iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VIII **Month of publication:** August 2017

DOI: http://doi.org/10.22214/ijraset.2017.8229

A Comprehensive Study on Various Haze Removal and Visibility Restoration Techniques for Image Processing

Meenu[1], V. K. Panchal[2], Sandeep Kumar[3]
[1]*Research Scholar, Mewar University, Chittorgarh, Rajasthan, India*
[2]*Founder President, Computational Intelligence Research Group, New Delhi, India*
[3]*Bhagwant University, Ajmer, Rajasthan, India*

Abstract: Haze removal technique refer to the procedure attempt to remove the haze from a hazy/degraded images effected by bad weather. Many researchers have proposed various method/Algorithms for improvement in the hazed images and get the better results using various restoration techniques. In this paper we have analyze various hazed removal techniques like Dark Chanel Prior method (DCP), Contrast limited adaptive histogram equalization (CLAHE). We also observed that a large research space exist for haze removal by combining nature inspired algorithms like PSO, ABC with the Techniques in vogue.
Keywords: Haze Detection, Dark Channel Prior, Image Processing, Visibility Restoration, Dehazzing

I. INTRODUCTION

Most of the time the quality of the outdoor image is degraded due to atmospheric weather condition. Hazed image fig1. (a)[4] is the result of atmospheric absorption and scattering of air light. Such images are captured under the bad visibility or bad weather condition. Haze free image shown in fig1. (b) The degraded images lose contrast due to attenuation and color fidelity due to increase the whiteness (air light) in the scene and Therefore haze removal is a challenging problem because the haze is dependent on the unknown depth information. During the past decade many researcher have explored many methods by using single or multiple images and some more constraints are obtained of multiple images of the same scene under different weather condition .

A dehazing method can significantly increase the visibility of the scene and correct the color shift caused by air light which are the phenomena of visibility restoration. A haze free image is more visually pleasing.

(a) (b)

Figure 1(a): Hazed Image and 1 (b): Haze Free Image

This paper explores the various dehazing methods, is divided into the following sections. following Introduction, Section 2. present the Literature survey : a view on different methods/Algorithms ; Section 3. represents detailed description of method ; Section 4. gives the comparison between various methods; Section 5. Summarizes the study ; Section 6 Gives future direction.

II. LITERATURE SURVEY

It is significant factor continuing to the haze removal is scene depth analysis. Several different atmospheric scattering or "haze" detection and removal technique has been reported in the literature survey. Which are summarily describe in this section.

Schechner, Y et al (2001) present an approach based on polarization of air light scattered by atmospheric particle this method efficiently remove the haze by effectively using the polarization filter to to remove the haze .[15]

Dal Moro at el (2007) proposed. A two-step procedure for haze removed using Hot-based haze removed algorithm was originally proposed by Zhang et al (2002) but hot based technique was not efficient for all type of surface such as water snow soil etc. This approach is efficient only for vegetated areas. Then Dal Moro improve in two step procedure and cover the water area also [10].

Bin Xie et al (2010) has been proposed an improved image dehazing algorithm using dark channel prior and Multi-Scale Retinex. In the proposed algorithm Multi- Scale Retinex algorithm implemented on the luminance component in YCbCr space .By combining with the haze image model and the dark channel prior, improve a high quality haze-free image compared with the original algorithm. Basic advantage of this algorithm is no user interaction is needed and much faster as compared with original [16].

He et al (2011) proposes an effective haze removal prior using dark Chanel prior method from a single input image. This method is satisfies for outdoor haze free images. It is based on key observation. This method is haze imaging model is used to directly estimate thickness of haze in this approach most of take local region is covered by neglecting the sky region because dark pixel can directly provide the accurate estimation of haze transmission [4].

S. Mohamed MansoorRoomi et al (2012) proposed method to estimate air light map on human visual model Based. Then optimal air light is estimated using ABC (Artificial bee colony optimization) and restore the dehazed image and also compare the result with particle swarm optimization technique [9].

Sos agaian et al (2013) has been proposed an algorithm for haze removal of different hazing image like from foggy and Smokey images. Optimized histogram mapping function is applied on original image. Then apply transformation from RGB color to HSV use the CLAHE enhancement approached on V channel at the end measurement for image enhancement is also introduced in which result is compared with NASA ratline algorithm [1].

Arora T et al (2014) has been proposed a new Integrated Dark Channel Prior (IDCP) method by the combination of Dark Channel Prior (DCP), Contrast limited adaptive histogram equalization (CLAHE) and Gama correction method.[3] main scope of this algorithm is improve the accuracy of Intelligent Transportation system (ITS).

Ansia et al(2014) has proposed a method focus on contrast based single image dehazing . A white balancing is used to annihilate the color [2]. The saliency map is estimated to determine the discernible region of image. Then morphological operator is used to remove the specularities. Then enhance CLAHE approach in used to enhance the color contrast this method produce better result for homogenous haze image.

JunMaro et al (2014) has develop a function for estimating the haze degree for automatic detection of fogy image with different haze degree value this method is useful for usual for weather conditions in video surveillance driver assistance and optical remote sensing [8].

Xiaoqiang et al (2014) has been proposed an algorithm to reduce the effect of the haze on outdoor traffic video monitoring system by using the dark channel prior method to remove haze and then apply the adaptive histogram equalization to enhance the contrast and brightens of the images and at end transmission platform was designed for high performance image acquisition by using the FPGA (field programmable gate array) as the core processer. Effectively enhance the image contrast and color definition of traffic video monitoring systems [6].

Harpoonamdeep Kaur et al (2014) has modified the Dark channel Prior **method** to dehaze the image by using the Gabor filter with CLAHE method. Gabor filter is used to reduce the noise ratio and effectively reduce the noise from the degraded image. using DCP, CLAHE method enhance the result of hazed images [7].

Qingsong Zhu et al (2015) has been propose a novel linear color attenuation prior based on the difference between the brightness and the saturation of the pixel within the hazy image. Scene depth brightness and saturation has been estimated and depth information is recovered using supervised learning method [18].

Manpreet et al (2015) compare his study of various haze/fog removal algorithm/Technique for image enhancement and conclude that the join trilateral filer based approach is more significant over the available techniques [14].

III. PERCEPTIBILITY REFORMATION TECHNIQUES

This block signifies the various visibility enhancement technique used for removing haze and this will help to researchers to view about the techniques widely used in image processing for removing haze.

A. Prior Based Method

Where we concentrate on specific pixel for removing haze for statistic outdoor images by different air light estimation method there are different method which used with different priorities on the bases of brightness in images.

1) *Dark Channel Prior Method:* Dark channel prior ***is proposed by He.K et al (2011)*** a prior for haze removal and the estimation of atmospheric light in the dehazed image to get the more accurate result. Limitation of this technique is only utilized for non sky region in which some pixels are often very low intensity of at least one color (RGB) channel. As shown in fig 1 (a), (b) [4]. Dark channel is mainly due to three factors.

a) Shadow of object (e.g. Shadow of Tree, car).

b) Colorful object or surface (e.g. Green Tree , Red , Yellow Surface)

c) Dark object surfaces (e.g. Stone).

Usually outdoor images are colorful and with full of shadows. The Dark channel of these images is dark. We can see that about 75 percent of the pixels in the dark channel have zero intensity value and 90 percent of the pixels is below 25 intensity value. The intensity of the dark channel is a rough approximation of the thickness of the haze. A hazed image is described as equation (1).

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

Where I is the Intensity, J is the scene radiance, A is the global atmospheric light, and t is the medium transmission describing the portion of light that is not scattered and reach the camera.

Dark Channel of an arbitrary image is described as in equation (2).

$$Jdark(x) = miny€\Omega(x)\ (minc€(r,g,b)J^c(y)) \tag{2}$$

Where J^c is a color channel of J and $\Omega(x)$ is a local patch centered at X. The intensity of Jdark is low and tends to zero.
Basically a dark channel prior can be used to estimate transmission t(x) and for air light estimation for preceding the solution.

2) *Integrated Dark Chanel Prior:* Integrated Dark Channel Prior (IDCP) proposed by Tarun Arora et al (2014) which is the Combination of Dark Channel Prior (DCP), Contrast limited adaptive histogram equalization (CLAHE) and Gama correction method. This Method is used for degraded images with various factors like for, mist and haze. In the Process of this algorithm first read the image, second apply CLAHE on RGB Color Space. Third step apply the DCP for estimation of air light in the dehazed image in Fourth Step apply the Gamma Correction method is applied as a post processing operation to enhance the brightness of the system [3].

3) *Color Attenuation Prior:* Color attenuation prior was proposed by Qingsong Zhu novel color attenuation prior for single image dehazing. This prior can help to create a linear model for the scene depth of the hazy image. By learning the parameters of the method, the bridge between the hazy image and its corresponding depth map is built effectively. With the recovered depth information, we can easily remove the haze from a single hazy image based on the difference between the brightness and saturation of pixel within the hazy image . In this method depth information is covered by assuming the scene depth and linear model is created as equation (3).

$$d(x) = \theta_0 + \theta_1 v(x) + \theta_2 S(x) \tag{3}$$

Where'd' is depth, 'v' is brightness,'s' is saturation component which is linear and θ_0 , θ_1, θ_2 are unknown linear coefficients One of the most important advantages of this model is that it has the edge-preserving property. In this method median filter is used for edge preservation experimental result show the effective result. [18]

4) *Improved Dark Channel:* The dark channel prior developed by Haoran Xu for dehazing the single image by combining the bilateral filtering with dark channel prior in this algorithm start with the atmospheric scattering model then estimate the transmission map by using DCP combine with grayscale to extract refine transmission map by using the fast bilateral filter . This algorithm has a fast execution speed then original DCP algorithm and greatly improves visual appearance as shown in fig : 2 (a) , (b) [17].

(a)

(b)

Figure 2 (a): show the H.E Result and 2 (b) is the result of Improve DCP

B. Swarm Intelligence Based Methods

Swarm Intelligence based methods are consist those algorithm which are inspired by the nature for enhance the Image.

1) *Artificial Bee Colony Optimization Method:* This novel algorithm is proposed by Mohamed MansoorRoomi.S for improving the visibility of image degraded by haze. Estimation of air light is evaluated by artificial bee colony optimization method. In Artificial bee colony optimization algorithm the position of food source represent the possible solution of optimization problem and the nectar amount of food source correspond to the quality of the association solution. The number of the employed bees or the onlooker bees is the equal to the number of solution in the population. An onlooker bee chooses a food depending on the probability value association with the food source [9] equation (4).

$$\mathrm{Pi} = \frac{\mathrm{fit}_i}{\sum_{n=1}^{SN} \mathrm{fit}_n} \quad (4)$$

Where fit_i is the fitness value of the solution I evaluated by its employed bee, which is proportional to the nectar amount of the food source in the position i and SN is the number of food sources which is equal to the number of employed bees (BN). In this way, the employed bees exchange their information with the onlookers. For dehazing the image an optimal air light is estimated using the artificial Bee colony Optimization (ABC).

C. Histogram Equalization Based Method

Histogram Equalization method that improves the contrast in an image in order to stretch out the intensity range. Equalization implies *mapping* one distribution (the given histogram) to another distribution (a wider and more uniform distribution of intensity values) so the intensity values are speeded over the whole range. On the basis of Histogram Equalization method exposed below for removing haze.

1) *Histogram Equalization Method:* Histogram equalization is one of the well Known enhancement techniques. Proposed by RA Hummel, in histogram equalization the contrast of an image is modified by altering the image such that its intensity histogram has a desired shape. This is achieved by using cumulative distribution function as the mapping function. The intensity levels are changed such that the peaks of the histogram are stretched and the troughs are compressed. [13] If a digital image has N pixels distributed in discrete intensity levels and n_k is the number of pixels with intensity level i_k and then the probability density function (PDF) of the image is given by Equation (5). The cumulative density function (CDF) is defined in Equation (6).

$$f_i(i_k) = \frac{n_k}{N} \quad (5)$$

$$F_k(i_k)=\sum_{j=0}^{k} f_i\,(i_j) \quad (6)$$

Though this method is simple, but it fails in myocardial nuclear images since the gray values are physically far apart from each other in the image. Due to this reason, histogram equalization gives very poor result for myocardial images. [7, 8]

2) *Adaptive Histogram Equalization:* AHE (Adaptive Histogram Equalization) method is well proposed by Zimmerman, J for the contrast enhancement in an image this method overcome the limitation of global linear –min-max window histogram equalization [19]. AHE is commonly used in medical related images to enhance the contrast. In this method describe the remapping of each pixel by calculating the histogram equalization on pixels contextual region. This method explores the effective result in clinical setting.
3) *CLAHE Method:* CLAHE (Contrast limited adaptive histogram equalization) method is proposed by Kim, T. K is used for enhance the contrast of the gray scale images [20]. This method does not need any predicted weather information for processing the hazed image. CLAHE operate separately on RGB (Red, Green, Blue)and HSV (Hue Saturation value) as shown in fig. 3.(a), (b), (c) [5] CLAHE method separates the images into number of sub image then it applies histogram equalization to sub images. To enhance the contrast of each sub images [11].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

(a) (b) (c)

Figure 3: Results of the improved underwater image using CLAHE technique. (a) Original image (b) CLAHE-RGB (c) CLAHE-HSV

4) *MIX CLAHE: This* method is proposed by Hitam, M. S by Combination of CLAHE – RGB (Red, Green, Blue), and CLAHE HSV (Hue Saturation Value). CLAHE RGB describe the color in terms of the amount of Red (R), Green (G) Blue (B) is the sum of incoming light [5] in eq. 7.

$$R - \int_{300}^{830} s(\Upsilon)R(\Upsilon)d(\Upsilon)\ ,\ G - \int_{300}^{830} s(\Upsilon)G(\Upsilon)d(\Upsilon)\ ,\ B - \int_{300}^{830} s(\Upsilon)B(\Upsilon)d(\Upsilon) \tag{7}$$

Where S (΄Υ) is the light spectrum ,R (΄Υ),G(΄Υ),B(΄Υ) are the sensitivity functions for the R ,G and B sensors respectively. CLAHE - HSV describe the Hue. (H) Saturation (S) and Value (V) HSV model takes RGB component range [0-1] and the V computed maximum value of RGB in eq. (8), (9) .

$$V = \max(R, G, B) \tag{8}$$

$$S = \frac{V - \min(R,G,B)}{V} \tag{9}$$

Hue H, which determines whether the color is red, blue, green, and yellow and so on, is the most complex to compute. This method effectively improves the visibility of underwater images.

D. Conglomerate

1) *Retinex Theory:* The Retinex theorem is one of the most vital used theorems which explore the Human Visual System (HVS) precise color. Retinex model is based on assumption that that HVS operate with their retinal – cortical system. Each processing independently the low, middle and high frequencies of the visible electromagnetic spectrum. Land and Mc Cann found the efficient way to compute the lightness value of a pixel in equation (10) ‘i’ in given chromatic channel C can be obtained by where jk is the starting point of the kth path (i is the end Point of every path) and [12]

$$L(i) = \frac{\sum_k l^{ijk}}{N},\ l^{ijk} = \sum_{x\epsilon path} \delta \log\left|\frac{I_{x+1}}{I_x}\right| \tag{10}$$

Where δ is

$$\delta = \begin{cases} 1 & if\ log\left|\frac{I_{x+1}}{I_x}\right| > threshold \\ 0 & otherwise \end{cases}$$

Figure 4 explains the flow chart of the sequencing of various methods.

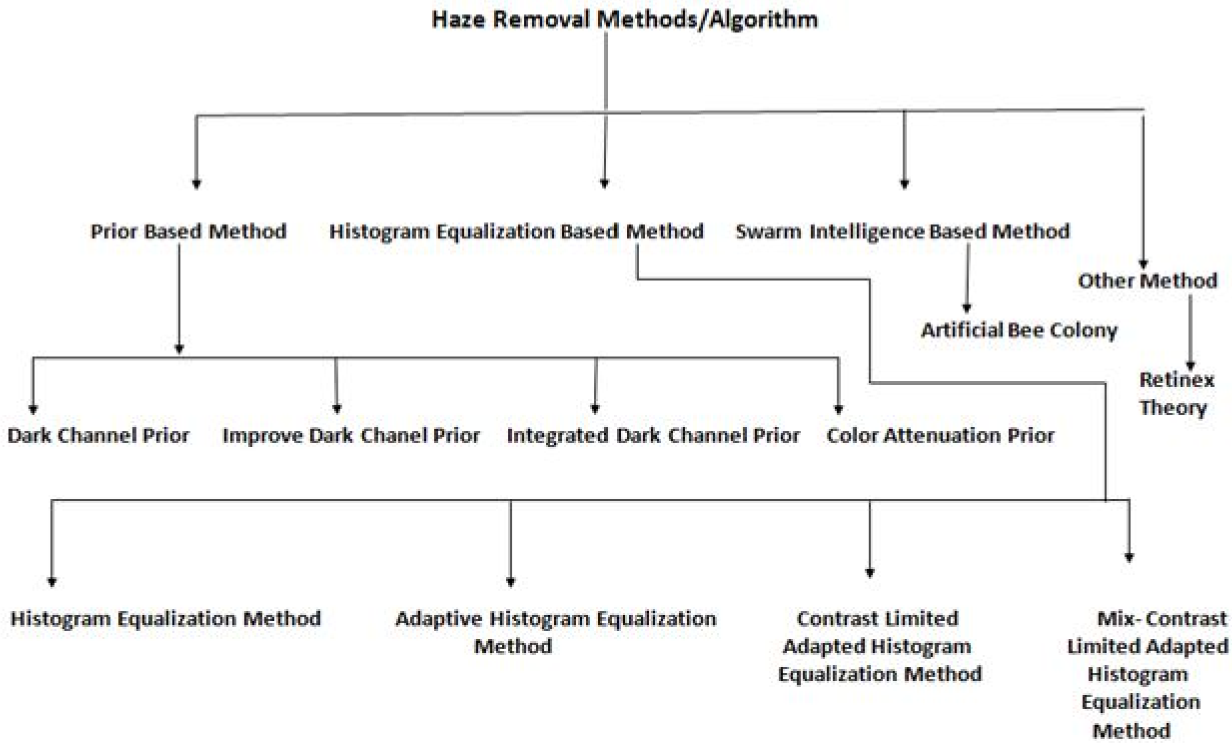


Figure 4: Flow Chart of the sequencing of various methods

2) Timeline for the Implementation of Algorithms

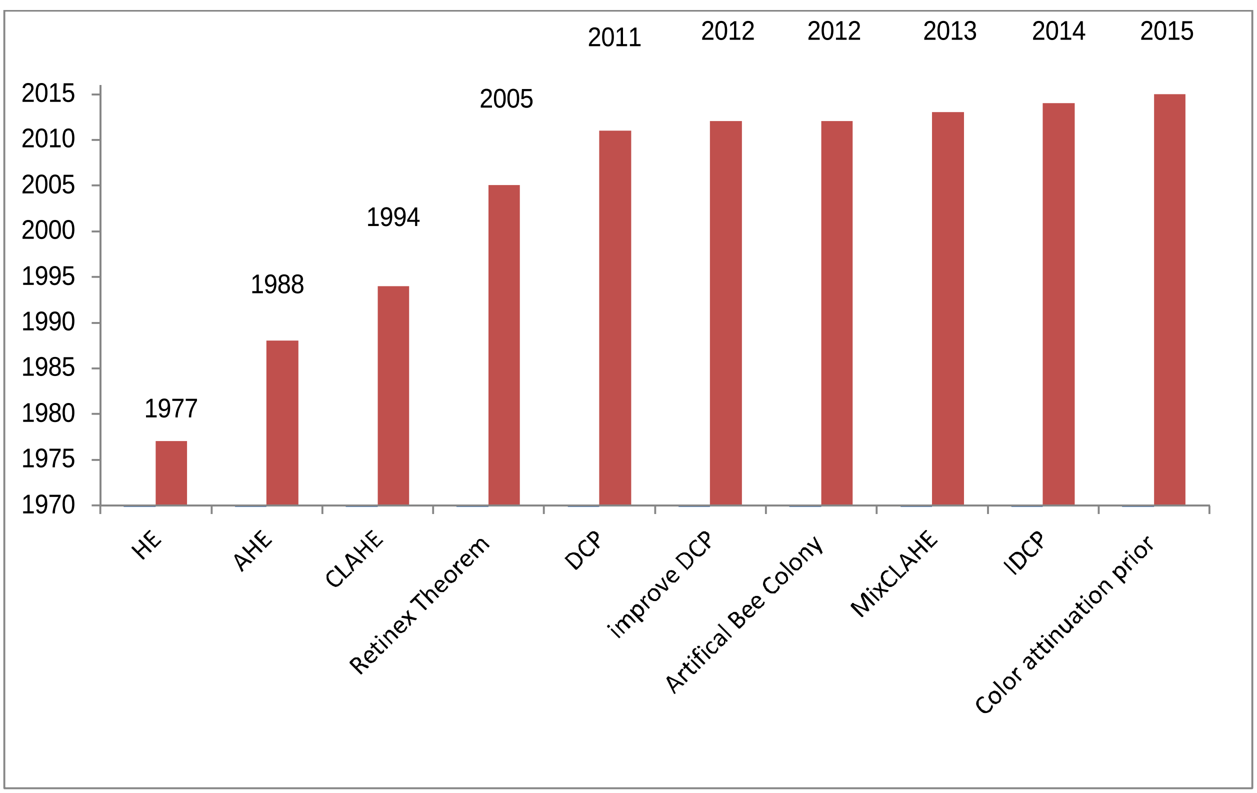


Figure 5: Timeline for the Implementation of Algorithms

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, August 2017- Available at www.ijraset.com

IV. COMPARISON BETWEEN DIFFERENT HAZE REMOVAL METHODS

TABLE 1 (a)
COMPARISON BETWEEN HISTOGRAM EQUALIZATION AND ADAPTIVE HISTOGRAM EQUALIZATION

Characteristics	Histogram Equalization (HE)	Adaptive Histogram Equalization (AHE)
Scope of Work	HE is global Operation hence it can't Preserve the image brightness.	The Region being processed has relatively small intensity range than the noise in that region get more enhanced
Application Area	HE is widely applied on images such as medical image processing , Radar image Processing , Speech Recognition etc.	AHE allow the 512*512 medical images to be processed in few 10 of seconds.

TABLE 1(b)
COMPARISON BETWEEN CONTRAST LIMITED HISTOGRAM EQUALIZATION AND MIXTURE OF CONTRAST LIMITED HISTOGRAM EQUALIZATION

Characteristics	Contrast Limited Histogram Equalization (CLAHE)	Mixture of Contrast Limited Histogram Equalization (MIX-CLAHE)
Scope of Work	Operate Separately on RGB and HSV Color model for improve the contrast.	It Mix the result of CLAHE RGB and CLAHE – HSV.
Application Area	Operate on small region in the image not Entire image.	Operate on large region in image like Underwater images.
Fierdelitly	CLAHE has low peak signal to noise ratio	CLAHE has high peak signal to noise ratio.
Efficiency	CLAHE has high mean square error.	CLAHE has high mean square error.

TABLE 2
COMPARISON BETWEEN DIFFERENT PRIOR METHODS

Characteristics	Dark Channel Prior (DCP)	Improve Dark Chanel Prior (IDCP)	Color Attenuation Prior (CAP)
Scope of Work	Depth map is extracted using Median Filter.	Refined Transmission map is extracted by using the atmospheric model, DCP and Transmission Map.	Explore the scene depth with the brightness and saturation of the hazy image.
Efficiency	Improve the Quality and Sharpness of the image.	The improved method normalizes the predicted haze values for the different gain and offset parameters used by the imaging system.	Efficiently remove the Haze and proposed an non linear color attenuation prior.
Limitation	DCP method can't work on the sky images and object has same color as sky.	Eliminate the effect present in DCP such as when object and sky are same color and sky area.	This method is the single image dehazing based on the constant β Assumption.

V. CONCLUSION

It is found that DCP and CLAHE explore the effective result but have some there limitation and many researches also try to improve the existing research limitation of DCP and CLAHE by combination with other filers or methods and shows the better result with comparison. However this is observed that research is focused on the prior based method namely the Dark Channel Prior (DCP) method and the Histogram based technique specially Contrast Limited Adaptive Histogram Equalization (CLAHE) nevertheless scope exists to explore the swarm techniques and other method based on Retinex theory.

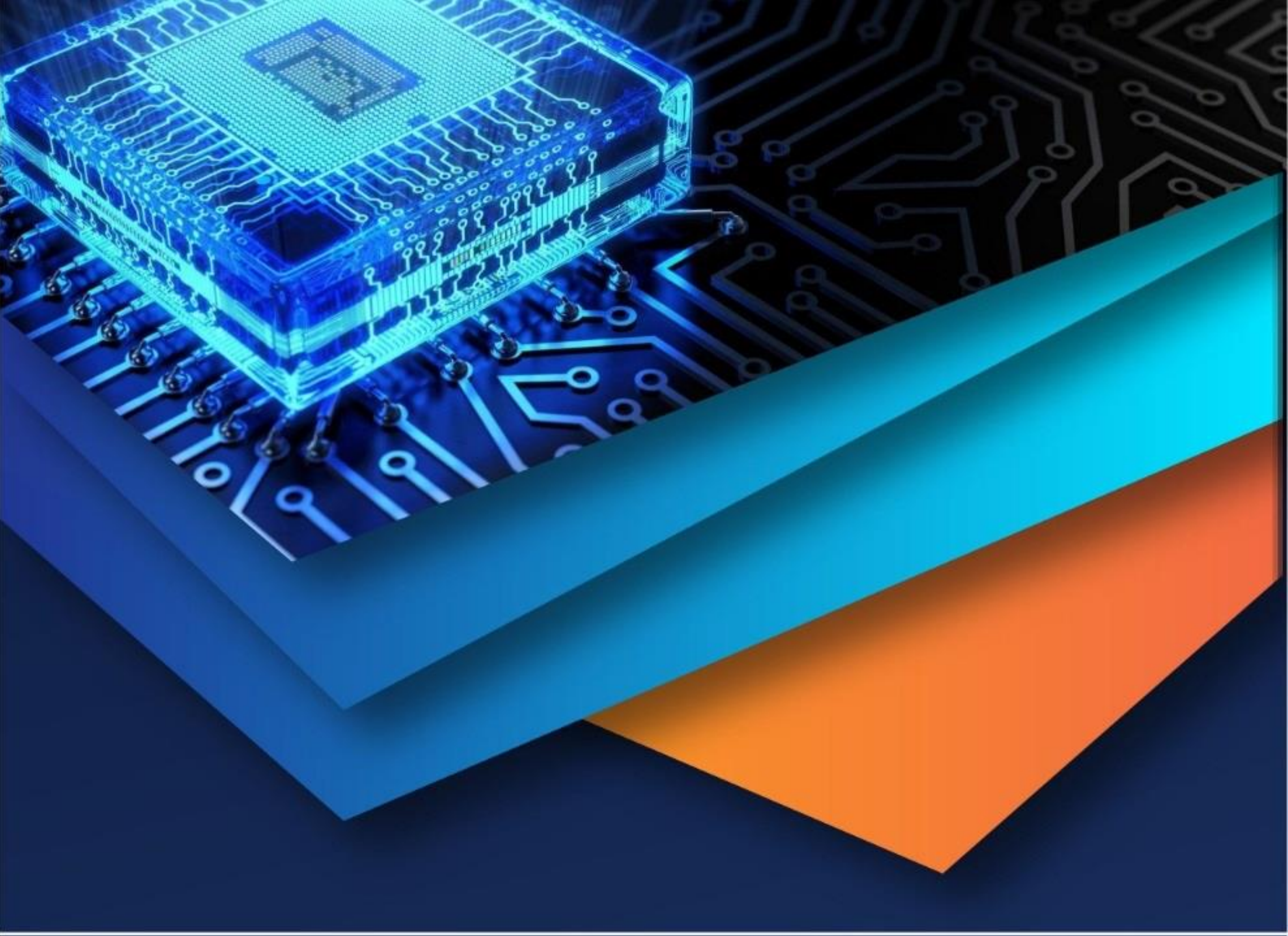
VI. FUTURE DIRECTIONS

This paper is positioned in the exploration, of different methods and the adaptation phases used for removing haze. As far as feature extraction was concerned, Swarm Intelligence based approached like Ant colony optimization, particle swarm optimization, Mosquito Algorithm, Dolphins Herds Algorithm etc. are not used in this direction by which work in the bad weather related images can be enhance much better and by this approach can also be adapted and implemented for real time scenarios such as driving in huge foggy areas.

REFERENCES

[1] Agaian, S., & Roopaei, M. (2013, June). New haze removal scheme and novel measure of enhancement. In Cybernetics (CYBCONF), 2013 IEEE International Conference on (pp. 219-224). IEEE.
[2] Ansia, S., & Aswathy, A. L. (2015). Single image haze removal using white balancing and saliency map. Procedia Computer Science, 46, 12-19.
[3] Arora, T. A., Singh, G. B., & Kaur, M. C. (2014). Evaluation of a New Integrated Fog Removal Algorithm IDCP with Airlight. International Journal of Image, Graphics and Signal Processing, 6(8), 12.
[4] He, K., Sun, J., & Tang, X. (2011). Single image haze removal using dark channel prior.
[5] Hitam, M. S., Awalludin, E. A., Yussof, W. N. J. H. W., & Bachok, Z. (2013, January). Mixture contrast limited adaptive histogram equalization for underwater image enhancement. In Computer Applications Technology (ICCAT), 2013 International Conference on (pp. 1-5). IEEE.
[6] Ji, X., Cheng, J., Bai, J., Zhang, T., & Wang, M. (2014, October). Real-time enhancement of the image clarity for traffic video monitoring systems in haze. In Image and Signal Processing (CISP), 2014 7th International Congress on (pp. 11-15). IEEE.
[7] Kaur, E. H., & Mahajan, R. (2014, September) modified haze removal using dark channel prior, gabor filter & clahe on remote sensing images.(IJCEA).
[8] Mao, J., Phommasak, U., Watanabe, S., & Shioya, H. (2014). Detecting foggy images and estimating the haze degree factor. Journal of Computer Science & Systems Biology, 2014.
[9] Mohamed, S., Roomi, M., Bhargavi, R., & Bhumesh, S. (2012). Visual model based single image dehazing using artificial bee colony optimization. Int J Inf Sci Tech, 2(3), 77-88.
[10] Moro, G. D., & Halounova, L. (2007). Haze removal for high-resolution satellite data: a case study. International Journal of Remote Sensing, 28(10), 2187-2205.

[11] Pizer, S. M., Johnston, R. E., Ericksen, J. P., Yankaskas, B. C., & Muller, K. E. (1990, May). Contrast-limited adaptive histogram equalization: speed and effectiveness. In Visualization in Biomedical Computing, 1990., Proceedings of the First Conference on (pp. 337-345). IEEE.
[12] Provenzi, E., Marini, D., De Carli, L., & Rizzi, A. (2005). Mathematical definition and analysis of the Retinex algorithm. JOSA A, 22(12), 2613-2621.
[13] RA Hummel, “Image Enhancement by Histogram Transformation, Computer Graphics Image Processing,” (1997), vol. 6, pp. 184195
[14] Saggu, M. K., & Singh, S. (2015). A review on various haze removal techniques for image processing. International Journal of Current Engineering and Technology, 5(3), 1500-1505.
[15] Schechner, Y. Y., Narasimhan, S. G., & Nayar, S. K. (2001). Instant dehazing of images using polarization. In Computer Vision and Pattern Recognition, 2001. CVPR 2001. Proceedings of the 2001 IEEE Computer Society Conference on (Vol. 1, pp. I-325). IEEE.
[16] Xie, B., Guo, F., & Cai, Z. (2010, October). Improved single image dehazing using dark channel prior and multi-scale Retinex. In Intelligent System Design and Engineering Application (ISDEA), 2010 International Conference on (Vol. 1, pp. 848-851). IEEE.
[17] Xu, H., Guo, J., Liu, Q., & Ye, L. (2012, March). Fast image dehazing using improved dark channel prior. In 2012 IEEE International Conference on Information Science and Technology (pp. 663-667). IEEE.
[18] Zhu, Q., Mai, J., & Shao, L. (2015). A fast single image haze removal algorithm using color attenuation prior. IEEE Transactions on Image Processing, 24(11), 3522-3533.
[19] Zimmerman, J. B., Pizer, S. M., Staab, E. V., Perry, J. R., McCartney, W., & Brenton, B. C. (1988). An evaluation of the effectiveness of adaptive histogram equalization for contrast enhancement. IEEE Transactions on Medical Imaging, 7(4), 304-312.
[20] Kim, T. K., Paik, J. K., & Kang, B. S. (1998). Contrast enhancement system using spatially adaptive histogram equalization with temporal filtering. IEEE Transactions on Consumer Electronics, 44(1), 82-87.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY