Smart Intelligent Computing and Communication Technology
V.D. Ambeth Kumar et al. (Eds.)

doi:10.3233/APC210055

Underwater Image Enhancement and Fish Detection

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Abstract. The oceans cover over 70 percent of the surface of the earth. Underwater images are vital to explore these oceans, but they are impacted by quality degradation. The quality degradation occurs mainly due to absorption and scattering of light in water. Degradation in underwater images is caused by problems like low contrast, haziness, colour deviation and blurring. This in turn has made it difficult to explore, study and unravel the mysteries of the oceans. Good quality images are vital to study and research about existing marine ecosystems and also to discover numerous undiscovered species present underwater. There are various dehazing, restoration and enhancement techniques available to improve this scenario. We in this paper look to study and analyse the idea of building a system to combine some of the dehazing, restoration and enhancement algorithms available to obtain quality enhanced images. Further the system would also perform fish detection to obtain better accuracy using the enhanced images. We go about studying and analysing the image outputs obtained from individual algorithms and combination of algorithms and look to open up a possibility of further study of combining restoration and enhancement algorithms to improve the quality of images. We have proposed the idea of adding fish detection to this system as there has always been a difficulty of identifying and differentiating fish from other objects and marine life in underwater images. Doing so would help in studying about and even discovering new species. The fish detection models suffer from the image qualitydegradation problems and it impacts the accuracy. Hence, we have brought about the idea to enhance images to improve the efficiency and accuracy of fish detection. Therefore, we propose a system which would have various dehazing, restoration and enhancement algorithms working in tandem to produce an enhanced version of the input image. Next, the enhanced image is used to improve the accuracy of fish detection. Our review of combining restoration algorithms with enhancement algorithms and analysing the improvement in accuracy of fish detection by enhancing would provide researchers to further look into the opportunities available for improvement.

Keywords. Scattering, Absorption, Restoration, Enhancement, Detection.

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1. Introduction

Numerous problems are present in underwater imaging. Water firstly is much denser than air. This leads to reflecting back of light in water[6]. Then, the amount of light entering starts reducing as we go deeper into the ocean. The colours also start to drop off depending on the wavelength as we go deeper underwater[1]. Initially, at depths of 3-5m, red and orange colours start disappearing. At a further depth yellow colour disappears and then finally green and purple colours start to disappear. This is the main reason why underwater images have a low contrast. Differentdehazing, colour restoration and enhancement techniques have already been proposed to improve the current situation. But, dehazing and colour restoration algorithms are only able to remove the basic haze in images. On the other hand, the enhancement algorithms provide improved contrast and visibility, but can cause colour distortions and also increase the noise present. Some of the other ideas proposed to improve the underwater image quality are too complex to implement in reality. Therefore, we have brought about the possibility of combining some of the existing dehazing, restoration and enhancement algorithms present to improve the overall image quality. In this paper we have analysed the effectiveness of the algorithms using a few image quality metrics. Different techniques and approaches have been proposed to detect fish[12]. Despite this, the accuracy of the model suffers if the quality of the image is low. Therefore, performing enhancement before detection would certainly improve the accuracy. We have performed fish detection using deep learning techniques. We have compared the effects of the different dehazing and enhancement algorithms on the accuracy of the fish detection model [13-14].

2. Proposed System

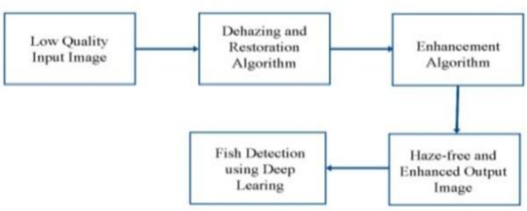

Figure 1.

3. Features of the ProposedSystem

3.1 Dehazing and Colour Restoration:

Algorithms tested and applied are:
a] Dark Channel Prior (DCP) [2]
b] Restoration based on Image Blurriness and Light Absorption (IBLA) [3]
c] Underwater Light Attenuation Prior (ULAP) for Underwater Image Restoration [4]

3.2 Image Enhancement:

Algorithms tested and applied are:
a] Contrast limited adaptive histogram equalization (CLAHE) [5]
b] Underwater Image Enhancement using Integrated Colour Model (ICM) [6]

3.3 Fish Detection:

We have performed fish detection using TensorFlow object Detection using faster R-CNN (Region based Convolutional Neural Networks) [7]. No. of fish correctly detected in input: -3;

Table 1. Image Quality Metrics And Number Of Fish Detected Correctly

Image 1	**IMAGE QUALITY METRICS AND NUMBER OF FISH DETECTED CORRECTLY** *Input: - BRISQUE = 48.994; NIQE = 3.804;*				
METHODS	**PSNR**	**SSIM**	**BRISQUE**	**NIQE**	**NO. OF FISH**
a) CLAHE	24.042	0.966	39.797	3.388	6
b) ICM	11.249	0.433	43.071	3.578	7
c) DCP	25.657	0.985	52.574	3.761	4
d) IBLA	8.607	**0.306**	44.834	3.181	2
e) ULAP	21.500	0.965	42.249	3.577	6
f) DCP+CLAHE	26.440	0.984	40.678	3.293	6
g) DCP+ICM	15.936	0.809	30.549	3.220	**8**
h) IBLA+CLAHE	19.551	0.765	30.783	3.191	3
i) IBLA+ICM	**48.547**	0.998	44.434	**3.024**	2
j)ULAP+CLAHE	20.076	0.925	**30.110**	3.519	7
k) ULAP+ICM	18.576	0.921	40.172	3.411	6

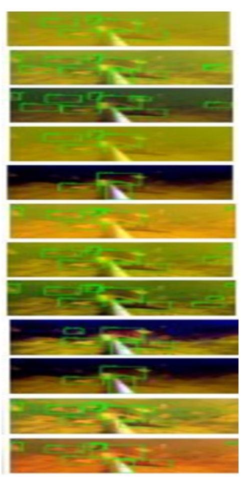

Figure 2.

4. Quantitative and Qualitative Analysis:

We have used two full reference (PSNR and SSIM)[8] and two no-reference (NIQE and BRISQUE) image quality metrics for analysis.

4.1 PSNR (Peak Signal to Noise Ratio):

A reference image is generally required which is treated as a ground truth image to calculate PSNR. Since we only have the distorted version of the image, it is used to compare with the enhanced version of the image to calculate the PSNR value. Higher the value of PSNR, lower is noise content and thus, higher the quality of image.

4.2 SSIM (Structural Similarity Index):

This metric is a technique used to evaluate the similarity between two images. The value of SSIM varies from 0 to 1. If the value is 0, the images are dissimilar while a value of 1 means the given images are identical. Since we do not have ground truth image, the improved quality images are compared with the low-quality input images. We require a value closer to zero as it would indicate that there has been an improvement in the quality of images leading to dissimilarity between the images.

4.3 BRISQUE (Blind / Reference less Image Spatial Quality Parameter):

This is a method which operates in the spatial domain and is a no-reference method quality assessment technique [9]. A default model is used to measure the quality of image. The lower the value, the better is the perceptual quality of the image.

4.4 NIQE (Natural Image Quality Evaluator):

This method is another No reference method by collection of some statistical features based on a space domain natural scene statistic (NSS) model [10]. The quality of image is concluded to be better if the value of NIQE is lower. We have obtained better values of NIQE for the enhanced images when compared to the low-quality input images.

For the image, the DCP + ICM combination detects a greater number of fish accurately Hence, despite obtaining much higher quality of images and improved fish detection accuracy from the system, it is difficult to identify the best performing combination of algorithms.

5. Conclusion and Future Work

The system proposed in this paper has used existing algorithms and methodologies, but tries to combine them for much better results. The systemopens up the possibility of being able to efficiently use combination of algorithms to obtain high quality underwater images which is useful for applications like fish detection. One drawback seen is the lack of efficiency of the image quality metrics. Despite the metrics helping us analyse the quality of images, there is a lot of variation between them for different datasets, which makes it difficult for obtaining conclusive results and evidence. Hence, there is a major scope in the future to come up with better metrics for better analysis purposes. Since there are large variations in the performance of different algorithms depending on the characteristics of the input image, research could be made in the future to calculate parameters like depth at which the image was captured. This may lead to some complexity, but might help in analysing which algorithm combinations would produce a better-quality output image for a certain given input image. Hence, it is the need of the hour to be able to come up with effective systems and models to improve the quality of underwater images to be able to explore deep parts of the ocean in a much more efficient manner.

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