IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 8, August 2016

An Algorithm for Enhancing and De-hazing Videos

Anna Mathew[1], Therese Yamuna Mahesh[2]

PG Scholar, ECE, AJCE, Kanjirappally, India [1]

Assistant Professor, ECE, AJCE, Kanjirappally, India [2]

Abstract: Haze removal from video is a composite process as the visual effect of haze are impenetrable. A haze removal method is put forward here which use Koschmiedars law in lack of prior. A boundary restricted smoothing technique is also used here. Image filter guided by weight is used which filters the out-turn based on details contributed by guidance image. A transmission map is determined and is employed to re-impose the haze free video. Power law transformation is used to enhance the quality of the output images.

Keywords: Koschmiedars law, Edge preserving smoothing technique, Image filter guided by weight, Power law transformation.

I. INTRODUCTION

Haze is an airspace occurrence where dust, smog and different withered fragments obscure the transparency of the sky. The usual lighting State of a view during daytime is that the sun is high in the airspace and cast light upon an object, from which reflected sunlight descend into the eye. There are thus two light rays involved in the process, the illumination ray (I-ray) travels from the sun to the object and the observation ray (O-ray) travels from object to the eye.In an air, light scattering alterboth the rays, I-ray and the O-ray - there can be in-scattering and out-scattering of light. Under overcast haze layerthere are three basic physical scattering mechanisms which can take place: Rayleigh, Mie and diffuse scattering.

On very tiny particles, Rayleigh scattering occurs. It is much powerful for blue light rather than red light and it has no preferred direction. Rayleigh in-scattering on air causes the blue clear sky occurs due to whatever point in the sky we look at, there's blue light from the sun scattered into the O-ray during the day.Mie scattering occurs on larger particles, usually water droplets (wet haze). It has no colordependence, but is much stronger at small angles than at large angles, i.e. Mie-scattered light almost keeps its original direction.

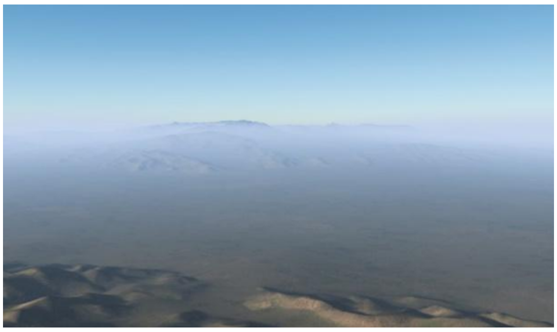

Fig. 1.A complex mixture of different haze layers

Mie scattering is the reason the sun is often surrounded by a bright halo. Diffuse scattering is not really a distinct elementary process but the effect of multiple scattering processes over which direction and color specific dependence is blurred, hence diffuse scattering has no color or directional dependence. Consider an overcast cloud layer - clearly there is light coming through, but it has no preferred direction and its color is a rather uniform blue grey.

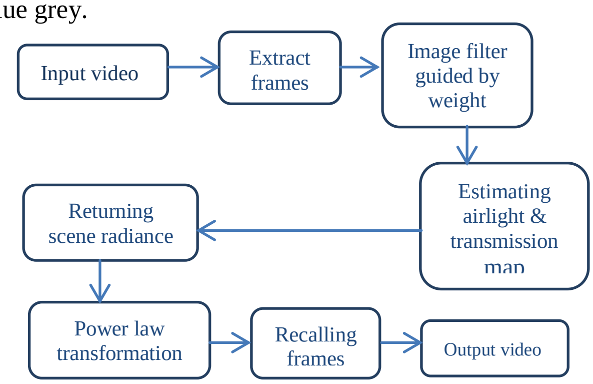

Fig. 2.Block diagram of haze removal

In this paper an algorithm is proposed where frames are extracted from the video. Image filter guided by weight is used to break down the haze frame’s dark channel. The frame used as guidance is calculated using the color channel of haze frame which is minimal. Koschmiedars law is used to model the haze image. Atmospheric light and transmission map of the haze frames are calculated and using these values, the scene brightness or radiance is calculated. Many de hazing algorithms have been proposed earlier. The algorithms before used multiple image of the same scene to recover the de-hazed image. This made it difficult to be used in real time applications. For example, one of the algorithms used the knowledge which is prior known, of the scene for de-hazing the

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frame.The factor which limits the application of these algorithms is that the requirement of multiple images which provide the extra information used to calculate the scene depth and thus de-haze the frame. Recent algorithms mostly give focus on image de-hazing sing a single frame, which require informationabout depth of the frame or assumptions on haze-free images and haze. For example, Fattal [4] in his method assumed that the reflected light from a particle has similar vector direction.

Tan [3] used an algorithm in which contrasts of haze and haze-free frames are compared. In recent works, assuming prior dark channel was proposed to estimate the information about depth based on comparing the clean frame and hazy frame [5]. In that method, they found out the depth of the objectin a hazy frame considering the prior dark channel, assuming that lower pixel value is contained in at least one of the color channels. To improve the depths of objects, alpha matting is also applied.

II. IMAGE FILTER GUIDED BY WEIGHT

Image filter guided by weight is the enhancement technique in spatial domain in which the output of filtering is the guidance image's linear transform. When the output pixels value is calculated, it also considers the probability of a region in the spatial neighbourhood of frame used as guidance. When bilateral filters are used gradient reversal is observed, which can be avoided by using filters guided by weight, having smoothing properties which preserve edge. When compared to filter that is bilateral, it performs well at edge pixels. Filter guided by weight have many improved function other than smoothing. Image used as guidance makes the output after filtering well-structured and low smoothed when compared to input. It also transfers the structure of the image used as guidance to the output after filtering, which enables new applications in filtering like guided featheringand haze removal. Filter guided by weightalso gives a good option for applications in real time in HD filtering and for linear time algorithm it works fast and in a non-approximation manner. Therefore, it is one of the fastest filters which is edge preserving.

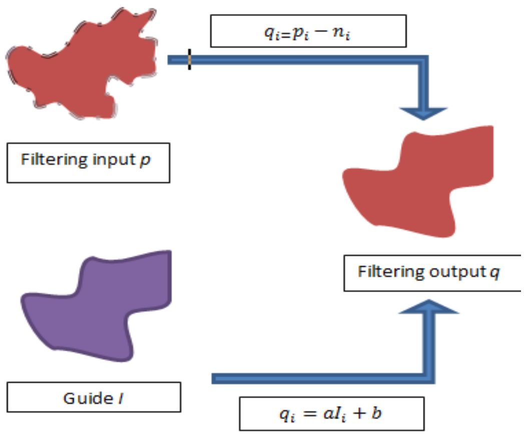

Fig. 3.Image of filtering process

Algorithm of Guided Filter

1. Image given as inputGwhich is considered as guidance image.
2. Make input image In equal to the guidance image G.
3. Input the assumed values of r and ϵ.
4. Calculate the mean

mean G = mean (G)
mean In = mean (In)
corr G = mean (G.* G)
corrIp = mean (G.* In)

5. Calculate the covariance and variance

var G = corr G - mean G. * mean G
covIp = corrIp - mean G. * mean In

6. Calculate the value of linear coefficients.

c = covIp / (var G + ϵ.)
d = mean In - c. * mean G

7. Calculate the mean of a and b

mean c = mean (c)
mean d = mean (d)

8. Obtain the image after filtering using mean of c and d

out = mean c . * G+ mean d

In this section, the equation of the filter guided by weight is considered. Main assumption of filterguided by weight is a model which is linear, between the output image that is filtered given by out and the image taken as guidance G, considering input image Inas illustratedin fig.3 that gives an idea of the filtering process guided by weight.

The output frame obtained is the linear transform of frame used as guidance in a window given as $W_r(p')$where $W_r(p')$ is the square window that have a radius r and which is centred at the pixelp'. The two fixed variables in the window $W_r(p')$ are $x_{p'}$and $y_{p'}$. The equation for windowing is given as

$$q(p) = x_{p'}I(p) + y_{p'}, \forall p \in W_r(p') \quad (1)$$

III.MODELLING OF HAZE FRAME

A frame filled with haze is in general modelled according to the Koschmiedars law by

$$K_C(y) = P_C(y)t(p) + B_C(1 - t(p)) \qquad (2)$$

Where c, an element of the set {r, g, b} is an index in colour channel, K_C is a frame containing haze, P_C is a frame free of haze, $B_C$is the global air light, and tdescribes the transmission medium, the amount of the light rays that reaches the camera and which are not scattered. The term given by$P_C(y)t(p)$shows the scene radiance, the direct attenuation and also gives its decay in the medium. The term $B_C(1 - t(p))$is called as air-light. Air-light is caused due to scattered light and leads to consequence like scene colour shift. The transmission $t(p)$when a homogenous atmosphere is considered can be expressed as:

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$$t(p) = e - \alpha d(p) \quad (3)$$

Where α is thecoefficient of scattering of light in the atmosphere. It implies that the frame radiance is exponentially attenuated with the depth d(p)of the scene. The termα is a function that is monotonically rising degree of haze.

When considering patches with lower size, the value of $t(p)$ is considered as not varying. If the gradient contrast field is taken into account, the frame can be calculated by using equation:

$$\|\nabla K_C(y)\| = \|t(p)\nabla P_C(y) + (1 - t(p))\nabla B_C\| = t(p)\|\nabla P_C(y)\| \quad (4)$$

The range of $t(p)$ is taken between 0 and 1. This shows that P_C which is the frame containing haze have reduced contrast than $K_C$which is the haze-free frame. When depth of the scene is compared, the contrast is exponentially reduced. The depth of the framed(p) is used to determine the haze in the frame that makes it harder for the haze free frame's restoration from the frame containing haze. The regaining of the de-hazed frame is given by:

$$P_c(y) = K_c(y) + \left(\frac{1}{t(p)-1}\right)(K_c(y) - B_C) \quad (5)$$

Where amplification factor is given as$\left(\frac{1}{t(p)-1}\right)$ which changes spatially andthe detailed layer is given by $(K_c(y) - B_C)$.

IV.HAZE FRAME'S SIMPLIFIED DARK CHANNEL

A new method to remove haze is formed from initial haze frame's simplified dark channel and de-hazed frame. Let $B_s(p)$ be defined by

$$B_s(p) = \min\{B_r, B_g, B_b\} \quad (6)$$

Similarly K_s is given as

$$K_s(y) = \min\{K_r(y), K_g(y), K_b(y)\} \quad (7)$$

And P_s is given as

$$P_s(y) = \min\{P_r(y), P_g(y), P_b(y)\} \quad (8)$$

Here K_s and P_s are the minimal colour factors of K and P respectively. The edge preserving decomposition method used here use a hierarchical search method to determine the global atmospheric light$B_c(c \in \{r, g, b\})$.
The factor $B_c(c \in \{r, g, b\})$ is considered as the brightest colour in an image having haze since the haze cause the bright colour. The guidance image W is calculated using K_C.

$$W(p) = B_s - K_s(p) \quad (9)$$

The scene radiance $P_c(y)$is calculated using the optimum value of $t(p)$

$$P_c(y) = \frac{1}{t^*(p)}(K_c(p) - B_c) + B_c \quad (10)$$

V.POWER LAW TRANSFORMATION

Power law transformation is used for contrast enhancement of the de-hazed image. Basic form of power law transformation is given as

$$PL = Cr^{\gamma} \quad (11)$$

Where C and r are positive constants.Similar to log transformation, power law curves with $\gamma < 1$.

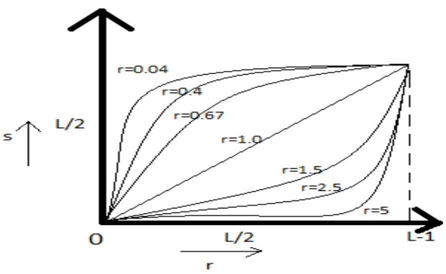

Fig. 4.Curves formed by power law transformation

Fig 4 shows the curves formed by power law transformation as the value of r is varied. When the value of γ is less than one, a range of dark input values is mapped into a range of output values. For higher values of input, the opposite is true.

VI.RESULT

The results after carrying out the experiment in MATLAB are as shown in fig 5 and fig 6.

Fig. 5.Frame from video containing haze

Fig. 6.Frame from video after haze removal

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In the algorithm the initial frame is resized to reduce the computation time. As the resize factor changes, the resolution and time taken for computation varies. The variation in the computation time is as shown in Table 1. In the table, the ratings of visual analysis are also included. Visual analysis was conducted among 6 persons with different rescaling factor and was rated in a scale of one to five.

TABLE I
TIME TAKEN AND THE VISUAL ANALYSIS

Input video/frame	Rescaling factor	Time taken(sec)	Visual analysis in a scale of 5
	0.2	270	2
	0.4	4200	3
	0.8	14400	5

VII.CONCLUSION

A de-hazing algorithm is presented here which uses an only a single frame for processing. Weight guided image filter is used here which uses a guidance image to decompose the haze frames. Using estimated transmission map and air light, the de-hazing is carried out. This algorithm can be used in real time purposes for example driving assistance, security surveillance etc. Further improvements can be made in reducing the time consumed for execution of the algorithm.

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