UNDERWATER IMAGE ENHANCEMENT BY WAVELENGTH COMPENSATION AND DE-HAZING

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Abstract— Pictures captured are very much helpful for research. Underwater photography is done to know about the underwater environment. These images would be degraded with low contrast and also, colorcast decrease the accuracy rate of underwater object detection and marine biology recognition. To overcome these limitations Image processing is done with de-hazing and contrast enhancement algorithms. This is built on a minimum information loss principle to restore the visibility, colour and natural appearance of underwater images. In this project super resolution and de-scattering methods based on ambient light and transmission map estimation of underwater images are used. A contrast enhancement algorithm which is based on histogram distribution is used, this increases the contrast and brightness of underwater image. Here MATLAB is used for simulation.

Keywords—Dehazing, enhancement, de-scattering, histogram

I. INTRODUCTION

Water is a strong attenuator of electromagnetic radiation, so with satellites can map entire planets from space using cameras and laser ranging, underwater vehicles must be within hundred meters at best for optical sensors to be useful. While mechanical waves travel well through the water, there are some practical trade-offs between source strength, frequency, and propagation distance. Sonars which are in-build on ships use lower frequencies to reach the bottom, but these use longer wavelengths which come at the price of reduced resolution. To map fine-scale features relevant to many practical applications, both optical and acoustic imaging platforms must operate relatively close to the seafloor. To overcome these difficulties, we use optical imaging because it captures the color and texture information, useful for distinguishing habitats and organisms.

An underwater photograph not only captures the scene of interest, but is an image of the water column as well. Attenuation of light underwater is caused by absorption, a thermodynamic process that varies nonlinearly with wavelength, and by scattering, a mechanical process whereby a photon’s direction is changed. At increasing depths, ambient light is attenuated which brings in much difficulty where colors can no longer be distinguished and eventually only darkness can be recognised. Artificial light sources must be used subsequently to illuminate the scene, but these sources contribute to scattering and also can introduce beam pattern artifacts in the image. In summary, uncorrected underwater imagery subsequently contains non-uniform illumination, reduced contrast, and colors that are saturated in the green and blue channels.

It is often desirable for an underwater image appear to be taken in air, which would be useful either for aesthetics or for a pre-processing step for automated classification. Methods range purely from post-processing techniques to novel hardware configurations, and the choice depends heavily on the imaging system, the location, and the goals of the photographer.

In this paper, we propose a super resolution (SR) of underwater images, to overcome the high-frequency information loss during de-scattering. Consequently, we have proposed a novel high turbidity underwater image SR algorithm. We have applied a convex fusion rule for recovering the final HR image. The super-resolved images have a reasonable noise level after de-scattering and demonstrate visually more pleasing results than conventional approaches.

The organization of the paper is as follows. In Section II, basic concepts along with the underwater imaging proposed in the earlier literatures have been discussed. The proposed methodology is presented in Section III. The simulation results has been presented in Section IV. Finally, the paper is concluded in Section V.

II. RELATED WORKS

Hitam, M.S et al. [1] has been worked on "Mixture contrast limited adaptive histogram equalization for underwater image enhancement.". Thus by improvising the quality of an underwater image which has been received substantial attention due to rundown visibility of the image which is caused by physical properties of the water. A new technique called hybrid Contrast Limited Adaptive Histogram Equalization (CLAHE) color spaces that has been developed for underwater image enhancement. The technique operates CLAHE on RGB and HSV color spaces. The results are joint together using Euclidean rule. Tentative results prove that the future approach considerably improves the visual quality of
underwater images by enhancing contrast, as well as dropping noise and artifacts.

Shamsuddin, N et al. [2] developed a technique on "Significance level of image enhancement techniques for underwater images". Underwater imaging is fairly a demand in the area of photography especially for low resolution and digital camera. There are some problems that arise in underwater images such as low contrast, non identical lighting, blur, intense artifacts, color diminishing and noise. This research concentrated on color diminishing. Major applications of typical computer vision techniques to marine imaging techniques are mandatory in dealing with those problems. The stretched histogram uses both manual and automatic method for image enhancement.

Ying-Ching Chen et al [3] researched on "Underwater Image Enhancement by Wavelength Compensation and de-hazing ". In this light scattering and color modification are two main sources in alteration for underwater image shooting. Light scattering is affected by light activities on objects both reflected and deflected many times by particles present in water prior to reaching the camera. This lowers the visibility and contrast of the image captured. Color change corresponds to the unstability in degrees of reduction encountered by light traveling in water with diversified wavelengths, depiction of ambient underwater environments conquered by a bluish quality. This literature proposed a novel systematic approach to improve underwater images by de-hazing algorithm and to give back the attenuation difference along the broadcast path, and to take the pressure of the possible presence of a false light source into consideration. Previously the deepness map, i.e., distances between the object and the camera is expected on the foreground and background within a view that are segmented. Thus by managing the effect of artificial light, haze occurrence and inconsistency in wavelength attenuation along the underwater broadcast path to camera are corrected. Secondly, the water deepness in the image scene is predictable, according to the remaining energy ratios of diversified color channels obtained in the background light.

Jinbo Chen et al [4] proposed that "A detection method based on sonar image for underwater pipeline tracker". The surveillance of underwater pipelines are carried out by operators who drive a remotely operated underwater vehicle (ROV) with camera mounted on it. Though in extremely coagulated water, the camera cannot capture all scenes, even with additional high-intensity light. The optical detection devices are unable to complete the surveillance task. In recent years, sonar is broadly applied to the underwater examination, which is not subject to the control of light and turbidity. Hence it is appropriate for the inspection of pipelines. But the current change of ROV by the water flow will show the way to the aim to escape from the sonar image effortlessly. In adding up, the sonar image with high noise and little contrast it is difficult for the operators to identify the pipeline from the image. Therefore, the observation of underwater pipelines is deadly and time constraint and it is easy to make mistakes due to the exhaustion and interruption of the operator. Thus, the study focuses on improving image processing algorithms to distinguish the pipeline continuously. By means of proposed image processing technique, firstly the images are improved using the Gabor filter and then these images are useful for an edge detector. Lastly, the parameters of the pipelining are designed by Hough transform. To desize the search area, the Kalman filter is explored to forecast the parameters of the pipeline on the upcoming picture. Thus the research is shown through vision system is on hand to the observation of underwater pipelines.

Iqbal, K et al [5] worked on "Enhancing the low quality images using Unsupervised Color Correction Method". The affected underwater images reduces contrast and non-uniform color cast because of the absorption and scattering of light rays in the marine environment. For that they proposed an Unsupervised Color Correction Method (UCM) for underwater image quality enhancement. UCM is based on color matching, contrast improvement of RGB color model and HSI color model. At first, the color casting is concentrated on equalizing the color values. In this case an improvement to a contrast alteration method is useful to increase the Red color by stretching red color histogram towards the utmost. Wisely the Blue color is concentrated by stretching the blue histogram to the minimum. Finally, the Saturation and Intensity parts of the HSI color model have been useful for contrast correction to enlarge the true color using Saturation and to address the illumination problem through Intensity.

III. PROPOSED METHODOLOGY

Underwater images are degraded due to scattering and absorption, this causes low contrast and color distortion in image. In this project, we propose a super resolution (SR) of underwater images is proposed. The traditional approach of preprocessing the image using an SR method, has the limitation that most of the high-frequency information is lost during descattering. Consequently, we propose a novel high turbidity underwater image SR algorithm. A convex fusion rule is applied for recovering the final HR image. The super-resolved images have a reasonable noise level after descattering and demonstrate visually more pleasing results than conventional approaches.

The principal idea of image super resolution is to reconstruct an HR image using interpolation and reconstruction of LR image patches, learning, and indexing for the best matching patches as the HR map. In this paper, we focus on a single-image SR method. As mentioned in the introduction, according to the source of training data, single-image SR can be summarized to 3 principal categories.
1) EXTERNAL DATABASE-DRIVEN SR

These kind of methods use learning algorithms to study the LR-HR mapping from an existing LR-HR database. There are many learning algorithms for super-resolving LR images, such as nearest neighbor, kernel ridge regression, sparse coding, manifold learning, and CNNs. The principal challenge is how to model the patch space effectively. Instead of studying a global mapping over the entire database, some models attempt to reduce computational complexity by partitioning or pre-clustering the external database. Other approaches such as dimensionality reduction and higher-level features extraction are also used for learning LR-HR mapping.

2) INTERNAL DATABASE-DRIVEN SR

Glasner et al. proposed a self-similar patch-based SR algorithm using a natural statics model. Freeman and Fattal determined further that self-similar patches is existed in spatial neighbor patches. Gao et al. λrst introduced sparse neighbor embedding for searching self-similar patches. Singh et al used the self-similarity ideas for solving noisy image SR.

3) UNIFIED DATABASE-DRIVEN SR

Singh and Ahuja proposed a sub-band texture patterns similarity-based method for SR. Zhu et al used optical low-based patch deformation as a dictionary searching rule. Huang et al. proposed a transformed self-exemplars method for single-image SR. Textures can be recovered well through the use of geometric variation.

PROPOSED ALGORITHM

1. Initial
   Estimate \( \Gamma \) by using NLM to denoise input image \( Y \).
   Estimate transmission \( t \) and ambient light \( A \) from \( \Gamma \) using color lines.
   Descatter \( \Gamma \) through an underwater dark channel prior.
2. Second round estimation of \( \Gamma \).
3. Iterate between the estimates for \( \Gamma \) and \( B \) until the minimum mean square error (MSE) is reached.
   While \( \text{MSE} \geq \text{MSE min} \)
   do:
   Estimate \( \Gamma \) using \( B \) (Eq. 1)
   Estimate \( B \) using \( \Gamma \) (Eq. 2).
   end while

**Figure 1:** PROPOSED FLOWCHART

Considering that scattering and noise are included in underwater imaging, the observation model is

\[
Y_\lambda(x) = DL \lambda(x) + n, \lambda \in \{r, g, b\} \tag{1}
\]

where \( Y_\lambda(x) \) is the LR underwater image, \( \hat{I}_\lambda(x) \) is the HR underwater image, the matrices \( D \) and \( L \) represent down sampling and blurring, respectively, and \( n \) is the noise generated.

The SR reconstruction problem is to estimate the underlying HR image \( \hat{I}_\lambda(x) \) of \( Y_\lambda(x) \). We assume the noise to be independent and identically distributed (I.I.D.), with variance \( \lambda^2 \).

Considering that the HR image \( \hat{I}_\lambda(x) \) contains scatters, (1) can be written as

\[
\hat{Y}_\lambda(x) = DL \left( J_\lambda(x) \hat{f}_\lambda(x) + (1-f_\lambda(x))A_\lambda \right) + n, \lambda \in \{r, g, b\}
\]

where \( J_\lambda(x) \) is the clean image, \( \hat{f}_\lambda(x) \) is the transmission map, and \( A_\lambda \) is the ambient light. Assuming that the ambient light and transmission map are known.

Non-local means (NLM)

Non-local means is an algorithm in image processing for image denoising. Unlike "local mean" filters, which take
the mean value of a group of pixels surrounding a target pixel to smooth the image, non-local means filtering takes a mean of all pixels in the image. Weighted by how similar these pixels when compared to the target pixel. This results in increased post-filtering clarity, and less loss of detail in the image compared with local mean algorithms.

If compared with other well-known de-noising techniques, non-local means adds "method noise" (i.e. error in the de-noising process) which looks more like white noise, which is desirable because it is typically less disturbing in the denoised product. Recently non-local means has been extended to other image processing applications such as de-interlacing and view interpolation.

Transmission Map Estimation

The estimation of transmission map is the most important step for foggy scene rendering and consists of image segmentation, initial map estimation based on MRF, and refined map estimation using bilateral filter.

The transmission map describes the portion of the light which is not scattered and reaches the camera. Since the map is a continuous function of depth, it thus reflects the depth information in scene. Koenderink experimentally measured the human’s ability to infer depth from an image, which shows that people cannot determine the relative depth of two points unless there is some visible and monotonic surface that connects them. Therefore, image segmentation technique is further used for estimating the transmission map and enhancing our knowledge towards image structure. The advantage of this technique is that it can also group large homogeneous regions of the image together while dividing the heterogeneous regions into many smaller parts.

Mean-shift (MS) algorithm is used as a classical image segmentation technique which is also a robust feature space analysis approach. It significantly reduces the number of basic image entities, and due to the good discontinuity preserving filtering characteristic, the salient features of the overall image is retained. Besides this, it is also particularly important in the partitioning of images, in which only several distinct regions are used in representing different scenes such as sky, mountain, building, lake, and animal, whereas other information within a region is often less important and can also be neglected. All these features are very much useful for acquiring the relative depth in information of scene objects. Thus, MS method is used as the first step to estimate the transmission map. Ambient Light Estimation

The first step applied to the proposed change detection process focuses on correcting the differences in ambient illumination. Variations in global luminance when no other changes occur are accurately detected with the use of image histograms. A change in the global illumination of an image causes shifting of its histogram towards brighter or darker regions. Therefore, one may expect that, with no content changes present, all pixels of the histogram of the image difference would concentrate in one peak. In practice, the noise effect dictates that the largest percentage of pixels will spread in a region around the histogram peak. The extent of this region depends on noise variance.

In real conditions, the difficulty that a change detection application encounters in luminance normalization is the fact that it needs to perform tracking of ambient luminance variations when both illumination and content changes exist. It is possible that content changes will introduce additional peaks to the histogram of the image difference. In such cases, plain peak detection does not suffice. It is based on the assumption that there’s no content change that occupies more than half of the image plane and causes homogeneous change of brightness to its entire extent at the same time. This assumption is valid in most cases and fails in the exceptional case of large objects with homogeneous luminance covering regions of also homogeneous luminance. The noise influence dictates that a large percentage of the image difference pixels will be strongly concentrated to a region around the peak of the histogram with index that lies close to the luminance offset. Therefore, one may take advantage of the fact that the peak corresponding to the luminance offset will be characterized by larger pixel concentration compared to peaks caused by content changes. Consequently, instead of the amplitude of a specific peak of the dress the issues of light temperature change and a problem of unequal change of ambient.

The proposed technique in the present the histogram, the amount of pixels concentrated to its neighbourhood is considered a reliable criterion for luminance difference detection. The aforementioned process can also be used to ad white balance readjustment. These scenarios represent minance between the colour channels, therefore they constitute a problem of a similar nature. In order to cope with such changes, it is enough to apply the luminance correction technique on each colour channel of the image difference independently.

### IV. EXPERIMENTAL RESULT

<table>
<thead>
<tr>
<th>S.NO</th>
<th>DATA SET IMAGE</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANCUT3</td>
<td>27.837</td>
</tr>
<tr>
<td>2</td>
<td>ANCUT11</td>
<td>27.7510</td>
</tr>
<tr>
<td>3</td>
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<td>27.3421</td>
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<tr>
<td>4</td>
<td>REEF1</td>
<td>20.57</td>
</tr>
<tr>
<td>5</td>
<td>REEF2</td>
<td>22.36</td>
</tr>
</tbody>
</table>

Table 1: Experimental result
V. CONCLUSIONS

In this project, we presented SR method for recovering distorted images in high turbid water. We have overcome the noise or artifacts in high resolved scattered images. The HR image of scattered and de-scattered images is obtained using a self-similarity SR algorithm. Then, a proposed convex fusion rule is applied to recover the final HR image. The super-resolved images have a reasonable noise level after de-scattering and demonstrate visually more pleasing results than images obtained using conventional approaches. Furthermore, numerical metrics demonstrated that the proposed algorithm shows consistent image improvement, with significant improvement for the edges.

REFERENCES


