Framework for Underwater Dataset Generation and Classification Towards Modeling Restoration

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Abstract

In this paper, we propose a framework for underwater dataset generation and classification towards modeling restoration. Underwater images suffer from low lightening conditions caused by depth and medium and are dependent on a factor called total illumination. Total illumination is the sum of atmospheric light and back scattered light during image capture. Atmospheric light reaches the object directly from the line of sight, unlike the diffused light that takes several indirect paths before reaching the object, resulting in haze formation. We propose to model this varying nature of light to generate synthetic underwater images based on depth information, towards restoration. Light attenuation modeling is represented in 3 folds. In first fold depth map of ground truth images are generated. Second fold includes introducing depth-based light attenuation. Third fold continues to add water and tint effect based on varying depths considering Jerlov standards. Synthetic data set generated is used to train KNN as a color classifier towards classification of real underwater images. The estimate of water type and depth can be used for restoration and enhancement of underwater images. Synthetic dataset generated through our model outperforms the current state of start considering depth-based light attenuation unlike the traditional methods that does not parameterize depth as input. We group the Jerlov water classes into 10 groups based on intutional similarity assisting restoration. We demonstrate the results of proposed framework on real underwater images, classified in 10 groups with increased accuracy.

1. Introduction

Restoration of underwater images is an ill-posed problem as the propagation of light in the euphotic region [8] of underwater differs from above water. The behavior of photons varies drastically in water as a medium, introducing haze, light attenuation, color attenuation, and blur resulting in low-quality data capture. The insufficient natural light in the underwater environment introduces the haze effect resulting in low-quality capture. Typically haze is modeled as an additive noise thereby ignoring its multiplicative nature [3] [4]. Attenuation of light in an underwater environment increases with depth resulting in low-quality hazy images. Modeling haze, blur, light, and color attenuation for generating synthetic data [10] towards image restoration and enhancement is a challenging task. Traditional methods of modeling synthetic underwater image generation are with an inclination of introducing haze [5] as additive noise and light attenuation as a constant value depending on the color space [11]. Recently proposed image formation model makes prior assumptions on camera parameters like lambda [1] (Spectral Response of the camera) and beta (artificial light) values.

Towards this,

- We propose a framework for generation of underwater synthetic data and classification model to assist restoration, as restoration framework is dependent on depth and water type.
  - We propose to model depth based light attenuation and blur towards generation of synthetic underwater images.
  - We develop KNN color classifier using generated synthetic data towards classification of real time underwater images.
  - We further propose to model generative adversarial network for restoration using synthetic data, towards restoration of real time underwater images using the classification labels as inputs.
- We demonstrate results of the proposed framework using generated synthetic data-set and validate the same on real underwater data-set and show higher classification accuracy.

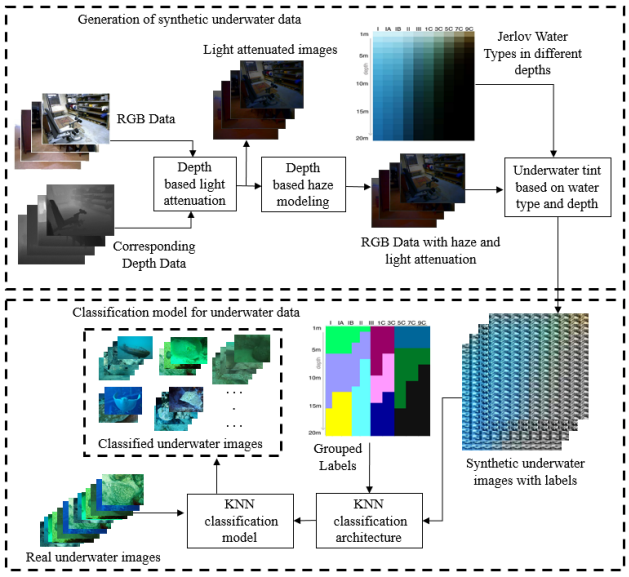

Figure 1. Framework for underwater dataset generation and classification

2. Framework for Underwater Dataset Generation and Classification

In this paper, we propose to generate synthetic data and then model K Nearest Neighbor(KNN) classifier towards classification of real data as shown in Figure 1. As proposed in image formation model [7] estimation of atmospheric light (A) and back scattered light β helps towards generation of synthetic data, estimating these parameters based on depth and water type facilitates underwater image restoration. Towards this, we propose to model synthetic data set generation and classification based on Jerlov water types and depths for restoration.

2.1. Synthetic Dataset Generation

We propose to model depth based light attenuation using NYU [6] depth data set. NYU depth data set provides R, G, B data and its corresponding depth information. We develop an algorithm to attenuate light and introduce blur based on depth information available.

Algorithm 1 : Underwater Dataset Generation Algorithm

Step-1:Read the input RGB-D image
Step-2:Represent RGB data in YCbCr color space.
Step-3:Attenuation of light in Y channel based on depth.
Step-4:Introduce Haze in Y channel based on depth.
Step-5:Accumulate YCbCr and represent into RGB space.
Step-6:Generate synthetic underwater image considering Jerlov water tint for 10 water types and 20 different depths.

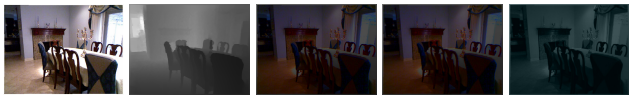

Figure 2. Generated synthetic underwater image; (left to right) RGB image, corresponding depth image, light attenuated image, image with haze and light attenuation, image with Jerlov tint.

2.2. Underwater Image Classification

200 classes of Jerlov water types are grouped into 10 distinct classes based on similarity. Classification of intra groups is challenging as it finds higher degree of mutual information in the underwater images. Towards this, we model the data into ten classes and design a classifier for estimating the water type and depth to assist restoration. Intutionally, similar restoration model works for each group of classes, and it is difficult to generalize a single restoration model across groups. We demonstrate the classification of underwater images into Jerlov water types using KNN classifier[12] for 10 distinct groups. KNN classifier is modeled using generated synthetic data. The estimations of Jerlov water type[2] and depth is used towards restoration and enhancement of underwater images.

3. Results and Discussions

Authors in [9] propose Nuissance classifier architecture to classify 10 Jerlov water type into six classes not for varying depths, as it finds challenges in differentiating between intra bed water types (Coastal and Ocean). Towards this, we show our results of 10 jerlov water types for 20 varying depths, total of 200 classes grouped into 10 classes using KNN classifier. 280 real world underwater images were tested on model trained using generated synthetic data with validation accuracy of 86.78 percent. Figure 2 shows visual representation of results obtained. The purpose towards designing classification framework is towards restoration and enhancement of underwater images.

4. Conclusions

In this paper, we have proposed a framework for generation of underwater synthetic data and classification model to assist restoration, as restoration framework is dependent on depth and water type. We have modeled depth based light attenuation and blur towards generation of synthetic underwater images. We have developed KNN color classifier towards testing of generated synthetic data along with validation of real time underwater images. We propose to use the synthetic data to model generative adversarial network for restoration of real time underwater images. We have demonstrated the results of the proposed framework using generated synthetic data-set and validate the same with real underwater data-set, and show higher classification.

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