is the scene radiance, A is the atmospheric light, t is the medium transmission which is calculated using second equation if depth is given. In Ideal case the depth is considered to be in the range 0 to +infinity. Thus,

$\mathbf{I}(x) = \mathbf{A},\ d(x) \to \infty$.

shows the intensity of pixel, where depth tends to infinity, can stand for atmospheric light A. If the value of depth is huge the transmission coefficient will be small, thus a threshold value, dthreshold, which must be found. This is done by:

I(x) = **A**, $d(x) \geq dthresold$

We must note that for distant objects the dthreshold value will be very large, thus accordingly if we consider all images taken too distant we have:

$d(x) \geq dthresold, x \in \{x|\forall y : d(y) \leq d(x)\}$

Thus A can be calculated by assumption using the following equation:

A = **I**$(x), x \in \{x|\forall y: d(y) \leq d(x)\}$.

Thus the dehazing was changed into a task of finding depth map. This restoration of the depth information of the hazy image is shown in the next section.

Fig 3: The above figure shows the transmission map.

Fig 4: Shows the position of atmospheric light.

V. COLOR ATTENUATION PRIOR

The phenomenon haze is usually caused by scattering of light that is caused by particles in the atmosphere. Thus the region where the scattering has occurred will have high brightness and low contrast or saturation. Thus we reach to the conclusion that the scene depth changes with density of haze and difference between brightness and saturation of image, that is:

$d(x) \propto c(x) \propto v(x) - s(x)$

where d is the scene depth, c is the density of haze, v is the brightness of the image, s is the saturation.

VI. RESTORING THE DEPTH

A. *The Linear Model Definition*

The concentration of haze can be found by creating a linear model which is the difference between brightness and saturation pixels. The is done by using the following equation:

$d(x) = \theta 0 + \theta 1 v(x) + \theta 2 s(x) + \varepsilon(x),$

Here v is the brightness component, s is the saturation component, $\varepsilon(x)$ the random variable representing the random error of the model, ε is the random image, x is the position within the image. $\theta 0$, $\theta 1$ and $\theta 2$ are unknown linear coefficients. The coefficient d is the scene depth to be found.

B. *Training data collection*

The training sample used here has hazy image and depth map. To learn the coefficients $\theta 0$, $\theta 1$ and $\theta 2$, the training data is important. As there is reliable method to measure depth of outdoor images, depth map is very difficult to obtain. The depth map for each image is found which has same size and from standard uniform distribution the values of pixels are drawn. Then random atmospheric light is generated A (k,k,k) where k is between 0.85 and 1.0.Thus the hazy image is transformed with atmospheric light and depth map.

C. *Depth information*

We can now restore the depth map from the depth information d, brightness v, and saturation. Now we compare each pixel with the pixels in the neighbourhood. But here we create the raw depth map considering white objects to be distant, so there may be inaccuracy in the dehazed image. This is a demerit of the proposed method.

Fig 5: The above figure shows the depth map recovered and the smoothened depth map.

VII. SCENE RADIANCE RECOVERY

The Scene Radiance Recovery is done we estimating scene radiance J by using the coefficients depth d and atmospheric light. The following equation is used for this purpose:

$J(x) = I(x) - At(x) + A = I(x) - A\, e^{-\beta d(x)} + A.$

The value of transmission t(x) is considered to be between 0.1 and 0.9 so that only less noise will be produced. Thus the equation used to recover the scene radiance is:

$$J(x) = I(x) - A \min\{\max\{e^{-\beta d(x)}, 0.1\}, 0.9\} + A$$

Here J is the dehazed image which is to be recovered. Here the coefficient β determines the intensity of the transmission map. β used here is considered to be a constant in homogeneous regions. If the value of β is considered very small the image will be hazy in distant regions, but if large value is considered it will be over transmission. Thus here β is considered to be 1.0, a moderate value.

VIII. EXPERIMENTAL RESULT ANALYSIS

In this module we check how efficient our dehazing algorithm is. To find it we use different images and we find their different values such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), and Normalised Cross Correlation of Image. The MSE or mean square deviation of an estimator measures the average of the squares of the dehazed image and original image and compares them. PSNR is also found to know the noise which has in our dehazed and original hazy image. The other method used for finding the errors and efficiency is Normalised Cross Correlation method in which the correlations between both estimator and dehazy image are found by cross checking both images. All these values are found for the comparison of dehazed and hazy image.

Fig 6: Haze removal done with experimental result analysis in MATLAB (2014a).

IX. CONCLUSION

In this paper we propose a method called colour attenuation prior algorithm which can do haze removal of single image very efficiently and easily. It is much better than the old methods used. In this method we find the depth map using a linear model. Then the transmission map is created with which depth information can be found very easily. Then the last step is scene radiance recovery from which we get the de hated image. The scene radiance recovery is done by the using the difference between saturation and the brightness of pixels. The experimental results show that the proposed method is very efficient and also has a very big merit, that is, it can dehaze sky images too. But the proposed method also has a demerit .The atmospheric coefficient used here is considered in homogenous that atmospheric condition. So this method cannot be used if the atmospheric condition is inhomogeneous.

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