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ENHANCEMENT OF UNDERWATER IMAGING WITH THE ALGORITHM OF THE ADVANCED MULTI- SCALE RETINEX

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Abstract:-
For the problem of the absorbing and scattering for Red in underwater imaging, the AMSR is put awarded. The red information of the underwater imaging is read by Matlab. The image enhancement used by Advanced Multi-scale Retinex algorithm. The Advanced Multi-scale Retinex algorithm is with the truncation of k time's standard deviation and the figure between the parameter k and the sigma is made. The best k is got for the images of various depths and the best k is between 1 to 1.5. The result shows that the AMSR is good method of enhancement for underwater imaging.

Keywords: - *Image enhancement; Advanced Multi-scale Retinex algorithm; standard deviation*.

1 INTRODUCTION

With the high development of land resources, the acquisition of underwater resources has become an important topic. Light is scattered and absorbed by the molecules in underwater environment. The scattering effect is caused by suspended particles in the water, which reflect light in other directions and the blur image is got. There are forward scattering and backward scattering for the light. The former is scattering along the direction of incidence, and the latter refers to scattering in the opposite direction from the direction of incidence. In general, the forward scattering causes light to scatter at a small angle during transmission. The received light is diffused and the image is blurring. The background of fuzzy is caused by the backward scattering. The atomization effect of the underwater image is caused by the backward scattering [1]. The contrast and clarity of the underwater imaging are caused by the forward scattering and the backward scattering. Secondly, the absorption of light is caused by the medium in water, which will reduce the energy of light according to the wavelength of light, so as to reduce the image's contrast and visual range. The property of the absorption depends on the density of water and turbidity; such as the river compared with tap water, underwater object visibility is greatly reduced. The water absorption properties are different for different wavelengths of light. The absorption properties of the water medium are big for ultraviolet and infrared spectrum. The absorption is biggest for red spectra and light green spectra in the visible spectra [2].

There are many processing method for underwater images. They include the image enhancement technology based on wavelet transform, based on the neighborhood of space (like processing, Retinex algorithm), and based on pixel (such as underwater image enhancement method based on histogram adjustment, image enhancement method based on fusion). In them, the Retinex algorithm has good image enhancement effect [3-4], especially for the effect of color image enhancement [3-5], atomization image filtering [6], and the aviation image processing. The Retinex algorithm simulates the mechanism of human visual system to perceive the world. The word "Retinex" is combined with the prefixes of "Retina" and "Cortex". When a scene is dominated by a certain amount of light, it tries to keep the color constant, as is the case in underwater environments. Color constancy in the visual nervous system reduces changes in light through mechanisms in the retina and the cerebral cortex. Some researchers believe that color constancy is greatly affected by differences between adjacent human cone cells. Similarly, the traditional Retinex algorithm applies convolution to a local window by using a Gaussian filter to estimate the component of a light source.

Multi-Scale Retinex algorithm said MSR is a comprehensive algorithm of the several single-scale Retinex algorithm with small scale, middle scale, and big scale. For single-scale Retinex algorithm that is simplest Retinex algorithm, if the scale is too small the color of the enhanced image is distortion, if the scale is too big the detail of the enhanced image is not clarity. The MSR algorithm can effectively solve the contradiction between the detail clarity and the color distortion.

This topic is based on Multi-scale Retinex. The Advanced Multi-scale Retinex that said AMSR is put forward. For example, the first step it can read the information of the red channel by $I(i, j, 1)$, i 1: n, j 1: m . The second step the weight parameters of red (R), green (G), and blue (B) could be changed. The third step the truncation section of k times the standard deviation could be changed. The best enhancement image could be got with best k parameter [7].

2 Advanced Multi-scale Retinex algorithm

Retinex is put forward by E. Land in the 1960s. The basis of Retinex has three aspects. The first one is that we are in the world and there is no color, and the color is interaction between the light and the matter. The second one is that any color can be built by red, green, and blue. The third one is that the arbitrary unit area is determined by the color of red, green, and blue. The Retinex algorithm was established in the 1970s by Land and McCann. The Retinex algorithm simulates the feature of the human eye vision system, and the enhancement effect of color image. The theory of the Retinex algorithm is that any image I can be decomposed into two images:

Reflection image R and incident image L as shown in figure 1.

$$I(x, y) = L(x, y) \times R(x, y) \quad (1.)$$

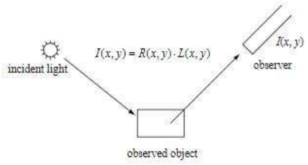


Figure 1 The basis idea of Retinex algorithm Figure 2 The shooting scene

Because the sensibility of the human eye has the logarithm property, formula (1) can be written as

$$\log[R(x, y)] = \log[L(x, y)] - \log[I(x, y)] \quad (2)$$

In formula (2), $L(x, y)$ is written as

$$L(x, y) = F(x, y) * I(x, y) \quad (3)$$

In formula (3), symbol "*" is convolution operation, the centered around function $F(x, y) = K \cdot \exp[\frac{-(x^2 + y^2)}{\sigma^2}]$.
Is Gaussian low-pass filterfunction. When the standard deviationσis small the details of the enhanced image can be grasped. When the standard deviation σ is very small the color of the enhanced image can be distorted.
The Multi-scale Retinex algorithm selects the small scale, middle scale, and big scale, so it is better than simple Retinex algorithm.

$$R(x, y) = \sum_{i=1}^{K} W_i R_i(x, y) \quad (4)$$

In formula(4), 11=∑=KiiW. In them, Kis the number of the scale. If K=1 the MSR backs to Retinex algorithm. To keep thebalancebetween thedetails and colorof the enhanced image, the small scale (50<σ), middle scale (10050<≤σ), and big scale (100≥σ) are selected. The weightiW, 3,2,1=iare weight coefficients for three channelsofR, G, and B.

Advanced Multi-scale Retinex algorithm is based on an arbitrary Gaussian distribution function.The possibility that is fellednear the average 1 time standard deviation is 68.3%. The possibility that is fellednear the average 2timesstandard deviation is 95.5%. The possibility that is fellednear the average 3timesstandard deviation is 99.7%.The σis selected as 15, 80, 250 and the weight coefficients are selected as 1/3, 1/3, 1/3. The truncation scape with k time's standard deviations selected and the best k could be found the enhanced image has details and avoids MSR color distortion.

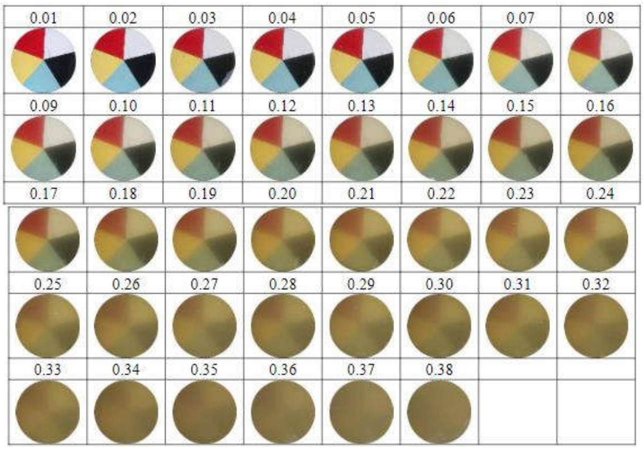
3 Underwater imaging experiment

When the light is transmitted in water, the received optical information includes three aspects. Firstly the light intensity after the absorption and scattering with the water medium is received. Secondly the forward scattered light in the transmission direction is received. Thirdly the backscattering light in the opposite direction of transmission is received.
The experiment material includes paper basket, color paper, single-sided tape, marking pen, measuring stick, glue, solar umbrella, bucket, mobile phone support, and sponge. The shooting scene is shown in figure 2.
First of all, the five sector cardboards of red, yellow, blue, black, and white are folded together and combine a circle. The diameter of the circle is 10cm. The angle of sector for each cardboard is 72 ° as shown in figure 2. A basket is prepared and the basket frame is vertical to the water face. The three scale bands are made with single-sided tape and marker pen. The scale bands are attached to the inner part of the basket at the third grade. The circular cardboard is adhered to the bottom of the basket with strong glue.
In the experiment, the holder of the mobile phone should be fixed to the edge of the basket and the mobile phone is hold with the holder so as to ensure the distance between the camera and the cardboard in all photos.
In each experiment, the underwater images are shoot from the basket in its bottom adhered the cardboard immersed in the water was lowered by 1cm, as shown in table 1. The distortion level of the red channel is calculated in terms of sigma as

$$\text{sigma} = \sqrt{\frac{\sum_{j=1}^{n}\sum_{i=1}^{m}(I_1(i, j) - I_p(i, j))^2}{m \times n}} \quad (5)$$

Where, $I_1$is the taken image at 1cm under water, $I_p$is the image taken at *p* cm under water, *m* is the column number of image pixels, and *n* is the row number of image pixels. Thus, the k-sigma curve diagram of the image taken from 0.02m depth to 0.38m depth is enhanced by the advanced Multi-scale Retinex algorithm, as shown in figure 3.

Table 1 water depth and corresponding images



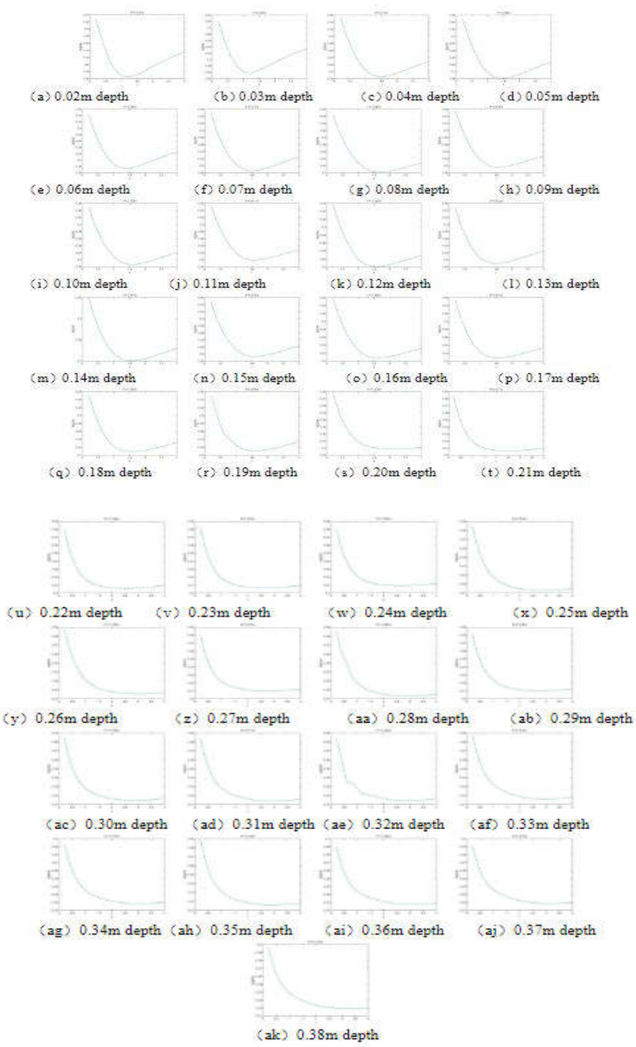


Figure 3 *k*-sigma curve of the enhanced images by the Advanced Multi-scale Retinex algorithm these images taken from 0.02m depth to 0.38m depth

The best enhancement images with *k*-standard deviation truncation near average for the images taken at different depths are shown in table 2.

Table 2 the best values of k for the images taken at different depths

depth / m	0.02	0.03	0.04	0.05	0.06
best k	1.2	1.2	1.4	1.4	1.4
depth / m	0.07	0.08	0.09	0.10	0.11
best k	1.6	1.6	1.6	1.6	1.6
depth / m	0.12	0.13	0.14	0.15	0.16
best k	1.6	1.4	1.6	1.6	1.6
depth / m	0.17	0.18	0.19	0.20	0.21
best k	1.6	1.6	1.6	2.2	2.6
depth / m	0.22	0.23	0.24	0.25	0.26
best k	2.6	2.6	2.8	2.8	3.0
depth / m	0.27	0.28	0.29	0.30	0.31
best k	2.8	2.8	2.8	2.8	2.8
depth / m	0.32	0.33	0.34	0.35	0.36
best k	2.8	3.0	3.0	2.8	3.0
depth / m	0.37	0.38			
best k	3.2	3.2			

It is not difficult to find from table 2. The larger of the depth for the image taken is, the bigger of the k is in the Red channel.

4 Conclusion

When the water depth is from 0.02m to 0.06m, there is a little distortion for the red channel and it is best enhancement effect when k is equal to 1.4. When the water depth is from 0.10m to 0.19m, the distortion of these images is not large. The best enhancement effect is when k is equal to 1.6. When the water depth is from 0.20m to 0.38m, the distortion of these images is too large in the muddy water.

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