FOG REMOVAL ALGORITHM USING ANISOTROPIC DIFFUSION AND HISTOGRAM STRETCHING

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Abstract*—Poor climate conditions which includes fog, mist, haze degrades atmospheric visibility. Image quality and efficiency of the computer vision algorithms like surveillance and object tracking degrades because of Low visibility.Thus, it's more critical to make vision algorithms more strong to the change in climate situations. Low visibility in poor climate is due to the suspension of water particles in surroundings .Light coming from the atmosphere and mild contemplated from an object are scattered by those water particles, resulting the low visibility of the scene. Fog removal algorithm is used to put off the fog from the foggy photograph/scene. The Existing Dark channel prior eliminates fog based on dark channel. But this technique fails when scene objects are similar to sky i.e. for sky image. In order to over this trouble we cross for anisotropic diffusion algorithm. Anisotropic Diffusion algorithm eliminates the fog from photograph and produces an image having better visibility as compared to existing techniques. This algorithm contains many steps like anisotropic diffusion, contrast enhancement and denoising. Proposed algorithm is independent of amount fog. The proposed method also applicable for gray scale images.Along with the RGB (red, blue and green) colour version, proposed algorithm can work for HSI version which further reduces the computation. Proposed algorithm has a huge application in tracking and navigation.

***Index Terms*—fog removal, Dark channel prior, Anisotropic Diffusion, Histogram Stretching.**

I. INTRODUCTION

Images or video suffer from loss of fine details under conditions poor weather conditions. Visibility restoration [1] refers to exclusive strategies that aim to lessen or cast off the degradation that have obtained while capturing the image. Because of parameters like blurring is due to digital camera misfocus, relative object-digital camera motion, relative atmospheric turbulence and numerous others. In this paper, we speak the degradations due to weather conditions like fog, haze, rain and snow in an image. The key purpose of deterioration of image details of outdoors scene in the mist and fog weather situation is for the maximum part the diffusing of a light before arriving at the digital camera because of suspended particles (e.g. Haze, dimness, smoke, impurities) within the climate. In foggy climate conditions, the picture contrast and shade are affected greatly. This degradation can be improved with the distance from digital camera to object. So the working condition of automatic monitoring system was affected greatly. To enhance strength and stability of the visual framework we use fog removal algorithms.

By koschmeider's law the fog image can be stated as

$$I(x) = J(x).t(x) + A\,(1-t(x))$$

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

Where I(x) is intensity of fog,

J(x) is the scene radiance of reference image,

A is the atmospheric light and

t(x) is transmission of light from the scene point to the camera

β is atmospheric scattering coefficient; d is the distance between the scene and the camera

The calculation of depth information is not done completely when we have single foggy image. Hence, for finding depth we require two images. So, many methods have been proposed which requires both reference image and input foggy image [2]. But these methods cannot be applied on a single image system. And also some algorithms will work efficiently even though we have only one foggy image. The proposed algorithm uses anisotropic diffusion which refines airlight and dark channel and requires pre and post processing algorithms for that we will use Histogram equalisation and Histogram stretching respectively.

This paper is listed as follows. In Section 2, Literature survey is mentioned. In section 3 proposed fog removal algorithms discussed. In section 4 Simulation and results are presented. Here performance of the proposed algorithm is compared with existing algorithms. Section 5 gives conclusion of this paper.

II. LITERATURE SURVEY

The distance between camera and object plays important role in degraded conditions. The calculation of Attenuation and airlight is also depend on this distance. The removal of fog requires estimation of depth map. We can't estimate this by using single image. Because of this, methods relays on multiple images are proposed. In [3] Schechner et al. does his work with polarising filters. But, the requirement of filters is a greater task and and not fit for the other databases. In recent years many methods have been proposed for the removal of fog using single image.

In [4] Fattal extended his work based on independent component analysis. This method relays on the colour information in the input foggy image so this is not opted for grey scale images. This algorithm fails when the image is degraded by huge amount of fog.

He et al. [5] proposed a method based on dark channel prior and soft matting. Here by using dark channel prior we can calculate airlight map and refined by soft matting. When scene objects are bright like that of sky, the limitations of this method are not valid and it also takes more time complexity for the elimination of fog from the image.

Xu, et al. (2009) [6] has examined that because of fog the images are degraded and results to form poor contrast. To remove the effect of fog from the input foggy image, he proposed Contrast limited adaptive histogram equalization (CLAHE).Here the limitation of CLAHE is that output image suffers blurring after restoration also cannot remove fog effectively.

The existing Dark channel prior removes fog by estimating local contrast. This method fails when the image contains pictures as like as sky .The output image of this algorithm has lower contrast than that of input image, and also it takes more time to process the image.

III. PROPOSED WORK

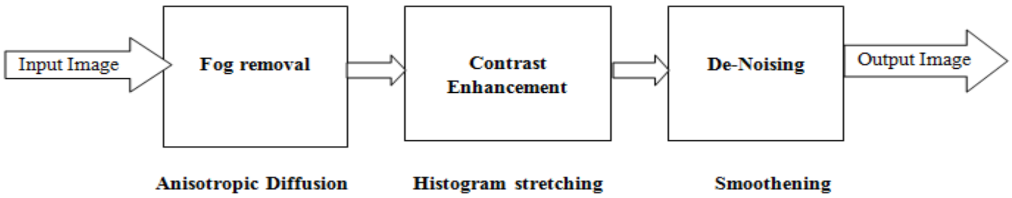


Fig 1: Block diagram of proposed Fog removal algorithm

The proposed method has three phases, first Anisotropic diffusion, second Histogram Stretching and De-noising. The Anisotropic Diffusion the foggy image converted into smoothed image. The algorithm performs smoothing by preserving edge information. Thus, where edge information is high, less smoothing or diffusion required. According to Persona and Malik [7], we have two diffusion functions stated below. Where D is the Edge information and C is the conduction coefficient of the diffusion process.

$$C=e^{-D^2}$$

$$C=\frac{1}{1+D^2}$$

Anisotropic diffusion has preserved edges while smoothing. It is due to the fact that instead of considering diffusion and edge detection, two independent processes, here both processes interact in one single process. Here, an independent process is applied which reduces the diffusivity at those pixels which have to be edges. First the differential equations are calculated and the gradient along N, S, E, W, NE, SE, SW, and NW are calculated. After that we are applying convolutions masks for the image and gradient values. By using Diffusion coefficient we can calculate conduction coefficient. The higher contrast pixel is compare with all other neighbourhood pixel if the neighbourhood pixel is less than higher contrast pixel smoothening will be done because the pixel is not degraded by noise.

$$I_o(X, y)=I_t(x,y)+\frac{1}{4}\sum_i^4 C(x, y)\, \nabla I_t{}^i(x,y)$$

Histogram Stretching:

Histogram stretching is used to enhance the contrast of the degraded image. It aims to increase the dynamic range of an image (Contrast enhancement). Steps involved in this are mentioned below.

- **i.** Obtain the inputs image from the anisotropic diffusion.
- **ii.** Pre-process the inputs: If the size of image is dividing with the number of tiles, then pad rows and columns to the image. Else go to step3.
- **iii.** Calculate histograms for each tile and determine real clip limit from the normalized value
- **iv.** Histogram values of each tile are compared with real clip limit. If histogram values are more than clip limit then replace the value with clip limit, and when it is less then add one to the histogram value.
- **v.** Process each contextual region (tile) thus producing gray level mappings. Interpolate gray level mappings in order to assemble final image.

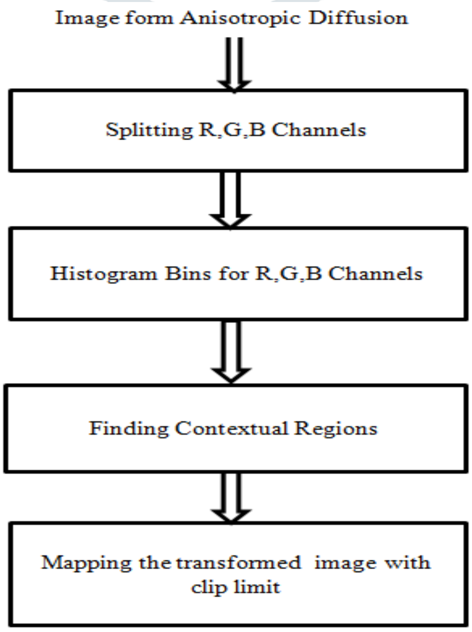


Fig 2: steps involved in Histogram stretching

De-Noising:

The proposed method uses Median filter for de-noising. For the original image, neighbouring pixels has strong correlation and the change between brightness and saturation values smaller. The pixel is said to be degraded by the noise when the value of a pixel is greater or less than the value in the neighbourhood, otherwise, the pixel is an not degraded. In the mask, max is the maximum value, min is the minimum value, average is the average value, med is the median value of gray levels. If f(x, y) is the central value of the mask, n is the size of the mask. The adaptive filtering requires two steps:

Step1: Alter the size of mask when it is even

1. Initialization: let n =3;
2. Computation: A1=med - min, A2= med-max
3. Judgment: if A1 > 0 and A2 < 0, then go to step 2;
   If not, increase the mask size, let n =n+ 2 and turn to (2).

Step 2: median filtering.

2. Colour Attenuation Prior (CAP)

In the proposed method the noise is amplified highly to reduce this we go for CAP. To recognise or remove the fog from a single foggy image is a challenging task in computer vision, because it contains little information about the scene structure is available, In that situations Colour Attenuation Prior stands best. It has four steps

- **i.** Scene depth
- **ii.** Transmission map
- **iii.** Atmospheric estimation
- **iv.** Scene recovery

i) Scene depth

In this we are identifying the concentration of fog in the image. Difference between brightness and saturation gives the concentration of fog present in the image.

$d(x) = \theta_0 + \theta_1 v(x) + \theta_2\, s(x) + \varepsilon(x)$

Where x-position within the image, d- scene depth, v-brightness component of the foggy image, s-saturation component, θ_0, θ_1, θ_2 are the linear coefficients, ε(x) is a random variable.

ii) Transmission map

Transmission map tells that the parts where we have to remove fog from foggy image. From the scene depth transmission map is calculated.

t (x) =exp (-β*d(x))

β- Constant

d (x)-Scene depth

iii) Atmospheric estimation

By using Atmospheric estimation we can recognise the brightest pixel in the image. Based on this 'A' value we can recognise the Scene.

iv) Scene Recovery

Here the fog is removed from the input foggy image.

Output image = $\frac{\text{inputimage}-A}{T(x)} + A$

A-Atmospheric value

T(x)-transmission map

IV. SIMULATION AND RESULTS:

The Simulation results are shown for the images given below. Dark Channel Prior and Anisotropic Diffusion and Colour Attenuation methods are compared by different parameters for this image.

a) MEAN SQUARE ERROR

The MSE gives the error between input and output images. The MSE Should be minimum which is the indication of the foggy image restored properly.

MSE = $\frac{1}{MN}\sum_{n=1}{}^{M}\sum_{m=1}{}^{N}[f(n,m) - g(n,m)]^2$

b) PEAK-SIGNAL TO NOISE-RATIO

The PSNR should be high it gives us better degraded image has been reconstructed to match the original image.

PSNR=20 $\log_{10}(\frac{MAX_f}{\sqrt{MSE}})$

c) ENTROPY

Entropy is a measure of degree of randomness between the output texture and input texture. Entropy is stated as

E = -$\sum p(x_i)\, log_2 p(x_i))$

d) IMAGE QUALITY INDEX

Image quality index shows how the output image improved compared with the degraded image. So for a good algorithm IQI must be high.

$$Q = \frac{1}{N \times M}\sum_{i=1}^{N}\sum_{j=1}^{M} Q_{ij}$$

Where, N=No. of columns in image, M= No. of rows in image

Where, Qij is defined as,

$$Q_{ij} = \frac{4\sigma_{xy}\overline{x}\overline{y}}{(\overline{x}^2 + \overline{y}^2)(\sigma_x^2 + \sigma_y^2)}$$

Where,

σ_x^2 is variance of input image, σ_x^2 is variance of output image

σ_{xy} is co-variance of input and output image


Image-1


Image-2


Image-3


Image-4

Fig3: Different type of images for comparing results

Fig4: MSE Comparison

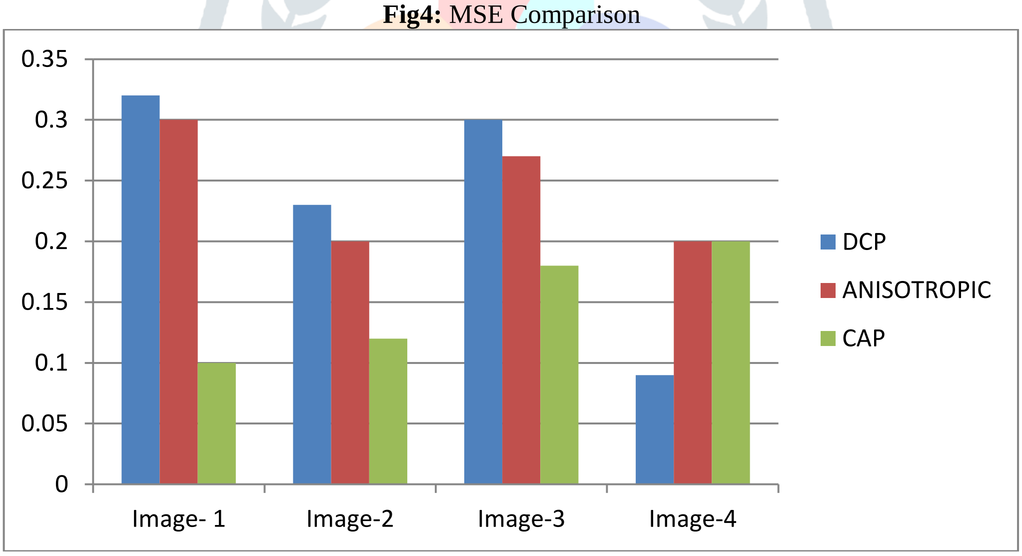


Fig5: PSNR Comparison

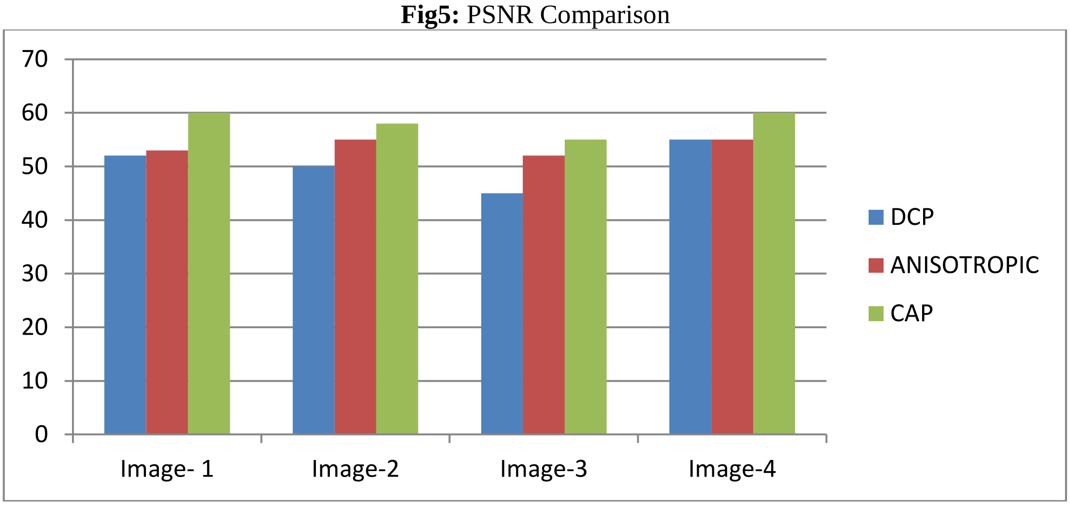


Fig6: Entropy Comparison

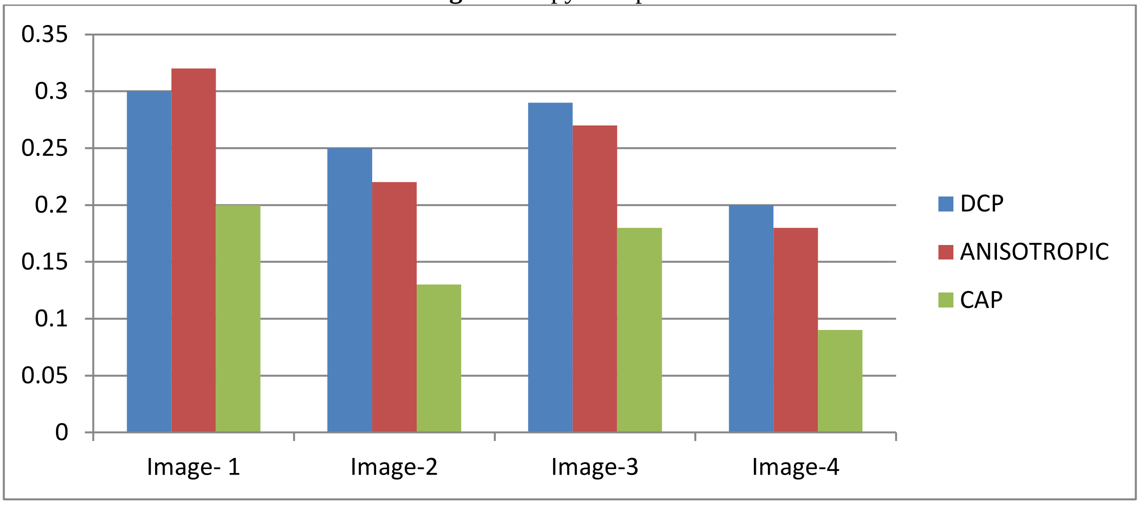
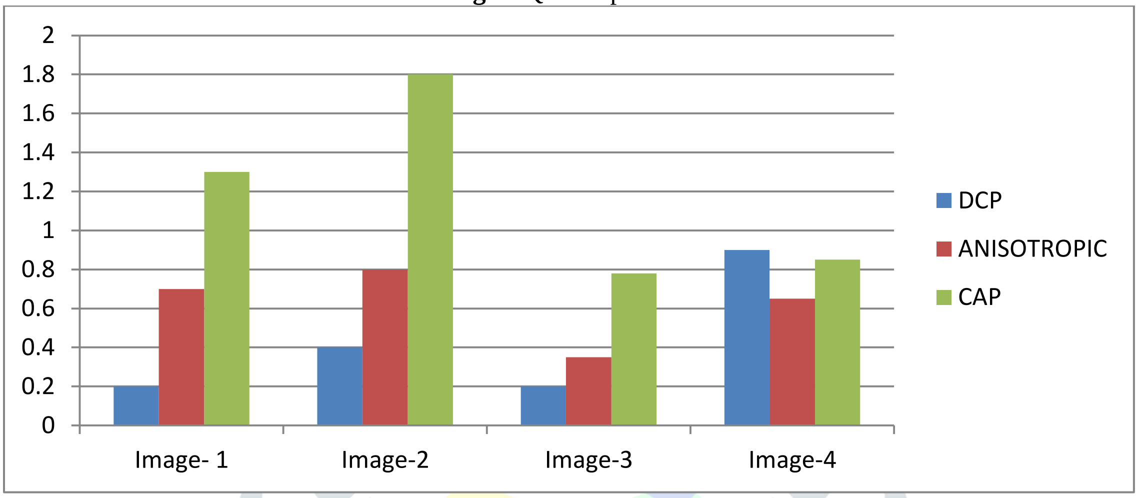


Fig7: IQI Comparison



V. CONCLUSION

Fog removal algorithms using Anisotropic Diffusion and Colour attenuation prior are proposed in this paper. These algorithms depend only on the foggy image and can be applied for colour and gray scale images. From the results we will conclude that Colour Attenuation Prior enhances foggy image better than prior state of the art algorithms.CAP algorithm takes less time complexity as compared with Anisotropic Diffusion and Dark channel Prior algorithms. These algorithms cannot degrade in their performance if the image contains dense fog. In the simulation results we compared MSE, PSNR, Entropy and Image Quality Index. From results we conclude that improvement in the Output image as compared existing methods.

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