Detection of Object in Underwater Images by Detecting Edges

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***Abstract*—Edge detection is a technique that aims to find places in the image where the image brightness changes significantly. Pixels that show significant changes in images will be the edges of the object in the image. This method is frequently used in image processing and computer vision applications. This report examines the removal of the distortion caused by natural conditions in underwater images and the methods of edge detection in the enhanced images.**

I. INTRODUCTION

Underwater photography has an important place in researching topics such as underwater archeology and underwater riches. Underwater conditions are not the same as on land. Natural phenomena such as dispersion, absorption, and refraction of light in underwater conditions cause distortions in the images. In addition, the insufficient light as you go deeper into the water further increases the distortions in the images. The level of obscurity in the image increases. Obscurity in the image means less difference in image pixels, decreased shading and restricted perceivability. With the development of technology, there are cameras that can adapt to underwater conditions, but this solution is quite expensive. Instead, images can be improved by applying image processing techniques used in these cameras. To detect objects in underwater images, we firstly need to image enhancement. Because, as mentioned above, underwater conditions cause deterioration in images. Operations to be done without improving these deteriorations may cause us not to get healthy results. After image enhancement, we will examine edge extraction from images by applying various edge detection techniques.

The aim of this project is to detect the edges of objects in the images by making necessary improvements in underwater images and using various edge detection methods. These images with edge detection can be used in image processing and computer vision applications such as templete matching, image segmentation or data / feature extraction.

II. IMAGE ENHANCEMENT

Image enhancement can be thought of as a process of making images ready for better processing. With the image enhancemet process, we can clear the noise in the image and sharpen the image. In addition, we can increase the brightness of dark images with the image enhancement process. With these operations, we can make the objects in the image more prominent. Median filtering, unsharp mask filtering, histogram equalization and contrast stretching are some of the image enhancement methods. In this project, primarily histogram equalization, which is one of the image enhancement techniques, was applied to underwater images.

Histogram equalization is an image enhancement method developed to increase the contrast of grayscale images. Since there is only one channel in grayscale images, histogram equalization can only be performed on this channel. But the underwater images that we have are RGB images. With a similar approach, we can apply the histogram equalization process separately for each channel of RGB (Red, Green, Blue) images. However, the chromaticity of the colors will also change owing to the correlation between the color channels and the result will not be what we want.

Fig. 1 : Performing histogram equalization process for each channel of RGB image separately (Left hand side is original underwater image)

In order to overcome this problem, we need to convert our RGB image into other color spaces where their colors and intensity are separated. Then we apply the histogram equalization process to the intensity channel. Finally, we convert the image we get back to RGB color space. So, we obtain our image with histogram equalization, without breaking the correlation between color channels and chromaticity of the colors.

These operations were applied as follows for the images used in the project:

1. First of all, underwater images were transformed from RGB space to HSV (Hue, Saturation, Value) space.
2. Then histogram equalization process was applied to the value channel.
3. Then the image was converted from HSV space back to RGB space and histogram equalized image was obtained.

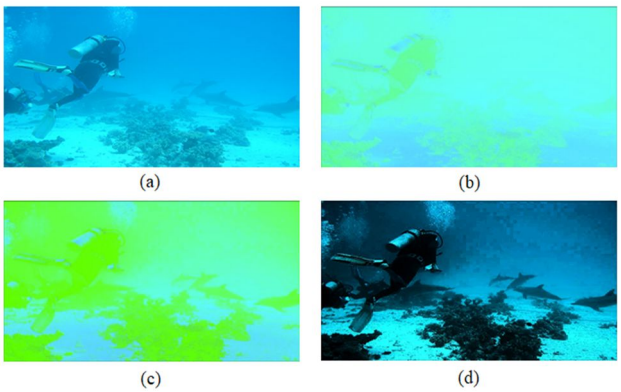

Fig. 2 : Performing histogram equalization process steps to RGB images (a) Original underwater image (b) Conversion of the image to HSV space (c) Applying histogram equalization to the 'value' channel of the image (d) Converting the image back to RGB space

By applying these steps in underwater images, we have performed image enhancement processes with histogram equalization technique. The images obtained by applying these processes to the underwater images of the statue, turtle and starfish are shown in Fig.3.

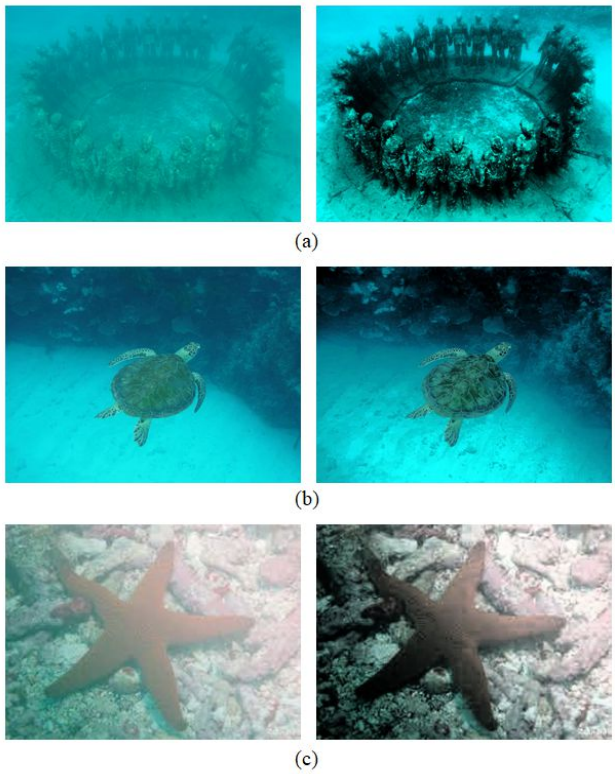

Fig. 3 : Performing histogram equalization process to underwater RGB images (Left hand side is original image, rigth hand side is enhanced image after histogram equalization) (a) Statue (b) Turtle (c) Starfish

III. EDGE DETECTION

Edge detection is a method applied to find the boundaries of objects in an image. The image whose edges are detected is a binary image. So, it consists of black and white pixels. The edges on the image are the pixels where the brightness changes significantly. By determining these pixels, we try to detect the edges of the objects in the picture. Edge detection applications are frequently used in image processing and computer vision applications. Edge detection can be used in feature detection, feature extraction, image segmentation studies. In this section, we will examine various edge detection techniques.

A. CANNY EDGE DETECTION

Canny edge detector is an operator used to detect edges in images. This detector, developed by John Francis Canny in 1986, uses a multi-stage algorithm to detect the edge of objects in the image. It extracts useful information from different objects in the images and reduces the amount of data that needs to be processed. It is widely used in Image Processing and computer vision applications.

The canny edge detection algorithm consists of the following steps:

1. Filtering the image with Gaussian derivative to reduce the noise in the image.
2. Finding the magnitude and direction of the gradient
3. Non-maximum suppression
4. Linking and thresholding (hysteresis)
    - Defining low and high threshold values
    - Using of high threshold value to start edge curves and low threshold value to continue

In the experiments, it has been observed that the edge detection is more successful when the image is passed through the blurring process before it is given to the canny edge detection algorithm. Threshold values was determined according to the median values of the images. Low threshold is either 0 or 70% of the median value, whichever is higher. High threshold is either 255 or 30% above the median value, whichever is lower.

Fig. 4 : Blurring process on enhanced dolphin image (Left hand side is enhanced image, rigth hand side is blurred image)

The edge detection images obtained by passing the other sample underwater images through the same stages are shown in Fig.5.

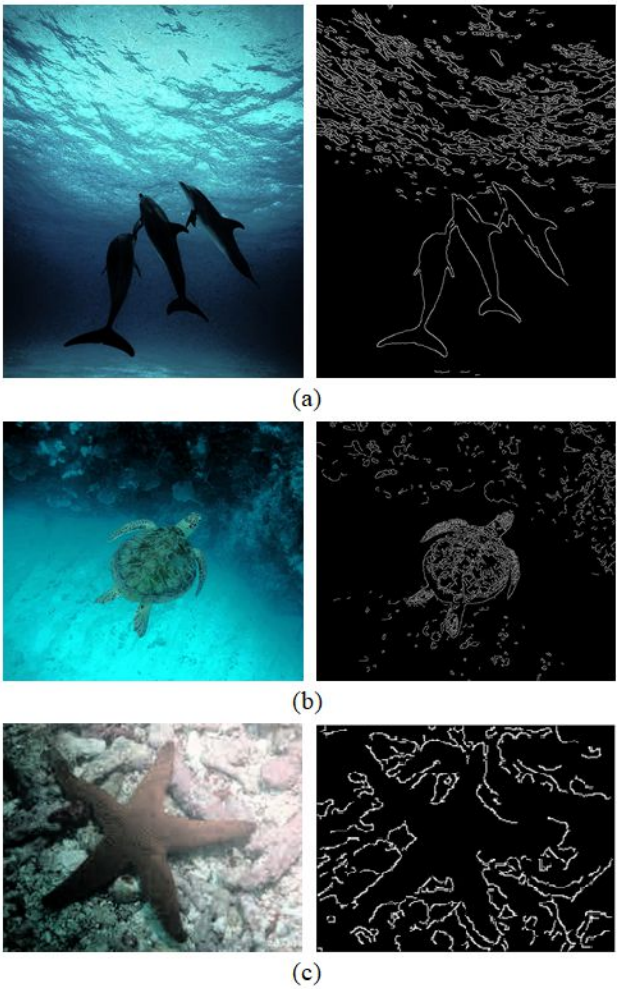

Fig. 5 : Edge-detected images obtained after Canny Edge Detection is applied to enhanced images. (Left hand side is enhanced images, right hand side is edge-detected images using Canny Edge Detection process) (a) Dolphins (b) Turtle (c) Starfish

B. SOBEL OPERATOR

The Sobel operator is one of the most widely used operators in edge detection. The Sobel filter has the advantage of providing both edge detection and smoothing in the image at the same time. The image is convolved with horizontal and vertical filters. So, we obtain horizontal and vertical edges.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig. 6 : The masks of Sobel Operator (Vertical and Horizontal mask)

Then, we combine the horizontal and vertical edge images we get according to the following equation.

$$G = \sqrt{G_x^2 + G_y^2}$$

Before applying the Sobel operator to the enhanced underwater images, the image was converted from RGB to grayscale. Then the Gaussian Blur filter was applied to remove the noise from the grayscale image. It was observed that a better result was obtained in this way. The image was then convolved with horizontal and vertical Sobel filters. By combining the obtained vertical and horizontal edges, the edge detection image obtained with the Sobel filter was obtained.

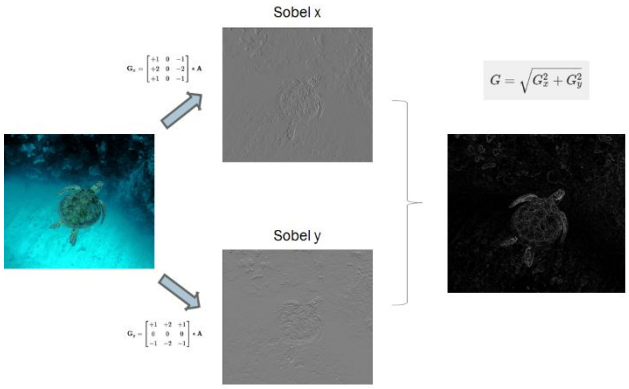

Fig. 7 : Applying the Sobel filter to the enhanced underwater image (The enhanced image was first converted to a grayscale image and the Gaussian Blur filter was applied to the grayscale image. Then, it was convolved with horizontal and vertical Sobel masks.)

You can see other underwater images with the same method applied sobel filter and images with edge detection in Fig.8.

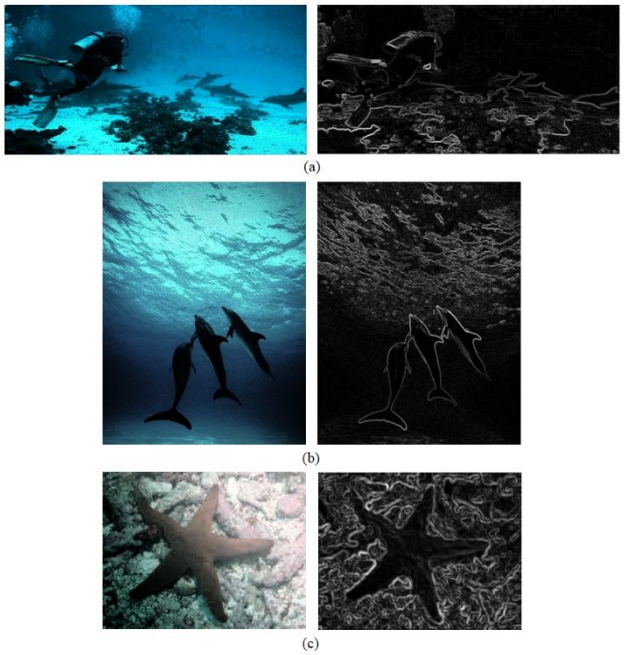

Fig. 8 : Edge-detected images obtained after Sobel Operator is applied to enhanced images. (Left hand side is enhanced images, right hand side is edge-detected images using Sobel Operator) (a) Diver (b) Dolphins (c) Starfish

C. PREWITT OPERATOR

The Prewitt Operator is also one of the most widely used operators for edge detection. It is similar to the Sobel operator. It is applied to the images in the same way. Two masks are used to detect the edges in the image, horizontally and vertically.

It was said to be similar to the Sobel operator. But there is a difference. "Unlike the Sobel Operator, this operator does not place any emphasis on the pixels that are closer to the center of the mask."

-1	0	+1
-1	0	+1
-1	0	+1

G_x

+1	+1	+1
0	0	0
-1	-1	-1

G_y

Fig. 9 : The masks of Prewitt Operator (Vertical and Horizontal mask)

You can see other underwater images with the same method applied Prewitt's Operator and images with edge detection in Fig.10.

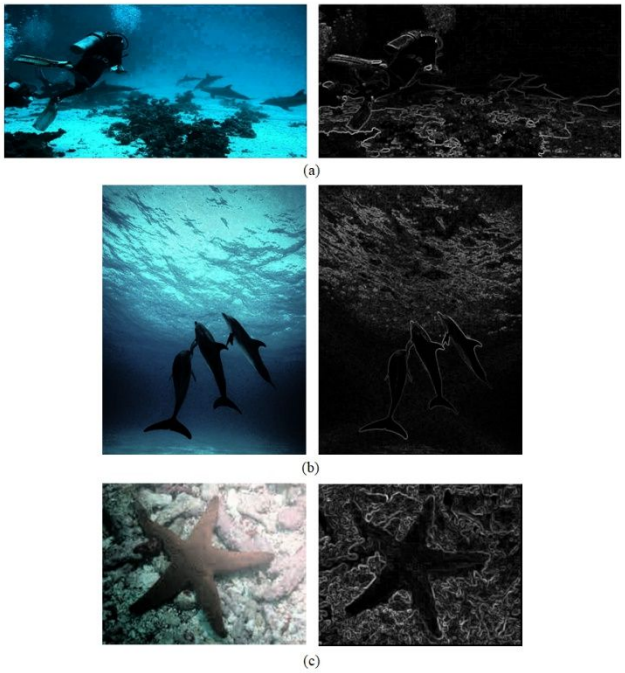

Fig. 10 : Edge-detected images obtained after Prewitt Operator is applied to enhanced images. (Left hand side is enhanced images, right hand side is edge-detected images using Sobel Operator) (a) Diver (b) Dolphins (c) Starfish

IV. WHERE CAN WE USE EDGE DETECTION ?

Edge detection can be used in feature detection, feature extraction, image segmentation studies. These areas are among the very important working areas of Image Processing and Computer Vision. Since the edge detected images are binary images, they take up less space and provide ease of operation. Image segmentation operations can be done better in an image whose edges are detected. The places where the pixels in the images are discontinuous are detected by performing an edge detection process. Thus, information can be extracted from images.

V. CONCLUSION

In this project, we have performed the image enhancement process for images that have deteriorated due to the natural conditions of the underwater. We examined how histogram equalization, one of the image enhancement methods, can be applied to RGB images. Edge detection is better performed in an improved image.

After performing image enhancement, we examined some edge detection algorithms and observed the differences between them. There are also edge detection methods different from the edge detection algorithms examined. (for example, Laplacian Filter etc.) Since the success of the analyzed edge detection methods is high and they are frequently used in Image Processing and Computer Vision applications, these methods have been examined.

Threshold values and filter size can be thought of as hyperparameters that determine the quality of edge detection. The fact that the edge detected images are binary images allows the image to take up less space and facilitates mathematical operations. We can use an image whose edges are detected in workspaces such as image segmentation, data extraction, templete matching. After examining edge detection algorithms, these edge detection methods have also been applied to videos that were taken underwater.

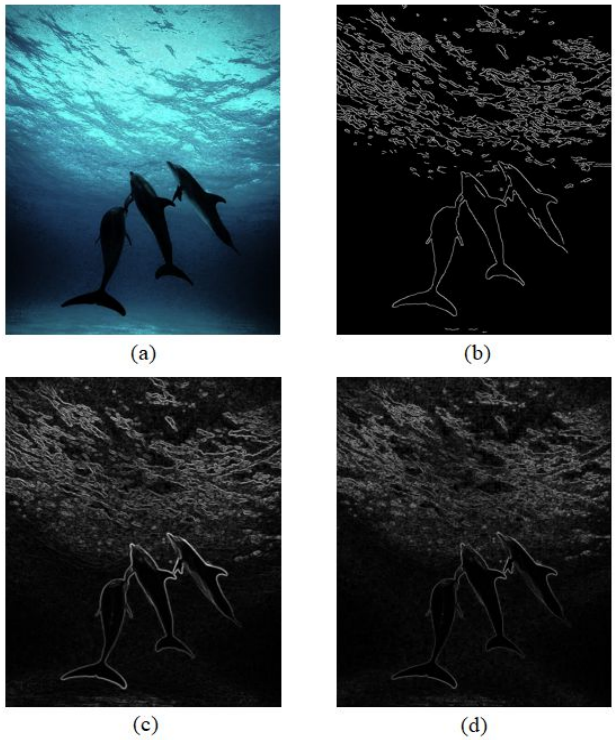

Fig. 11 : Comparison of examined edge detection methods (a) Enhanced image (b) Canny Edge Detector (c) Sobel Operator (d) Prewitt's Operator

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