ANT COLONY OPTIMIZATION BASED MIXED CLAHE FOR UNDERWATER HAZE REMOVAL

Dilraj Kaur[1], Pooja[2]
Punjab Technical University: Dept. Computer Science Engineering
CT-Institute Of Engineering Management And Technology
Jalandhar, India
rajrandhawa0592@gmail.com[1], poojachoudhary80@gmail.com[2]

Abstract: Visibility restoration refers to various ways that aim to reduce and remove the degradation that have occurred while the digital image has been obtained. The degradation may be due to various factors like relative object-camera motion, blur due to camera misfocus, relative atmospheric turbulence and others. Underwater image enhancement based algorithms become more useful for many vision applications. It is found that most of the existing researchers have neglected many issues i.e. no technique is accurate for different kind of circumstances. The existing methods have neglected the use of ant colony optimization to reduce the noise and uneven illuminate problem. The main objective of this paper is to evaluate the performance of Ant colony optimization over the available MIX-CLAHE technique.

Keywords: Underwater haze removal; ACO; Mix-CLAHE; Dark Channels

I. INTRODUCTION

Presence restoration [1] is the term for various ways in which make an effort to decrease as well as eliminate the degradation that has occurred while the digital picture has been received. The particular degradation might be caused by several components just like comparative object-camera motions, blur caused by video camera misfocus, comparative atmospheric disturbance among others. In this, the actual degradations caused by bad conditions including haze, rain as well as excellent skiing conditions in the picture can also be bundled to become taken away.

Fig.1 captured during the haze condition which is not clearly visible using various haze removal method we can improve visibility of an image. The haze removal methods may be split into two categories: image enhancement and image restoration.

Fig.1.(a) Original image (b) Processed image

This process can enhance the contrast of haze image but loses a few of the information regarding image. After observing that degradation style of haze, image will undoubtedly be established. After that the degradation process is inverted to generate the haze free image without degradation. MIX-CLAHE method was proposed to overcome the problem related to visibility of underwater images. But the methods have neglected the methods to reduce noise. The issue of uneven and also over illumination may also be an issue for haze removal methods. So new propose strategy may continue steadily to function better. The paper proposes a new method which is Ant Colony Optimization based Mixed CLAHE and results of this technique seems to be justifiable. In previous paper we will propose methodology as given below:

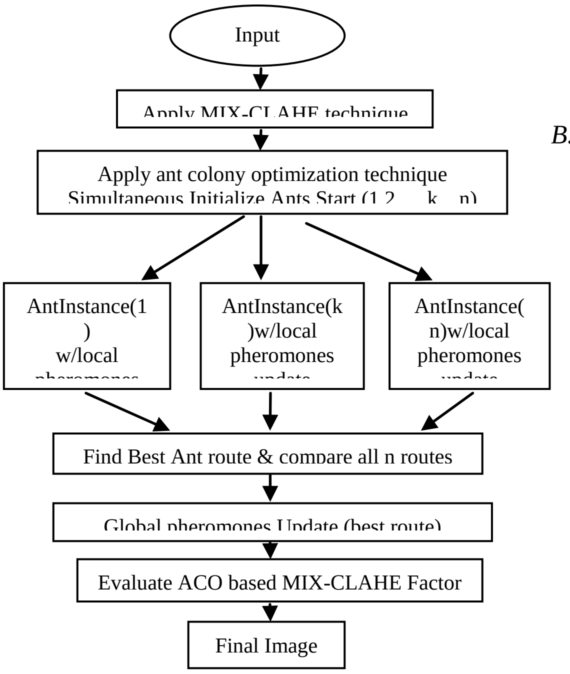

Fig.2.Flow Chart of Ant colony optimization

II. IMPLEMENTATION

A. Dataset

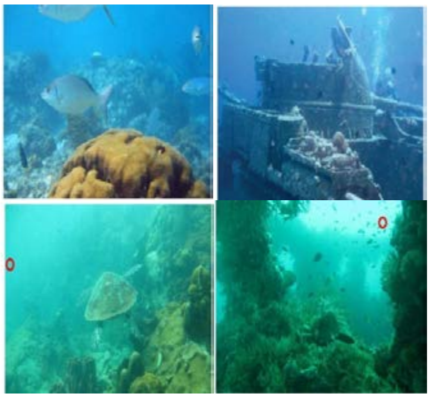

Fig.3. (adapted from dataset)

In total, the images are divided into 25-30 clips, taken at different locations inside the ocean. Some examples are shown in the Fig. 2. Dataset is named as 51957-under-water-images, (https://in.mathworks.com/matlabcentral/fileexchange/51957-under-water-images) **[33]**

III. PROPOSED ALGORITHM

Below are the steps for the proposed algorithm:

A. Phase 1

Select the input image. Any digital image is represented as an array of size M*N pixels. Following fig 4.1 shows the input image.

B. Phase 2

First of all, apply MIX-CLAHE technique on the input image..This technique was invented to reduce undesired artifacts as well as brightness in an image. MIX-CLAHE technique mixes the results of CLAHE-RGB and CLAHE-HSV. The main aim of this technique was to enhance the contrast of an image and give natural look to underwater images. This method first normalize the result of CLAHE-RGB.

$$\{r_{c1}, g_{c1}, b_{c1}\} = \left[\frac{R_c}{(R_c + G_c + B_c)}, \frac{G_c}{(R_c + G_c + B_c)}, \frac{B_c}{(R_c + G_c + B_c)}\right] \quad (1)$$

Then the result of CLAHE-HSV is converted to RGB color model by finding chroma.

Fig.4.1.Input image (underwater hazed image)

The following fig 4.2 shows the result of MIX-CLAHE:

Fig.4.2.Result of MIX–CLAHE technique

$$C = V * S \quad (2)$$

$$H' = \frac{H}{60^0} \quad (3)$$

Then, by using C and H' , X is determined as follows:

$$X = C(1 - |(H' \bmod 2) - 1|) \quad (4)$$

The conversion from HSV to RGB which is denoted by:

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$$\{r_{c1}, g_{c1}, b_{c1}\} = \begin{cases} (0,0,0), if\ H\ is\ undefined \\ (C,X,0), \quad if\ 0 \le H' < 1 \\ (X,C,0), if\ 1 \le H' < 2 \\ (0,C,X), if\ 2 \le H' < 3 \\ (0,X,C), if\ 3 \le H' < 4 \\ (X,0,C), if\ 4 \le H' < 5 \\ (C,0,X), if\ 5 \le H' < 6 \end{cases} \quad (5)$$

Finally, both conversions' from eq.1 and eq.5 are integrated using Euclidean norm:

$$[\![RGB]\!]_n=\sqrt{(r_{c1}^2+r_{c2}^2}+\sqrt{(g_{c1}^2+g_{c2}^2}+\sqrt{(b_{c1}^2+b_{c2}^2}$$
(6)

This image has clear visibility but still uneven illumination and noise are the main issues there, so our proposed method will work on this issue. Fig 4 is taken from dataset, which I have discussed earlier. Then, I have performed all the operations of MIX-CLAHE technique.

C. Phase 2

ACO based MIX-CLAHE will work as following:

First, we have to apply ACO (Ant Colony Optimization) technique. For this, first we have to initialize the ants and nodes (states).we can use from (1 to n) ant instances. Further, choose next edge probabilistically according to attraction and visibility (distance).

$$Distance(i,j) = sqrt((x(i) - x(j)^2 + (y(i) - y(j)^2)) \quad (7)$$

x, y location co-ordinates such that is Euclidean distance between location i, j.

Basically the numbers of independent runs are 30 and maximum iterations are 1000000. We also have to set various parameters like alpha, beta and rho. In this algorithm, we have set Alpha= 1.5, Beta=2 and Rho= 0.9. Alpha used for pheromone information; Beta used for heuristic information; and Rho used for pheromone persistence. Using distance formula we will find the distance between ants and the distance between ants change at run time.

Moreover, each ant maintain TABU list of ant solution infeasible transaction for that iteration. Side by side updating of attraction of an edge done according to number of ants passed through. Then we have to update local pheromone value.

$$\tau_{ij}(t) = (1-\rho)\tau_{ij}(t) + \rho.\tau_0 \quad (8)$$

τij describes the amount of pheromone on edge [i,j] at time t.

ρ describes pheromone decay $0<\rho<1$; and $\tau 0$ is the initial value of pheromone on all edges.

Experimentally, the optimal value for ρ has been found to be 0.1 and good formulation for $\tau 0$ has been found to be:

$$\tau_0 = 1/(n.L_{nn})$$

Where n is the number of nodes in the graph; and
Lnn is the length of the tour found by a nearest neighbour heuristic.

Phase 3

In this step technique will compare all n routes and sort the best ant route according to ranking system.

Phase 4

Then if local best solution better then save local best solution as global solution .When all ants have completed a solution ,the trail are updated by:

$$\tau_{ij}(t) \leftarrow (1-\rho)\tau_{ij}(t) + \rho.\Delta\tau_{ij}(t) \quad (9)$$

Where τij (t) is the amount of pheromones on the edge (i,j) at time t; ρ is a parameter governing pheromone decay such that $0<\rho<1$; and where $\Delta\tau ij$ (t) is the length of the current best tour.

Phase 5

At the end we have to merge pheromone value and then evaluate ACO based MIX-CLAHE factor.

$$\frac{\sqrt{r_{c1}^2 + r_{c2}^2} + \sqrt{g_{c1}^2 + g_{c2}^2} + \sqrt{b_{c1}^2 + b_{c2}^2}}{((fsh * fsv) + 255)} \quad (10)$$

In above equation we have fsh is the value of pheromone on horizontal side and fsv is the value of pheromone on vertical side.

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D. Phase 6:

Then the final image is obtained. Fig 4.3 shows the output image of ACO based MIX-CLAHE which is clearer.

Fig.4.3.Result of ACO based MIX–CLAHE technique (proposed enhancement method)

Fig 5.1 Other input image which shows the results of proposed technique (ACO based MIX-CLAHE technique).

Fig.5.1.Input image

Fig 5.2 shows the output of enhancement technique (MIX-CLAHE) for fig 5.1.

Fig.5.2.Enhanced image using MIX-CLAHE**.**

Fig.5.3. Proposed Enhancement Method (ACO based MIX-CLAHE).

IV. RESULTS AND DISCUSSION

The algorithm is applied using various performance indices peak signal to noise ratio (PSNR), Mean squared error (MSE) and Root Mean Square Error (RMSE).

In order to implement the algorithm, design and implementation has been done in MATLAB R2010a version 7 using image processing toolbox. The developed approach is compared against a well-known image dehazing technique. We are comparing proposed approach using some performance metrics. Result shows that our approach gives better results than the existing technique.

Mean Square Error

Table 1 is showing the quantized analysis of the mean square error. As mean square error needs to be reduced therefore the algorithm is showing the better results than the available methods as mean square error is less in every case. The mean Square error is reduced in each case. The method is tested on the number of images and in each case shows the better results than the existing method. For example in given table it is clearly shown that the 4, 7, 9 images have very much less MSE values so this technique work efficiently.

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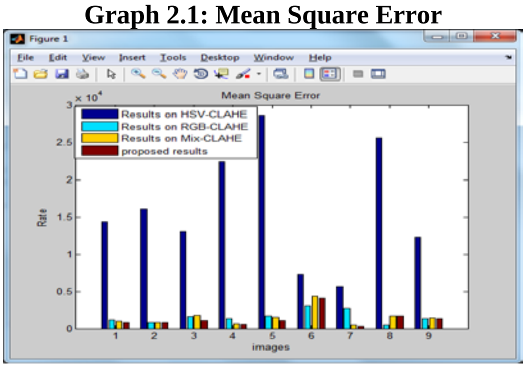
TABLE 1: MSE Evaluation

Images	Results on HSV-CLAHE	Results on RGB-CLAHE	Results on Mix-CLAHE	Proposed results
1	14309.70	1195.483	991.6318	823.4952
2	16005.32	832.2210	832.5355	817.2272
3	13060.62	1648.870	1762.560	1071.750
4	**22374.29**	**1389.822**	**696.1084**	**612.1575**
5	**28652.12**	**1700.179**	**1546.954**	**1088.406**
6	7278.215	3063.898	4309.123	4068.933
7	**5621.792**	**2644.050**	**519.6979**	**303.2442**
8	25560.98	485.3160	1729.360	1677.561
9	**7621.892**	**5944.350**	**577.6879**	**383.2842**
10	12207.08	1330.753	1467.562	1349.558

Graph 2.1 has shown the quantized analysis of the Mean Square Error of different images.

Graph 2.1: Mean Square Error



A. Root Mean Square Error

Table 2 is showing the comparative analysis of the root mean square error. Table has clearly shown that is less in our case therefore the algorithm has shown significant results over the available algorithm. The highlighted rows clearly had shown the better results of proposed techniques.

TABLE 2: RMSE Evaluation

Images	Results on HSV-CLAHE	Results on RGB-CLAHE	Results on Mix-CLAHE	Proposed results
1	**119.6232**	**34.5758**	**31.4902**	**28.6966**
2	126.5122	28.8482	28.8537	28.5872
3	**114.2831**	**40.6063**	**41.9829**	**32.7376**
4	149.5804	37.2804	26.3839	24.7418
5	169.2694	41.2332	39.3313	32.9910
6	85.3125	55.3525	65.6439	63.7882
7	**74.9786**	**51.4203**	**22.7969**	**17.4139**
8	159.8780	22.0299	41.5856	40.9580
9	115.9648	29.5158	3.5814	3.1788
10	110.4857	36.4795	38.3088	36.7363

Graph 2.2 has shown the quantized analysis of the Root Mean Square Error of different images. It is very clear from the plot that there is decrease in RMSE value of images with the use of method over existing method. This decrease represents improvement in the objective quality of the image

B. Peak Signal To Noise Ratio

Table 3 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Table 3 has clearly shown that the PSNR is maximum in the case of the algorithm; therefore algorithm is providing better results than the available methods. The method is tested on the number of images and in each case shows the better results than the existing method.

Graph 2.2: Root Mean Square Error

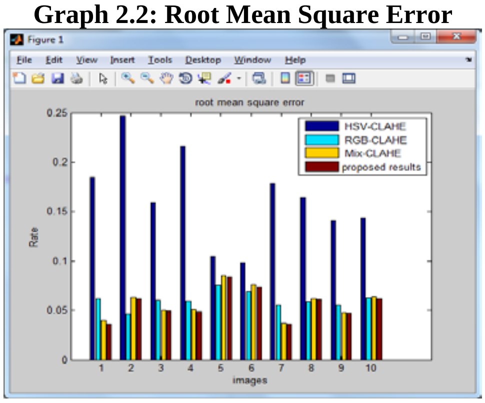


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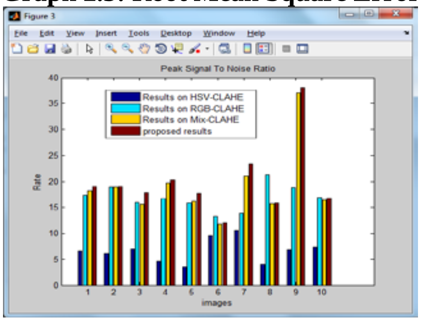
TABLE 3: PSNR Evaluation

Images	Results on HSV-CLAHE	Results on RGB-CLAHE	Results on Mix-CLAHE	Proposed results
1	6.5745	17.3554	18.1673	18.9742
2	**6.0882**	**18.9284**	**18.9268**	**19.0074**
3	**6.9712**	**15.9589**	**15.6694**	**17.8299**
4	**4.6333**	**16.7012**	**19.7040**	**20.2622**
5	3.5592	15.8259	16.2360	17.7629
6	9.5106	13.2681	11.7869	12.0360
7	**10.6321**	**13.9081**	**20.9733**	**23.3129**
8	4.0550	21.2706	15.7519	15.8840
9	6.8443	18.7297	37.0497	38.0855
10	7.2647	16.8898	16.4648	16.8289

Graph 2.3: Root Mean Square Error



Graph 2.3 has shown the quantized analysis of the Peak Signal to Noise Ratio of different images.. It is very clear from the plot that there is increase in PSNR value of images with the use of method over existing methods. This increase represents improvement in the objective quality of the image.

Conclusion

This paper proposed a new technique which basically used for underwater haze removal. The review analysis shows that underwater images are suffering from low contrast and low visibility. This paper has offered a new technique ACO based MIX-CLAHE which is integrated technique of MIX-CLAHE and ANT colony optimization. The proposed technique has been designed and implemented in MATLAB using image processing tool. The experimental results indicates that proposed technique offers better results as compare to available methods.

In near future, we use more quality metrics to judge the potency of the proposed technique.

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