Auto Level Color Correction for Underwater Image Matching Optimization

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Summary
The absorption of the light by sea water and light scattering by small particles of underwater environment has become an obstacle of underwater vision researches with camera. It gives impact to the limitation of visibility distances camera in the sea water. The research of 3D reconstruction requires image matching technique to find out the keypoints of image pairs. SIFT is one of the image matching technique where the quality of image matching depends on the quality of the image. This research proposed HSV conversion image with auto level color correction to increase the number of SIFT image matching. The experimental results show the number of image matching is increase until 4 %.

Key words:
Auto Level Color Correction, HSV, SIFT Matching, Underwater Image.

1. Introduction

Indonesia is a country that is part of the Coral Reefs Triangle owned total ranging from 18% of coral reefs around the world, but it is becoming a major concern in the world, because only 5.23% of coral reefs in Indonesia are still in a good conditions, this is what puts Indonesia as the country with the status of coral reefs are most threatened, according to the reef at risk and Indonesia institute of science [1], [2].
The coral reef data are collected at Karimunjawa Island Central Java. Karimunjawa is a National Marine Park declared as a Natural Conservation Area by Decree of the Minister of Forestry [3]. The high level of biodiversity represents the ecosystem of northern coast of Central Java, Indonesia.
Underwater images become a challenging work since the main constraint is the degraded image quality due to light absorption and scattering [4]. Several researches have been conducted to enhance underwater images [4], [5], [6], [7]. The quality of underwater image is necessary as it is needed in the field of deep-sea study. Since, there are several problems such as limited range visibility, low contrast, non-uniform lighting, blurring, bright artefacts, color diminished and noise [8], [9], [10].

Fig. 1 Karimunjava's Coral Reefs

Due to the light absorption, the polarization of reflected amount of light occurred partly horizontally and vertically enters the water. Regarding to the vertical polarization, the object becomes more shining thus easier to capture deep color [11].
The density of water also becomes one of the major constraints in underwater image processing. This is due to the density of water in the sea is 800 times denser than air, therefore water surface effects divided the moving light from air to water into reflected light and penetrating light (see Fig. 2) [11]. Moreover the penetrating light that enters the water reduced gradually as going deeper and deeper to the bottom of the sea. Regarding to this, underwater images are getting darker and darker following the depth of the sea level.
Based on [5], underwater image processing can be classified into two types: image restoration techniques and image enhancement methods. Image enhancement methods are quite simple than image restoration techniques. Image enhancement methods do not need a prior knowledge of

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the environment such as attenuation coefficients, scattering coefficients and depth estimation of the object in a scene.

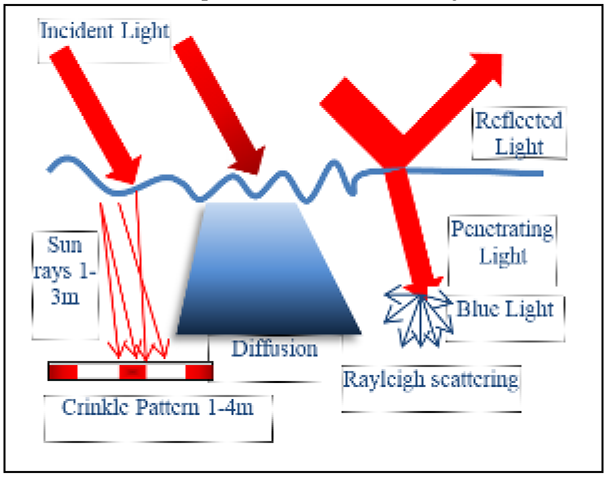

Fig. 2 Water surface effects [12]

The previous works that conducted to image preprocessing for underwater image enhancement. In [6] authors Padmavathi et al have proposed three image filtering namely homographic filter, anisotropic diffusion and wavelet denoising by average filter to improve the image quality. The comparison showed that wavelet denoising by average filter gives the desirable result in term of Mean Square Error (MSE) and Peak Signal Noise Ratio (PSNR).
In [4] authors Iqbal et al proposed underwater image enhancement using an integrated color model. The model consists of contrast stretching Red Green Blue (RGB), transform RGB to Hue Saturation Intensity (HSI), saturation and intensity stretching of HSI. The result showed promising result.
Iqbal et al [7] also proposed an Unsupervised Color Correction Method (UCM) approach for underwater image enhancement. The proposed method efficiently removes the bluish color cast and improves the low red color, the low illumination and true colors of underwater images. The other research that also concern to enhance the image quality could be seen at [12], [13], [14].
Several research for enhancing the SIFT image matching also has been conduct, where the improvements are not in image enhancement area such as in [15], [16], [17], [18], [19]. Regarding above, we employ the idea from [1] to use the V component of HSV color space for SIFT process, then combine it with auto level color correction method based on research of [20] for better result in SIFT image registration.

2. Image Enhancement Framework

This section discusses the proposed image enhancement framework. The flowchart is shown in Fig. 3. Our proposed image enhancement is performed to improve the performance of image matching for 3D image reconstruction based on our previous work in [21]. This research performs the enhancement of underwater image for image registration by employing SIFT image matching technique as feature detection on multi-view camera system consisting of 6 identical waterproof cameras arrayed on a stereovision fashioned. SIFT has become well-known technique in the feature matching field. Poor image quality causes low feature detected for image matching.

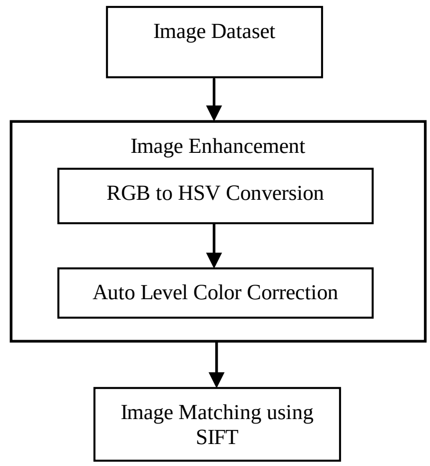

Fig. 3 Flowchart of proposed image matching using auto level color correction

2.1 RGB to HSV Conversion

There are two advantages of Hue Saturation Value (HSV) for underwater image enhancement [4]. Firstly, true color of underwater image can be obtained by using saturation parameters. Secondly, lighting problem can be solved using intensity parameters. The conversion of Red Green Blue (RGB) space into HSV space can be seen in formulae (1), (2), and (3).

$$H = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}} \right\} \quad (1)$$

$$S = 1 - \frac{3}{R+G+B}[\min(R,G,B)] \quad (2)$$

$$V = \frac{1}{3}(R+G+B) \quad (3)$$

2.2 Auto Level Color Correction

This paper used auto level color correction to adjust the lighting of an image automatically. Auto level color correction is proposed based on [20], whereas auto level color correction applied histogram clipping that more effective than existing histogram equalization method to enhance the contrast [22]. Fig. 4 shows histogram before and after histogram clipping. Although manual adjustment is more precise than automatic adjustment, auto level color correction overcomes the problem of time consuming. For the experiment, we set the level of color correction from 0.01 to 1.

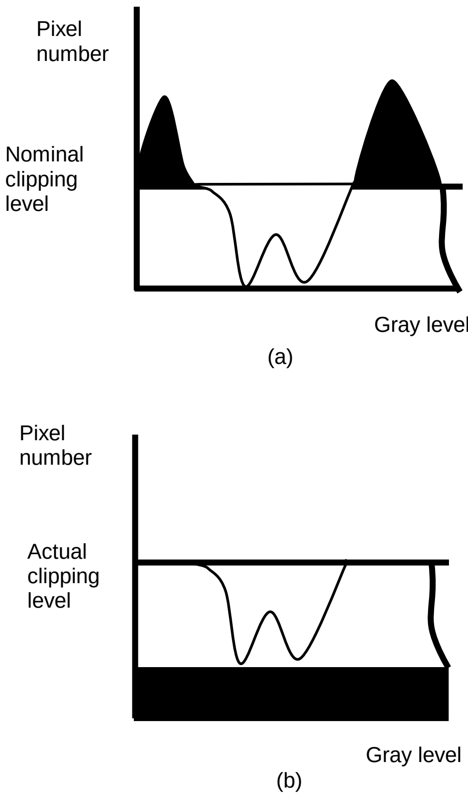

Fig. 4 Histogram (a) before and (b) after clipping histogram [23]

2.3 Image Matching using SIFT

SIFT has become well-known technique in the feature matching field developed by [24]. The method includes four phases:

a) Extreme Detection of Scale-Space

The first stage, identify all potential key point on all scales. Scale an image space is defined as a function of L(x,y,σ) which is the product of convolution between the Gaussian kernel G(x,y,σ) with the image I(x,y). To find features on the imagery used operators Difference of Gaussian (DOG) by compiling octave image pyramid with different scales.

b) Localization of Keypoint

From the keypoint candidates obtained from a), high stability keypoint will be selected. The emergence of feature-level stability is based on the features of each octave.

c) Assignment of Orientation

Orientation of the keypoint based on local gradient direction of each image. Any operation performed on the image based on the direction, orientation and location of the keypoint.

d) Keypoint Descriptor

Local gradient image is computed at each scale region around the keypoint, then transformed to local distortions and illumination changes in the area around the keypoint.

3. Experiment

The dataset of our experiment was collected at Karimunjawa Island Central Java Indonesia. One-pair camera Olympus Tough-8010 cameras and two-pairs Panasonic Lumix FT3 are used to obtain the scene. In this research, we installed six cameras into one stereo frame as shown in Fig. 5, 6. The acquisition of our data is shown in Figure 7.

Fig. 5 Multi-View Camera Installation.

Fig. 6 Front view of Multi-View Camera Installation.

Fig. 7 Data Acquisition.

4. Analysis and Results

This section describes the experiment on image dataset to evaluate the performance of SIFT matching before and after image enhancement respectively. Fig 8 shows the matching points comparison before and after image enhancement respectively for 30 image-pairs. It is clear that image enhancement using HSV conversion and auto color correction provide better extraction of keypoints and the matching points, although the improvement of image matching does not give the significant result. Table 2 shows the average matching points for 30 image-pairs. Averagely the proposed method increases the number of matching points up to 4 %. The performance of auto level color correction in each image pairs could be shown at Fig 9. For 30 image-pair, the best result is obtained when the level of auto color correction is between 0.6 - 1.0. Image matching results are shown in Fig 10.

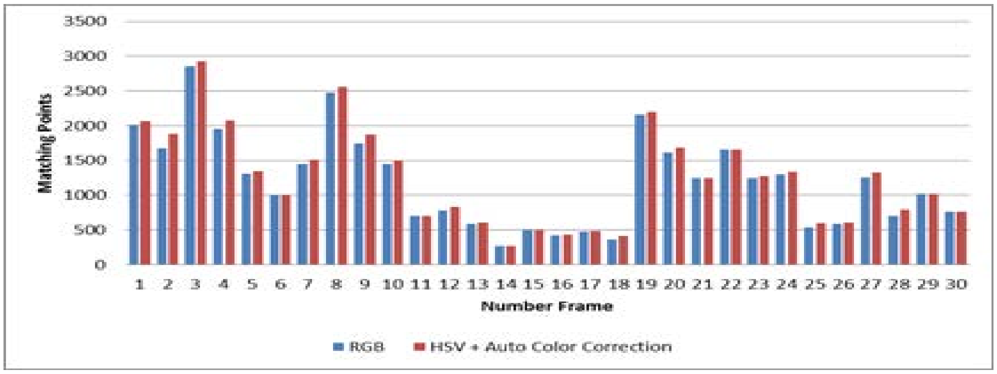

Fig. 8 SIFT performance before and after image enhancement

Table 1 SIFT performance before and after image enhancement

	Avg. Keypoints		Avg. Matching Points
	Camera 1	Camera 2	
RGB	10199.43	9302.40	1204.37
HSV + Color Correction	11000.33	10204.00	1249.60
Improvement	8 %	10 %	4 %

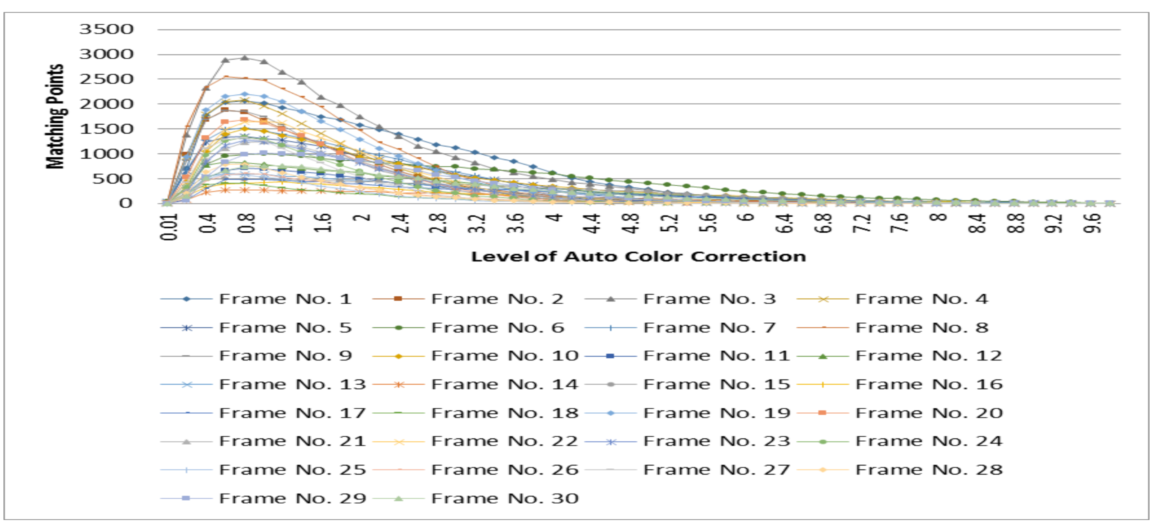

Fig. 9 The performance of auto level color correction

5. Conclusions and Future Works

This research explains the preprocessing step of underwater image registration using image enhancement framework. The framework consists of RGB to HSV conversion, followed by auto color correction for the V component of HSV color space. The experimental results demonstrate that the image enhancement framework increases the performance of SIFT image registration up to 4 %. For the road ahead, we are going to evaluate our proposed image enhancement to different image matching algorithm to provide underwater 3D image reconstruction.

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