International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Image De-Hazing based on Krill Herd Optimization Algorithm

Sunkavalli Jaya Prakash*[1], Manna Sheela Rani Chetty[2], A Jayalakshmi[3]

Submitted: 02/11/2022 **Revised:** 20/12/2022 **Accepted:** 05/01/2023

Abstract: In digital images, haze damages the image quality which are taken in outdoor environment. This causes the degradation of image quality in terms of colour distortion and there exists a huge loss in the contrast. Because of the difficulty and importance of the problem, a lot of study has been done on picture de-hazing. A significant number of approaches were done based on dark channel prior shows successful results among picture haze removal approaches. Furthermore, the addition of a guided filter has greatly improved its efficiency. To address this issue, an optimization approach-based Image-Dehazing technique is applied in this research paper. It generates pixel-wised transmission without additional refining. Furthermore, image de-hazing procedures based on noise filtering perspective are used to achieve the goal of saturation enhancement while adhering to the minimum hue change constraint. The usefulness and efficiency of the suggested algorithm were evaluated by qualitative and quantitative analysis of the results.

Keywords: De-Hazing, Krill Herd Optimization algorithm, Noise filtering.

1. Introduction

When taking photographs outside, a high concentration of atmospheric particles might detract from the overall quality of the image. Because of their similar impact on the clarity of vision, haze, fog, and smoke are all grouped together under the umbrella term of "haze." In addition to this, air interference is the root cause of coloring distortion [1]. Images that are crisp, bright, and brilliant, with high saturation, comparison, entropy, and other fine characteristics, are essential for a wide range of applications [2,3].

This is a challenging endeavor, and a significant amount of research has been put into finding solutions to the pollution problem. In recent years, a variety of approaches to picture dehazing have been presented; in 2015, Liu [4] published a note and classification on Dark Channel Prior (DCP) [5]. There are three different types of procedures that can be used to remove haze from images: multiple photograph de-hazing [2, 6, 7], haze removal requiring additional facts [8–10], and unmarried photograph de-hazing [11, 12]. The principal techniques are not suitable for use in applications that operate in real time since they demand an excessive amount of resources and have a high computational complexity. As a result of its ease of use and effectiveness in the process of photograph de-hazing, single photo de-hazing has captured the attention of a significant number of students. In 2011, he [11] proposed a method that became into mostly predicated at the idea of DCP, and it's far through a ways the exceptional unmarried photograph de-hazing remedy to have been discovered up to now.

This article offers a description of a method known as image Krill Herd - Haze (KH-H), which is fully predicated on a concept that Gandomi, et al. [13] suggested. Photos that have been tainted by haze in the form of noise typically have high intensity but low saturation. These are the key characteristics. As a direct result of this, the depth and saturation of the photo that was used as input are weighted to reflect the degree to which the haze was present.

The same method has been utilized in order to estimate the light ambience; nevertheless, when photographs contain products that are excessively shiny, a slight adjustment is required. After the two weighted maps have been constructed, neighborhood records from the severity map are used in the picture noise filtering process. Utilizing the Krill Herd method allows for the optimization of four different parameters. This project's goal is to increase the level of saturation in the very last photograph.

The further paper is organized as follows: Section 2 discusses on the related work carried out on de-hazing the images. Section 3 discusses on image dehazing problem definition. Section 4 discusses, on the Krill Herd Algorithm and its application to solve image De-Hazing. Section 5 discusses on the experimental results and its analysis and finally section 6 concludes the paper.

[1]*Research Scholar, Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India.*
[2]*Professor, Department of Computer Science and Engineering,Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India.*
[3]*Professor& Head, Department of CSE,Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, AP, India*

** Corresponding Author Email: prakashsunkavalli@gmail.com*

2. Literature works

The RGB-HSV conversion [14] is used as a technique to rework the colored picture into its equivalent monochrome depiction. This is accomplished by converting the RGB values to HSV values. Modifications are applied to the intensity of the V-data channel's before it is shown in RGB format. These adjustments are made so that comparisons can be performed in a manner that is more acceptable (CHE). The Mean Brightness Preserving Bi-Histogram Equalization (BBHE), which is described in [15], became developed for the purpose of bettering comparability while still retaining the output image's mean brightness. This equalization method is described in greater detail in [15]. Similarities exist between the Dualistic Sub-Image Histogram Equalization (DSIHE) [16] and the BBHE in terms of the popular theory behind each technique. When it divides the photo intensity into two subphotographs, DSIHE utilizes the median charge rather than the advise charge. This is the most significant difference between the two methods. It is possible for the median price to be significantly lower or higher than the mean price at any one time. The median price is completely dictated by the content of the photograph. The method that was proposed in the article [17] has been given the acronym RMSHE, which stands for recursive mean-separate histogram equalization. This method can be conceptualized as an excellent example of a more evolved paradigm, such as the BBHE method. For illustration's sake, the procedure of subdividing the primary snap snapshot into several sub-snap shots is carried out a total of four times with the intention of producing four sub-photos.

The Recursive Sub-Picture Histogram Equalization (RSIHE) [18] collection of rules turned into evolved with the idea that the input photo should be divided up into four different components. [Citation needed] The method of division was modified so that it now relies on the deciles of the many different pixels that are arranged in ascending order according to their depth values. This trade became made as a result of a trade that took place inside of the department. The steps that are left to take in the process of enhancing the strategy adhere to the same sample as the stages that were taken in the preceding strategies. In [19], the approach known as Fuzzy Fusion based High Dynamic Range Imaging with Adaptive Histogram Separation (FFHAHS) was defined. This method divides the shot into multiple parts according to a predetermined intensity level. After the sub-snap pictures have been created, the next step is to perform range stretching and range clipped histogram equalization. The input and stronger intermediate photos are merged together, and then fuzzy inference is used to the combined data in order to produce the ultimate improved picture. A fresh image is produced using this method.

3. Image Dehazing

The notion of picture dehazing is to recover the real scene radiance of an image from ambient light (A) and the distance from the object to the camera lens (t). A pixel in a picture may be described formally as

$$P(i) = J(i) \times t(i) + A(1 - t(i)) \quad \text{Equation (1)}$$

Where P stands for the actual depth measured in RGB values, J for the radiance price at distance t, and A for the price of the ambient light. On the other hand, an image is composed of a set of pixels that originate from either one layer (in the case of black-and-white photos) or three layers when the photo is coloured. Black-and-white images have only one layer, whereas coloured photos have three layers (RGB). As an immediate consequence of this, the primary objective is to ascertain the strength of the general ambient light as well as the distance between the virtual camera and the subject in order to calculate radiance from pixel values. One way to do this is by determining the distance between the digital camera and the subject of the photograph.

The results of recent studies suggest that it is possible to reconstitute the brightness of a scene using the pixels that have been captured after first applying noise filtering+The standard image representation has been recast in this style as follows:

$$P(i) - A = (J(i) - A) \times n(i) \quad \text{Equation (2)}$$

where the transmission distance (t) is treated as noise disturbance (n).

According to the findings of the research, the pixel value that is affected by haze has a high brightness fee (B), but a low saturation value (S). Based on those two factors, B and S, the noise in a photograph can be reframed as follows:

$$M_n = \rho(1 - B) + (1 - \rho)S \quad \text{Equation (3)}$$

In this equation, B represents the average of the photo's Red, Green, and Blue (RGB) colours, and S represents the difference between the numeric cost 1 and the pixel's minimal value P to the maximum fee pixel's ratio.

The parameter suggests the weight element that restricts the participation of brightness value and saturation. This suggestion is based on the radiance of the scenic environment.

Where B represents the average of the picture's R, G, and B colours, and S represents the difference between P (the minimum cost of a pixel) and the ratio of the pixel with the highest value. The value of the parameter reflects the burden aspect, which restricts the involvement of brightness value and saturation depending solely on the radiance of the scenery. The noise map has been fine-tuned largely with regard to the shift-scale feature in the following manner:

$$M_s = \alpha + \beta M_n \quad \text{Equation (4)}$$

Now that the total noise has been calculated, the final pixel creation in the real picture (i.e. Equation (2)) may be reorganised as follows:

$$P(i) - A = (J(i) - A) \times M_s(i) \quad \text{Equation (5)}$$

In addition to the noise that is brought on by transmission distance, the ambient mild also has an effect on the vividness of the scenery. And because that is related to the brightness and saturation charge, every other issue that this is restricted comes from this, M_a is formed from B and S as follows:

$$M_a = \varphi B + (1 - \varphi)S \quad \text{Equation (6)}$$

where φ is the weight factor. And thus the value of A can be identified as

$$A = \max\{M_a(i)\} \quad \text{Equation (7)}$$

The final A can be cummulated as

$$A = A + \gamma \quad \text{Equation (8)}$$

where γ is a correlation scalar value related to the atmospheric light.

When dealing with all of the values of $\rho, \alpha, \beta, \gamma$ as weight factors, it should be ideal such that they do not deviate from the scene's real radiance value. As a result, the parameter values are optimised using a Krill Herd optimization model.

4. Krill-Herd based Image Dehazing

The field of optimization, in which a better solution must be found for a scenario that has an exponentially vast variety of possible answers proportionate to the importance of the difficulty, is one in which bio-stimulated algorithms play a major role. [Citation needed] The Krill Herd algorithm [13] (KH) is an efficient optimization method that is utilised in bioinspired optimization algorithms to address a significant number of challenges and problems. Style of running adopted by KH: As predators like seals, penguins, or seagulls attack krill, they take the character krill with them when they go. Because of this, there are less krill in the water.

After a predation event, the krill herd returns to its previously established order for a variety of reasons. The process of herding individual krill has multiple goals, but the top two priorities are (1) increasing the population density of the krill and (2) collecting food. The purpose of this method is to suggest a swarm-based algorithm as a means of addressing global optimization issues within the context of the current test. The density-based attraction of the krill (increasing density) and the search for food are used as goals, leading to the herding of the krill towards the global minima. When a krill uses this strategy to find the most food and density, it moves in the direction of the alternative that offers the best chance of success. To put it another way, the importance of the desired feature reduces as the distance between the high density and the food grows.

This Krill-Herd optimization strategy will take as input the weight factors of,,, and in order to obtain the values with the highest ratings possible. The level of output image saturation is the intention feature that needs to be optimised for maximum effect. Increased photograph saturation that goes beyond acceptable limits, on the other hand, will result in a synthetic output that is unable to accurately communicate the true details that are there in the original photograph. Particles that can be seen to have undergone a discernible and significant colour shift as a consequence of the dehazing method are disqualified from the use of a penalty object ().

$$\aleph = 1 - \mathcal{E} \quad \text{Equation (9)}$$

where $\mathcal{E}$ is the value of t-test for every individual in the population. Every individual's fitness value may be calculated using the fitness function, which is theoretically defined as follows:

$$f(x_i) = (1 - \aleph)\hat{S} + \aleph(1 - \aleph) \quad \text{Equation (10)}$$

where $\hat{S}$ is the average saturation rate. Algorithm1 contains the algorithm for determining optimal parameter values.

Image De-Hazing using Krill Herd Optimization algorithm

Input: The parameters $\rho, \alpha, \beta, \gamma$ upper and lower bound, Objective function (f)

Step 1: Initialize $Iter \leftarrow 1, i \leftarrow 0, k \leftarrow 0$

Step 2: $\forall\ Ind_{KH} \in N_{KH}$ ***do***

$P_{Ind_{KH},j} \leftarrow LB_j + (UB_j - UB_j) * rand() \quad | j \in \rho, \alpha, \beta, \gamma$

end for

Step 3: $\forall\ Ind_{KH} \in N_{KH}$ ***do***

$Fit(P_{Ind_{KH}}) \leftarrow f(P_{Ind_{KH}})$

end for

Repeat

Step 4: Movement Induced by other Krills

Step 4.1: Repeat till 4.3 Until $i < N_{KH} \mid i \in Ind_{KH}$ else Step 5

Step 4.2: $\vartheta_i = \vartheta_i^{local} + \vartheta_i^{target}$

Step 4.3: $N_i^{new} = N^{max}\, \vartheta_i + \omega_n\, N_i^{old}$

Step 5: Foraging motion of individual krill

Step 5.1: Repeat till Step 5.3Until $i < N_{KH} \mid i \in Ind_{KH}$ else Step 6

Step 5.2: $\varphi_i = \varphi_i^{food} + \varphi_i^{best}$

Step 5.3: $F_i = V_f \beta_i + \omega_f F_i^{old}$

Step 6: Individual movement of Krill Herd in random manner

Step 6.1: Repeat till Step 6.2Until $i < N_{KH} \mid i \in Ind_{KH}$ else Step 7

Step 6.2: $D_i = D^{max} \left(1 - \frac{I}{I_{max}}\right)$

Step 7: Repeat till Step 7.2 Until $i < N_{KH} \mid i \in Ind_{KH}$ else Step 8

Step 7.1: $\frac{dX_i}{dt} = N_i + F_i + D_i$

Step7.2: $\Delta t = C_t \sum_{j=1}^{NV}(UB_j - LB_j)$

Step 7.3: $X_i(t + \Delta t) = X_i(t) + \Delta t\ \frac{dX_i}{dt}$

Until $Max_{IT} \leq Iter$

Step 8: Return min $(Fit(P_{Ind_{KH}}))$

Output: min $(Fit(P_{Ind_{KH}}))$

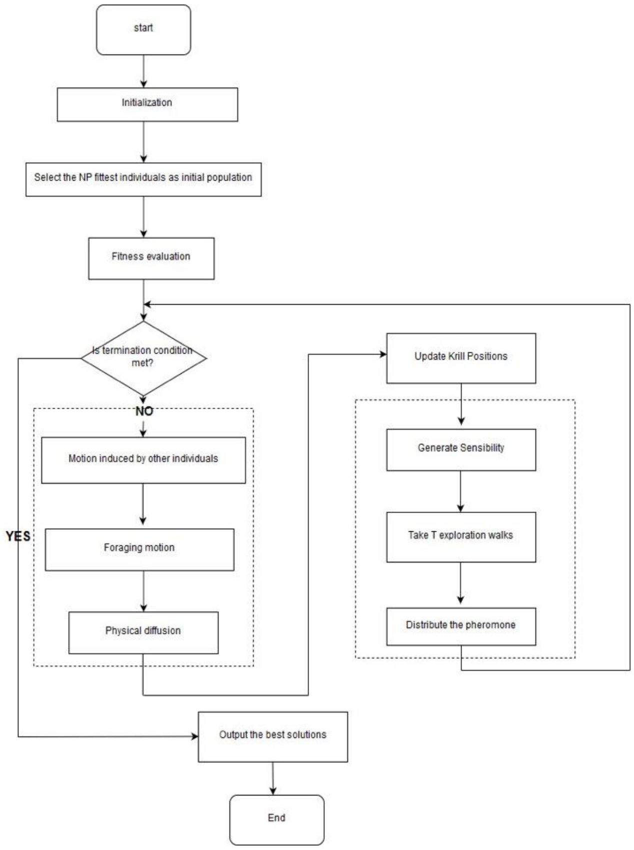

Fig 1. Flow Chart of Krill Herd Algorithm for Image De-Hazing

5. Experimental analysis

In order to evaluate the usefulness of the method that was provided and determine whether or not it was effective, a test was performed on one hundred color photographs that had been taken in a variety of settings. They include photos that have haze, inadequate illumination, and poor comparison. The JPEG format, with eight bits, is used to save these images for safekeeping. The computer scripts were constructed with the help of the MATLAB 2018a software program, and they were executed on a personal computer that has a Core i7 tenth-generation CPU, 16GB of RAM, and a 256GB SD card.

Table 1. Results of KH-H

S.No	Haze affected Image	De-hazed image using KH-H
1		
2		

3		
4		

In Table 2, The overall performance metrices values of KH-H are compared with those of other existing algorithms. These metrics include colourfulness, saturation, assessment, sharpness, suggest brightness, and entropy.

Table 2. Comparison of Mean values of KH-H vs other existing algorithms

	Colorfulness	**saturation**	**contrast**	**Sharpness**	**Mean brightness**	**Entropy**
Fattal 08	0.098	0.32	0.02	0.02	0.363	6.267
Tarel 09	0.17	0.36	0.04	0.05	0.397	6.937
Tarel 10	0.15	0.502	0.03	0.04	0.226	6.618
He11	0.16	0.539	0.03	0.02	0.205	6.425
Meng13	0.14	0.425	0.04	0.03	0.250	6.700
Zhu 15	0.12	0.286	0.03	0.03	0.370	6.939
KH-H	0.11	0.542	0.04	0.03	0.228	6.221

On comparing the results of existing approaches, KH-H outperforms the existing approaches in a varied number of metrices.

In Colorfulness, KH-H outperforms all the existing approaches except Fattal 08 which goes less than 0.1. In terms of saturation KH-H outperforms all the existing algorithms and the second level of algorithm goes with Hel 1 which goes less with 0.003 points in terms of saturation. In the contrast model KH-H outperforms all the existing approaches except Hel 1 with just 0.001 unit of contrast value.

On comparing the value for sharpness, the proposed model outperforms with half of the existing approaches and at the same time it performs less when compared with Tarel 09 and Tarel 10. The mean brightness is optimal when compared with all other existing approaches and the Entropy value seems to be very compromising when compared with existing models.

6. Conclusion

A modern method for dehazing photos is proposed in this study. This method makes use of a noise filtering technique. This method can be utilized to clean up any haze that may have been present in the restored snapshots. A pixel-touchy noise estimate appears to be more accurate than neighborhood-patch-based answers when it comes to managing the depth shift that takes place towards the rims of a photograph, as indicated by the outcomes of the quantitative research. This has been discovered by comparing the two different kinds of answers to one another in order to see how they stack up against one another. Another advantage of utilizing the KH-H strategy is that it does not incur any penalties on account of the presence of incredibly brilliant objects in the photographs that it analyses. Simply put, this is only one of the numerous advantages that can be obtained by utilizing this strategy. Alterations have to be made to the price that is anticipated to be paid for the atmospheric rate in order to accomplish this goal. Utilizing the Krill Herd Algorithm to automatically change the settings normally based on each incoming photo is a great way to further expand the method's versatility. This may be accomplished in an efficient and effective manner by using this strategy. This is a point that has been argued for previously. This optimization strategy, which makes use of a hue exchange constraint, is used with the intention of achieving the maximum amount of saturation that is possible in the final picture.

7. References

[1] Kim J.-G.. Color correction device for correcting color distortion and gamma characteristic. 1999. US Patent 5,949,496

[2] Narasimhan SG, Nayar SK. Contrast restoration of weather degraded images. Pattern Anal Mach Intell IEEE Trans 2003a;25(6):713–24.

[3] Henry RC, Mahadev S, Urquijo S, Chitwood D. Color perception through atmospheric haze. JOSA A 2000;17(5):831–5.

[4] Liu S, Rahman M, Wong C, Lin S, Jiang G, Kwok N. Dark channel prior based image de-hazing: a review. In: Information science and technology (ICIST), 2015 5th international conference on. IEEE; 2015. p. 345–50.

[5] Lee S, Yun S, Nam J-H, Won CS, Jung S-W. A review on dark channel prior based image dehazing algorithms. EURASIP J Image Video Process 2016;2016(1):1–23.

[6] Schechner YY, Narasimhan SG, Nayar SK. Polarization-based vision through haze. Appl Opt 2003;42(3):511–25

[7] Nayar SK, Narasimhan SG. Vision in bad weather. In: Computer vision, 1999. The proceedings of the seventh IEEE international conference on, 2. IEEE; 1999. p. 820–7.

[8] Tan K, Oakley J. Enhancement of color images in poor visibility conditions. In: Image processing, 2000. Proceedings. 2000 international conference on, 2. IEEE; 2000. p. 788–91.

[9] Narasimhan SG, Nayar SK. Interactive (de) weathering of an image using physical models. In: IEEE workshop on color and photometric methods in computer vision, 6. France; 2003b. p. 1.

[10] Kopf J, Neubert B, Chen B, Cohen M, Cohen-Or D, Deussen O, et al. Deep photo: model-based photograph enhancement and viewing. In: ACM transactions on graphics (TOG), 27. ACM; 2008. p. 116.

[11] He K, Sun J, Tang X. Single image haze removal using dark channel prior. Pattern Anal Mach Intel IEEE Trans 2011;33(12):2341 53.

[12] Lee J-S. Digital image enhancement and noise filtering by use of local statistics. Pattern Anal Mach Intel IEEE Trans 1980(2):165–8

[13] Gandomi, Amir Hossein, and Amir Hossein Alavi. "Krill herd: a new bio-inspired optimization algorithm." Communications in nonlinear science and numerical simulation 17.12 (2012): 4831-4845.

[14] R. C. Gonzalez and R. E. Woods, Digital Image Processing, 3rd ed. Prentice-Hall Inc., Upper Saddle River, NJ, USA, 2006

[15] Y.-T. Kim, "Contrast enhancement using brightness preserving bi-histogram equalization," Consumer Electronics, IEEE Transactions on, vol. 43, no. 1, pp. 1–8, 1997

[16] Y. Wang, Q. Chen, and B. Zhang, "Image enhancement based on equal area dualistic sub-image histogram equalization method," Consumer Electronics, IEEE Transactions on, vol. 45, no. 1, pp. 68–75, 1999.

[17] S.-D. Chen and A. R. Ramli, "Contrast enhancement using recursive mean-separate histogram equalization for scalable brightness preservation," Consumer Electronics, IEEE Transactions on, vol. 49, no. 4, pp. 1301–1309, 2003.

[18] K. Sim, C. Tso, and Y. Tan, "Recursive sub-image histogram equalization applied to gray scale images," Pattern Recognition Letters, vol. 28, no. 10, pp. 1209–1221, 2007.

[19] R. Duvar, O. Urhan et al., "Fuzzy fusion based high dynamic range imaging using adaptive histogram separation," IEEE Transactions on Consumer Electronics, vol. 61, no. 1, pp. 119–127, 2015.

Acknowledgements

We thank our colleagues from [Koneru Lakshmaiah Education Foundation] who provided insight and expertise that greatly assisted the research. We thank [Manna Sheela Rani Chetty] for assistance with [Krill-Herd Optimization algorithm], and [A Jayalakshmi] for comments that greatly improved the manuscript.

Author contributions

Sunkavalli Jaya Prakash: Conceptualization, Methodology, Software, Field study, **Manna Sheela Rani Chetty:** Data curation, Writing-Original draft preparation, Software, Validation., Field study, **A Jayalakshmi:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.