Impact of Dehazing methods on AR marker detection

Abstract

The modern era of underwater AR development is constricted by the availability of efficient dehazing methods. Dehazing makes the AR marker detection precise and stable. In this paper we look at dehazing methods DCP,BCP,UICCS and evaluate their applicability in underwater AR scenarios. We propose a novel Fusion method combining the characteristics of BCP and DCP for better underwater dehazing.We have utilised different tools vis a vis RMSE,SSIM,UIQI,UIQM,PSNR for analysing the employability of the dehazing methods in underwater AR marker detection.

1. Introduction

AR (Augmented Reality) applications have scaled up and added tremendous functionality to a wide variety of Industries including but not limited to Healthcare, Gaming, Art, Culture, Machine Maintenance, Tourism and many more. However, there is little development in the underwater AR applications sector, prominently due to the absence of efficient, reliable and fast paced real-time image processing methods to detect and remove the underwater haze accurately. The goal of this paper is to study a reliable image processing method and test it in real-time underwater environment and analyse its employability in underwater scenarios

AR applications are limited by two things in the modern Industry, Processing power and image quality. In any condition less than ideal the AR applications face unexpected errors and the desirable end result is not obtained. The variability of atmospheric conditions severly limit the scope of AR applications. The presence of hazyness in various real life environments severly impacts the usability of AR applications and directly affects its robustness. This impacts the monetary ability of the AR applications.The uncertainity in its output in various environments has degraded the investments of industries in the field.

In an ideal operation of taking a picture of an object we assume that the light rays reflected from the object is captured by the sensor of our camera and we obtain a crisp image with good contrast, color and sharpness. However, in various environments of operation there are various small objects scattered in the atmosphere which block the direct light rays reflected from the object and scatter them. The various objects that scatter the directly reflected rays lead to the presence of "hazyness" in the acquired picture. Dehazing aims to get an image as close as possible to the image obtained in the ideal conditions. Dehazing tries to remove the hazy component of the picture by application of various methods. One of the prominent methods to remove the hazyness from a picture is using the dark haze.

Markers are an important part of Augmented Reality. Use of markers have led to stable and accurate AR Applications. Underwater however, the markers are not clearly detected and their robustness is underutilized due to presence of heavy haze in the underwater body. The light particles are dispersed, blocked, absorbed and scattered by the impurities present in water body. This makes the use of Markers in Underwater AR Applications redundant. The utilization of dehazing algorithms and processes can make the marker detection accurate and precise. The image input is directly dehazed using various methods and this may lead to better AR application in underwater The above mentioned technique can be utilized in: Archeological exploration, Maintenance of large ships,Interactive underwater AR simulation

The rest of this paper is organized as follows. In section II, related work is discussed. DCP,BCP,UICCS and fusion methods are discussed in section III. Section IV analysis of results are demonstrated. Finally, section V concludes the paper.

2. Related work

The various Dehazing methods can be widely divided into two major types.Image enrichment and Image restoration. Furthermore, the Image restoration methods can be divided into two types, namely Single Image methods and Multiple Image methods Single image methods utilise a single image as input and they are usually fast paced solutions. However, they are not reliably accurate.

The other type of methods utilised in Dehazing utilise multiple images as input. These images are enhanced at the raw format by passing through various filters and it forms the inference systems of these methods. These types of methods are highly effective and their data retention is respectable.

2.1. Image Enhancement Methods

Normalized correlation. Normalized correlation is a realistic assets of similarity (1992) By Brown Normalized correlation of alerts is unwavering to nearby adjustments in suggest and contrast. When we took alerts are linearly associated o their, their normalized correlation is 1. When the 2 indicators are not linearly related still they have one thing to take in consideration and that thing is but do incorporate similar spatial variations, normalized correlation can be nonetheless yield a cost close to unity (Irani, 1996). The lack of so many capabilities in underwater imagery before encompass indirect feature based methods, and experimental proof or you could say that results from the experimentation suggests that direct correlation based techniques yield good effects. It employs a completely close neighborhood normalized correlation to discover actual correspondence between pix or Pictures . The shape of the neighborhood normalized correlation surfaces will be concave and have a prominent top is at the proper displacement. It fits a quadratic floor close to the floor top and analytically check for concavity (Mandelbaum, 1999) as a way of outlier rejection.

Contrast Limited Adaptive Histogram Specification. The propagation of light underwater abide from fast attenuation and intense scattering. These become in compounding with the constrained camera-to-light separation available on most of the underwater imaging platforms, places intense boundaries on underwater imagery. To cope with the lights artifacts of non-uniform illumination and low assessment underwater imagery, It additionally relatively makes use of the classical techniques relared with evaluation limited adaptive histogram equalization (CLAHE) (Zuiderveld 1994). With this technique the photo is fragmented up into sub-regions. The most effective grey scale distribution is calculated for every such a sub-regions, primarily based upon its histogram and a previously determined transfer function, which is based totally upon the preferred histogram of the sub-region. Then, each pixel of the image is adjusted primarily based upon interpolation between the manipulated histograms of the neighboring sub-regions. This method has counseled that the model of a Raleigh distribution is most suited for underwater imagery

2.2. Image Restoration methods

Single Image Methods.

- Galdran at el.Citer1 bring a method to remedy the colliding advert noise trouble simultaneously and forward a likely kernel length de-scattering technique after de scattering a few halos and artefacts remain within the image a slight attenuation inversion after processing the rgb color place contraction the usage of quaternions. An underwater photo first-rate evaluation is also crucial to measure the overall performance of various underwater image processing techniques the important draw-back is that histogram equalization to address non uniform lighting fixtures and haze. In many instances nearby histogram equalization to deal with non-uniform lights and haze usually local histogram equalization does not perform well in very darkness

- Lu et al cite proposed a unmarried picture dehazing method the use of depth map refinement. The improved bilateral filtering can easy the depth map, at the same time as there are some residual noises exist at the photograph. As a mild absorption approach Torres-mendez et al proposed a Markov random filed mrf learning technique to estimate the associated coloration price of every pixel of hyper spectral imaging and mathematical balance model to evaluate the attenuation coefficients the use of depth map.

- Zuiderveld et al cite proposed evaluation constrained adaptive histogram equalization (CLAHE) to alter the goal region in keeping with an interpolation among the histograms of neighbouring regions. However, non-uniform slight remains at the processed image, as it operates on neighborhood regions instead of whole image. Inspired by way of HDR imaging, in excessive turbid water, the espouse fusion technique can't cast off the scatter well.

- Liut el a citer4 measured the PSF and MTF of seawater in the laboratory via the image transmission concept and used Wiener filters to repair the blurred underwater snap shots. The degradation feature is measured in a water tank. An test is constructed with a slit 4 photo and a mild source. In a primary step, one dimensional mild depth distribution of the slit snap shots at unique water direction lengths is received. The one dimensional PSF of sea water may be obtained thru the deconvolution operation. According to the assets of the circle symmetry of the PSF of seawater, the 2-dimensional PSF may be calculated through mathematical method. In a similar way, MTFs are derived.

Multiple Image Methods.

- Garcia et alcite on this paper, we tend to offered a whole review of underwater image process. we tend to divided the underwater photograph process techniques into 2 classes in step with their imaging sorts. the trendy day methods of the two categories were mentioned and analysed intimately. For software- based underwater image process, wavelength compensation approach, e.G. physical version, non- physical version and shade reconstruction technique are mentioned. Finally, the fine assessment methods and destiny tendencies are summarized. one among the leading techniques refers to bcc estimation that changed into evolved earlier

- Cifuentes et alcite used as a body work eco estimate physiological factors concerning the carrying capacities in monte hermoso seashore this frame paintings estimates the maximum quantity of human beings that an area can support considering Its physical and management conditions as said above 3 tiers of sporting capacities are stated bodily sporting functionality percent real sporting potential rcc and effective sporting ability five p.C considers the most restrict of site visitors in space during a specific time rcc is maximum restriction of site traffic within the area during a particular time rcc is the maximum range of site visitors that could support primarily based mostly on rcc and management capability PCC=A/Au * Tf Where a is the size of the look at location Au represents the region availability and Transfer feature is the amount of times that someone is able to visit the vicinity in an afternoon A in truth may also variety widely consistent with tidal situations in the have a look at reportedly right here we don't forget the worst case scenario that is location in excessive tide .The occupancy standards were based totally on the version installed through normacubana which considers three possible situation

3. Single Image Dehazing Methods

4. Single Image dehazing methods

4.1. Underwater Image Restoration Using UICCS Method

The primary attributes of an image are its colorfullness, sharpness and contrast. This method seeks to evaluate these core attributes of the image and enhance them. The enhancement of the attributes are done by a formula by giving weightage to each core attribute. The formula is worked out for a given scenario by trial and error

The following are the key highlights of this method:

- The UICCS comprises a colourfulness measure (UICM), a sharpness measure (UISM), and a contrast measure (UICoM). Each attribute measure can be used separately for specific underwater image processing tasks.

- Several properties, consisting of luminance and comparison masking, the colour notion property, and relative contrast sensitivity, are incorporated in the formulations of the measures.

- Therefore, comparing with other exceptional measures used in existing underwater photograph processing algorithms, the UICCS has more potent correlation with human visible perception, and it effectively measures the underwater picture satisfactory in a entire and complete means.

- This approach is a simple method which gives 70 percent of records from the raw image handiest by adjustments of coloration, sharpness and contrast. .

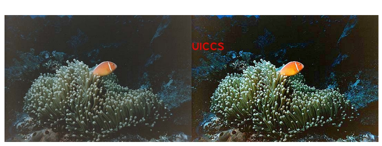

Figure 1: Sample UICCS Image

Figure 2: Sample UICCS Image

4.2. Bright Channel Prior (BCP)

The BCP underwater dehazing method changed into presented by way of Gao et al. (2016) and originates from a dehazing approach for atmospheric photographs superior in He et al. (2011). He et al. test that considered one of the coloration channels of a local vicinity in haze-unfastened pix has low intensity and phone this assumption the Dark Channel previous. Visible light with longer wavelength is absorbed more quickly, which results in underwater scenes being in general green or blue due to very low intensities of the red color channel. Because of this, the BCP method considers adjusted values of color channels. Haze Removal Procedure: • Estimate the Bright Channel • Improve Stability by rectified further Blended With Maximum Colour Difference images. • Restore Atmospheric Light • Transmittance (it describes the properties of the environment, which allows removing the haze from the image

$$J^{\text{bright},c}(x) = \max_{c\in\{r,g,b\}}\left(\max_{y\in\Omega(x)}(J^c(y))\right).$$

$$J^{\text{bright},c}(x) \to 1.$$

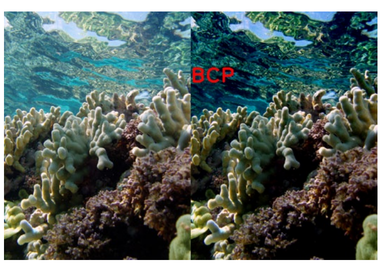

Figure 3: UICCS sample Image

Figure 4: UICCS sample Image 2

4.3. Dark Channel Prior (DCP)

DCP or Dark Channel Prior Dehazing Method: First step is Haze Imaging. Soft matting interpolation method is used to get high Quality Haze Free image. • Estimating Atmospheric Light is rearmost step to get High quality Haze Free image. • With the atmospheric light and the transmission , we can recover the scene radiance. • scene radiance is usually not as bright as the atmospheric light, the image after haze removal looks dim so Exposure is added. • A key parameter is the patch size ,On one hand, the dark channel prior becomes better for a larger patch size because the probability that a patch contains a dark pixel is increased. The step to define dark channel prior method , for the any image J, its dark channel J(dark) is given by:Following method

$$J^{\text{dark}}(\mathbf{x}) = \min_{\mathbf{y}\in\Omega(\mathbf{x})} \left(\min_{c\in\{r,g,b\}} J^c(\mathbf{y}) \right),$$

There was the observation on it that J in outdoor Haze free Image except the sky region the Intensity In the J's Dark channel is low and tend to zero.

$$J^{\text{dark}} \rightarrow 0.$$

The Dark channel prior essentially subtracts the dark parts of the Image. It does this by calculating the dark part from the luminescence provided by the atmospheric model. The patch size is varied according to the speed and ghosting that can be tolerated in the final output.

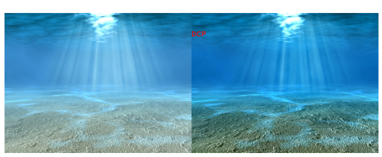

Figure 5: DCP sample Image

Figure 6: DCP sample Image

4.4. DCP And BCP Fusion

In this DCP(Dark channel Prior) And BCP(Bright channel Prior) Fusion Method we actually combine both Matrices of the Dark channel and Bright

Channel prior methods;This allows us to get a better image which combines the Dark part and the bright part of the image and removes the hazyness. When we perform BCP the hazyness is removed to a higher degree but we get a dark image.If we combine this image with its DCP counterpart we have now pieced back together the original image with almost negligible haze present.

The addition of DCP and BCP image matrices can be done with weights added. The values of these weights are found by trial and error Both Matrices are following:
BCP matrix:

$$J^{\text{bright},c}(x) = \max_{c\in\{r,g,b\}}\left(\max_{y\in\Omega(x)}\left(J^c(y)\right)\right).$$

$$J^{\text{bright},c}(x) \to 1.$$

DCP matrix:

$$J^{\text{dark}}(\mathbf{x}) = \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c\in\{r,g,b\}} J^c(\mathbf{y})\right),$$

$$J^{\text{dark}} \to 0.$$

Figure 7: Fusion sample Image

Figure 8: Fusion sample Image 2

5. Analysis of Dehazing methods

5.1. DCP(Dark Channel Prior)

Dark channel prior is the most versatile method for dehazing in underwater scenarios. The test images were divided into 4 groups viz a viz different underwater scenarios. Uiqm (underwater image quality measure , uiqi (underwater image quality index), psnr(peak signal to noise ratio) ,ssim(structural similarity index) ,rmse(root mean square error) were the different measures being used.

RMSE (root mean square error): The rmse value is observed to be very low among all the different dehazing methods across all 4 groups. The lower values indicate a strong absence of error in the images. DCP is the most sought out method as it has the least amount of error.

SSIM(structural similarity index): The ssim is used to represent if the modified image is structurally altered or not. A value of 0 is undesirable and a value close to 1 is sought after. The dcp method consistently gets the closest number to 1 across all the groups and is the most structurally similar method.

PSNR(peak signal to noise ratio): The psnr values signify the presence of noise in the final modified image. The higher number is attributed to more noise in the image and less value is attributed to lower noise levels. Therefore it is observed that dcp method has the highest pane signifying that it is not adapted to correct the noise. It is also noted that across all groups the dcp has the highest psnr showing that some noise elements may have been inserted by the DCP method.

UIQI(underwater image quality index): the uiqi is a combination of various measures which accurately reflect the quality of an underwater image. DCP across all groups has the highest uiqi value indicating its higher quality. The fusion method comes in a close second.

UIQM(underwater image quality measure): the uiqm is another underwater quality measure, it is observed that in this measure the dcp method lags behind. It consistently has the lowest scores across all the groups. It suggests that the uiqm measure which measures contrast , colourfulness and sharpness finds that dcp does not produce a quality image.

5.2. BCP(Bright Channel Prior)

Bright channel prior is the reverse method for dehazing in underwater scenarios. The test images were divided into 4 groups viz a viz different un-

derwater scenarios. Uiqm (underwater image quality measure , uiqi (underwater image quality index), psnr(peak signal to noise ratio) ,ssim(structural similarity index) ,rmse(root mean square error) were the different measures being used.
RMSE (root mean square error): the rmse value is observed to be very high among all the different dehazing methods across all 4 groups. The higher values indicate a strong presence of error in the images. Hence BCP is not the most sought out method as it has the highest amount of error
SSIM(structural similarity index):the ssim is used to represent if the modified image is structurally altered or not. A value of 0 is undesirable and a value close to 1 is sought after. The bcp method consistently gets the average number to 1 across all the groups and is the averaged structurally similar method.
PSNR(peak signal to noise ratio): The psnr values signify the presence of noise in the final modified image. The higher number is attributed to more noise in the image and less value is attributed to lower noise levels. Therefore it is observed that bcp method has the lowest level signifying that it is adapted to correct the noise. It is also noted that across all groups the bcp has among the lowest psnr showing that some noise elements may have been corrected by the BcP method.
UIQI(underwater image quality index): the uiqi is a combination of various measures which accurately reflect the quality of an underwater image. Bcp across all groups has the lowest uiqi value indicating its lower quality. The fusion method comes in at second.
UIQM(underwater image quality measure): the uiqm is another underwater quality measure, it is observed that in this measure the bcp method lags behind. It consistently has among the lowest scores across all the groups. It suggests that the uiqm measure which measures contrast , colourfulness and sharpness finds that bcp does not produce a quality image.

5.3. DCP AND BCP Fusion

Fusion(DCP+BCP): Fusion is the combination method for dehazing in underwater scenarios. The test images were divided into 4 groups viz a viz different underwater scenarios. Uiqm (underwater image quality measure , uiqi (underwater image quality index), psnr(peak signal to noise ratio) ,ssim(structural similarity index) ,rmse(root mean square error) were the different measures being used.
RMSE (root mean square error): the rmse value is observed to be av-

erage among all the different dehazing methods across all 4 groups. The average values indicate a presence of error in the images. Hence Fusion is not the most sought out method as it has error

SSIM(structural similarity index): the ssim is used to represent if the modified image is structurally altered or not. A value of 0 is undesirable and a value close to 1 is sought after. The fusion method consistently gets above average number to 1 across all the groups and is the above averaged structurally similar method.

PSNR(peak signal to noise ratio): The psnr values signify the presence of noise in the final modified image. The higher number is attributed to more noise in the image and less value is attributed to lower noise levels. Therefore it is observed that fusion method has the below average low level signifying that it is Not adapted to correct the noise. It is also noted that across all groups the fusion has among the lowest psnr showing that some noise elements may not have been corrected by the Fusion method.

UIQI(underwater image quality index): the uiqi is a combination of various measures which accurately reflect the quality of an underwater image. Fusion across all groups has one of the highest uiqi value indicating its higher quality.

UIQM(underwater image quality measure): the uiqm is another underwater quality measure, it is observed that in this measure the fusion method is second to only uiccs method. It consistently has among the highest scores across all the groups. It suggests that the uiqm measure which measures contrast , colourfulness and sharpness finds that fusion produces a quality image.

5.4. UICCS

Uiccs is the novel method made by combining contrast , colourfullness and sharpens enhancement for dehazing in underwater scenarios. The test images were divided into 4 groups viz a viz different underwater scenarios. Uiqm (underwater image quality measure , uiqi (underwater image quality index), psnr(peak signal to noise ratio) ,ssim(structural similarity index) ,rmse(root mean square error) were the different measures being used.

RMSE (root mean square error): the rmse value is observed to be high among all the different dehazing methods across all 4 groups. The high values indicate a presence of error in the images. Hence Uiccs is not the most sought out method as it has error.

SSIM(structural similarity index): the ssim is used to represent if the

modified image is structurally altered or not. A value of 0 is undesirable and a value close to 1 is sought after. The fusion method consistently gets average number to 1 across all the groups and is the averaged structurally similar method.
PSNR(peak signal to noise ratio): The psnr values signify the presence of noise in the final modified image. The higher number is attributed to more noise in the image and less value is attributed to lower noise levels. Therefore it is observed that uiccs method has the below average low level signifying that it is not adapted to correct the noise. It is also noted that across all groups the uiccs has among the lowest psnr showing that some noise elements may not have been corrected by the Fusion method.
UIQI(underwater image quality index): the uiqi is a combination of various measures which accurately reflect the quality of an underwater image. Uiccs across all groups has one of the highest uiqi value indicating its higher quality.
UIQM(underwater image quality measure): the uiqm is another underwater quality measure, it is observed that in this measure the uiccs method is the best method. It consistently has among the highest scores across all the groups. It suggests that the uiqm measure which measures contrast , colourfulness and sharpness finds that uiccs produces a quality image.

Table 1: Evaluation of Different Dehazing methods(using average value of all groups)

Dehazing Method	Evaluating tool			
	UIQI	PSNR	SSIM	RMSE
DCP	0.793	24.469	0.882	16.008
BCP	0.428	13.849	0.545	53.517
FUSION	0.760	15.647	0.725	42.772
UICCS	0.748	15.849	0.634	46.140

6. Conclusion

The various methods of dehazing vis a vis DCP , BCP, Fusion and UICCS were studied thoroughly and implemented on a test set of images and videos. The results were quantised using different methods vis a vis PSNR, SSIM,UIQI,RMSE and analysed. The various methods were tested with AR marker detection by comparing their ssim and uiqi results. It is evidently found that Fusion is the best method for getting a better quality image as shown by its score in UIQI,SSIm and PSNR scale. In the AR detection, fusion method involves heavy processing and thus without a proper pipelined architecture it renders AR at very low frames. The UICCS method is the fastest one with higher frame rates throughout. AR marker recognition and detection highly depends on the structural quality of the frame. The DCP and fusion methods render the most bright and accurate image, most feasible for underwater AR detection.

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