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Underwater Image Classification

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Abstract

Underwater images are degraded by attenuation of light in water. Many enhancement techniques are proposed by researchers for underwater images. But no researcher provided classification technique for underwater images. The classification helps to select enhancement algorithm which is best suited for a particular class of image, so that unnecessary computation will be avoided. This paper proposed a technique for classification of underwater images. It classifies image into three classes as image with artificial light source, natural light deep water image or natural light shallow water image. Artificial light source images have non-uniformly illuminated bright area in the image, natural light deep water images are hazy and dominated by greenish-blue hue where as natural light shallow images are full color hazy images. This proposed method extract luminance and hue features of image for classification. The method proposed in this paper works good for classification based on light source the misclassification percentage is only 10%. But classification based on depth, needs some improvement, as colored objects in the image misleads the classification. Major problem arises for natural light shallow water images. The method is discussed with examples of successful and misclassified images.

Keywords: Classification of underwater images, artificial light source, natural light source, deep water image, shallow water image.

1. INTRODUCTION

Underwater images are degraded by scattering and absorption of light in water. The scattering is of two types forward scattering and backward scattering. Together scattering and absorption is called attenuation. This attenuation is affected by many parameters like salinity of water, chlorophyll concentration, pH, wavelength and depth etc. As depth increases underwater images looses it's colour one by one. Therefore deep underwater images are dominated by blue-green colour. As one go deeper the visibility also decreases because of lack of natural sunlight. Sometimes underwater images are captured using artificial light source to increase visibility in deep water. But this artificial light source itself introduce a problem of non-uniform illumination. So before providing solution to degradation of underwater images it is necessary to classify these images. This classification helps to select proper algorithm to enhance the degraded image. No researcher provided any such classification technique for underwater images.

Most of the literature for underwater image classification perform classification based on objects in the image i.e. application dependent. This paper classify images based on light source used and depth of scene in water where image has been captured. The technique classify images into three classes, image with artificial light source, natural light deep water image or natural light shallow water image. Rest of the paper is divided as, section 2 presents features extracted, section 3 describes method of classification, section 4 give discussion about results and section 5 give concluding remarks.

2. FEATURE

Input images are processed in two different color spaces, NTSC and HSV color space for feature extraction. The luminance value in NTSC color space decides source of light in image. The Hue value in HSV color space decides depth. These two features of image are used to classify image into three classes. This method perform hierarchical classification of low level features.

3. METHOD OF CLASSIFICATION

As discussed in section 2 the underwater images are classification based on its' luminance and hue value. The decision tree is given in figure 1.

3.1 Classification Based on Light Source (Artificial or Natural Light Source)

For classification of image based on the light source used to capture image, refer the image formation model given in Eq. (1) by Fattal[1]

$$I(x) = J(x)t(x) + A(1 - t(x)) \tag{1}$$

where I is observed image, J is scene radiance, t is transmission, A is atmospheric light and x is (x,y) pixel.

With the assumption that medium is homogeneous transmission t can be expressed by Beer's Lambert law[2] given as

$$t(x) = e^{-\beta d(x)} \tag{2}$$

β is scattering coefficient of medium and d is scene depth.

We can estimate t based on Eq. (1) as discussed by P. Drews-Jr et al [3] given in Eq. (3)

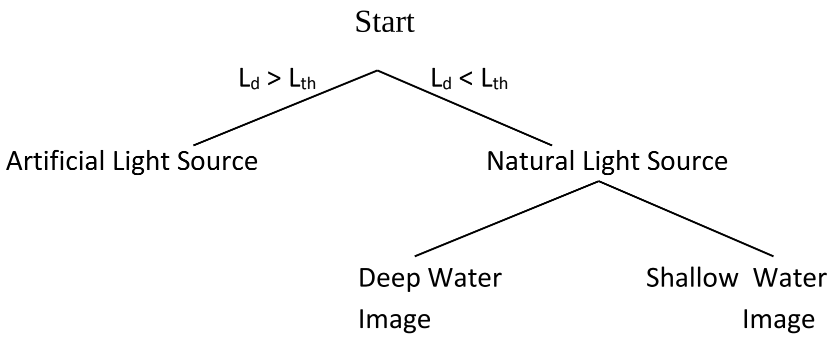


Figure 1. Decision Tree for classification

$$\tilde{t}(x) = 1 - \min_{y \in \sigma(x)} \left(\min_{c \in G,B} \frac{I^c(y)}{A^c} \right) \tag{3}$$

where, σ(x) is patch size and c is colour channel. Transmission map is then refined by matting technique given by He et al[5].

The existence of artificial light source can be determined as given by Eq. (4) by using average luminance of foreground and background as given by Chiang and Chen[5].

$$area = \begin{cases} foreground, & L < th \\ background, & L \geq th \end{cases} \tag{4}$$

L is luminance and th is threshold. As given by Raimondo Schettini and Silvia Corch**s**[6] artificial light source produce bright spot at the centre with poorly illuminated area surrounding. So the difference in average luminance value for foreground $(L_f)$and background (L_b) given in Eq. (5)is large when artificial light source is present.

$$Ld = L_f - L_b \tag{5}$$

So underwater image is classified as image with artificial light source when Ld is more than threshold value L_{th}, otherwise it is classified as image with natural light source as follows.

$$Light\ Source = \begin{cases} Natural, & L_d < L_{th} \\ Artificial, & L_d \geq L_{th} \end{cases} \tag{6}$$

3.2 Classification Based on Depth (Shallow Water or Deep Water Image)

According to Raimondo Schettiniand and Silvia Corchs [6] as depth increases color drops of one by one. The loss of color depends upon wavelength therefore blue color travels longest because of its shortest wavelength. So underwater images are dominated by greenish blue hue. This dominating hue of underwater image can be used to classify image as deep and shallow water image.

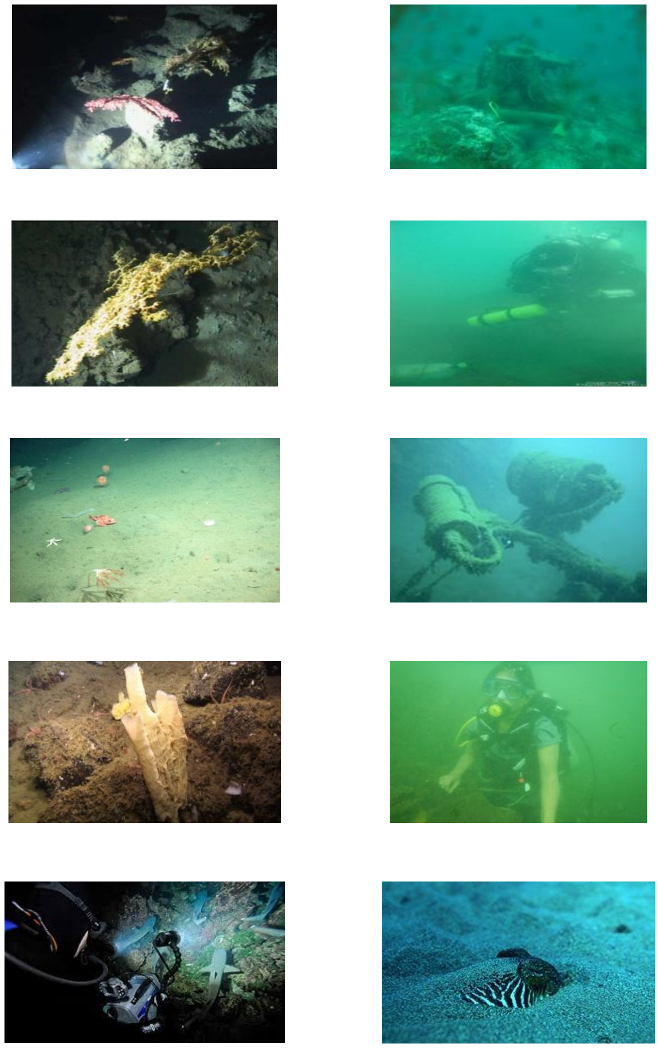
For this classification HSV model of image is used. Then average hue (H_{avg})value of image will decide depth of water. If it is less than threshold H_{th} then the image is classified as shallow water image otherwise deep water image as follows.

$$Depth = \begin{cases} Shallow, & H_{avg} < H_{th} \\ Deep, & H_{avg} \geq H_{th} \end{cases} \tag{7}$$

4. RESULTS & DISCUSSION

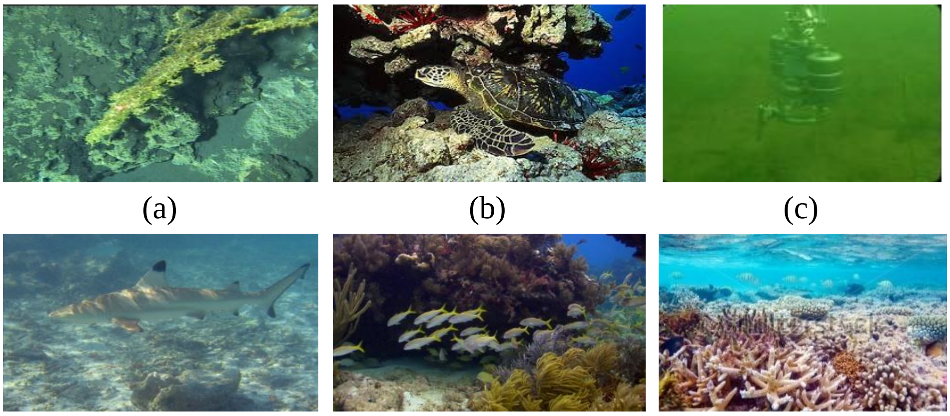
Luminance value decides source of light present in image and hue decides depth of water where image is captured. The image with greenish-blue hue is considered as deep water image otherwise it is shallow water image. Correctly classified images are given in figure 2.

There is high possibility of wrong classification of Natural Light Shallow Water images as Artificial Light images, because of similar features of the image this ambiguity is solved using this method. Figure 3 shows some wrongly classified images. In figure 3 (a) & (b) are images with artificial light source which are wrongly classified as images with natural light source. Image (c) in figure 3 is natural light deep water image which is wrongly classified as natural light shallow water image. Image (d), (e) & (f) in figure 3 are natural light shallow water images which are wrongly classified as deep water images.



(a) (b) (c)

Figure 2 Correctly Classified Images (a) Image with Artificial Light Source (b) Natural Light Source Deep water Image (c) Natural Light Source Shallow water Image



(a) (b) (c)

(d) (e) (f)

Figure 3 Wrongly Classified Images

4.1 Light source

Feature chosen for this classification is average luminance value. Only 10% of images are misclassified.

Table 1. Confusion matrix

Natural Light Source	Artificial Light Source	Classified as
50	08	Natural Light Source
00	22	Artificial Light Source

4.2 Depth

Feature chosen for this classification is average hue value. 30% of images are misclassified.

Table 2. Confusion matrix

Deep Water Images	Shallow Water Images	Classified as
19	16	Deep Water Images
01	14	Shallow Water Images

5. CONCLUSION

This is the first attempt made for classification of underwater images according to light source and depth of image. This classification method uses luminance and hue features for classification. This classification makes further processing of underwater images easier. From the results it is seen that classification method for light source gives good results. But for depth it needs to be improved, as with this method colors of the objects in the image may leads to wrong classification.

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