

DISCUSSION ON METHOD TO EXTRACT SCALLOP AREAS IN SEABED IMAGES FOR FISHERY RESOURCES INVESTIGATION

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ABSTRACT

In this research, we propose a method to extract scallop areas in seabed images in order to construct a system that can measure automatically the number, size, and state of fishery resources, especially scallops, by analyzing seabed images. Our algorithm is based on information about the hue, characteristic pattern, and the shape of scallop shells. The effectiveness of the proposed method is illustrated through an experiment.

1. INTRODUCTION

Investigating the amount of fishery resources is extremely important in order to prevent the depletion of such resources and to assist in the efficient operation of fisheries. One method to investigate fishery resources is to obtain images of the seabed with a camera. Images of areas where fishery resources exist are taken by a camera attached to the bottom of a ship. The advantage of this method is that it has no effect on the ecosystem of fishery resources. These images are usually analyzed manually, though, which is a very time-consuming operation. The purpose of this research is to construct a system that can measure automatically the number, size, and state of fishery resources by analyzing seabed images. Our main target is the scallop. However, there are some problems in constructing this system, as follows:

The target environments are ones with high noise that have significant differences in illuminance and where various objects (stones, sand, mud, other living things, etc.) exist.

Estimation of the state of the target (whether alive or dead) is expected in addition to a calculation of the number of scallops.

In this research, we attempt to solve these problems using image-processing technology. The first step was to construct a method to automatically extract areas where scallops were located from images of the seabed.

2. PLAN FOR OPERATION

About 600 seabed images were used in this study. These images were taken by the Hokkaido Abashiri Fisheries Experiment Station in both gravel fields and sand fields. Only gravel field images were used in this experiment.

Fig. 1 shows a sample of a seabed image we used. TABLE I indicates the parameters of the images used.

Table 1: Seabed image parameters.

Size	1536 (pixels) 1024 (pixels)
Color / Monochrome	24-bit (True color)



Fig. 1: Seabed image.

The characteristics of scallops are as follows:

Scallops are typically light brown in color.

Scallops have characteristic radial striped patterns.

The shape of the scallop shell is like a fan, and characteristic.

With these characteristics, we tried to extract scallop areas from seabed images. In the following sections, we describe in detail the method used in this process.

3. MODELING OF SCALLOP AREA BASED ON COLOR INFORMATION

In order to obtain clear color characteristics for the scallop areas, we manually collected about 10,000 sample points of

scallop areas from 35 seabed images. Then RGB data of every sample point data were translated to HLS data, which gave us the hue, lightness, and saturation distribution. We also did the same operation using a whole image, and tried to find characteristics in the scallop areas by comparing the distribution in the whole image with that in images only of a scallop shell.

The distribution graphs plotting hue, saturation, and lightness of the 10,000 sample points are shown in Fig. 2, Fig. 3, and Fig. 4.

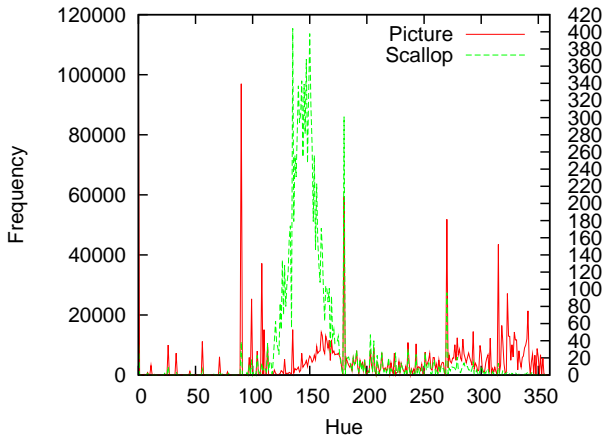


Fig. 2: Comparison between whole image and scallop area: hue.

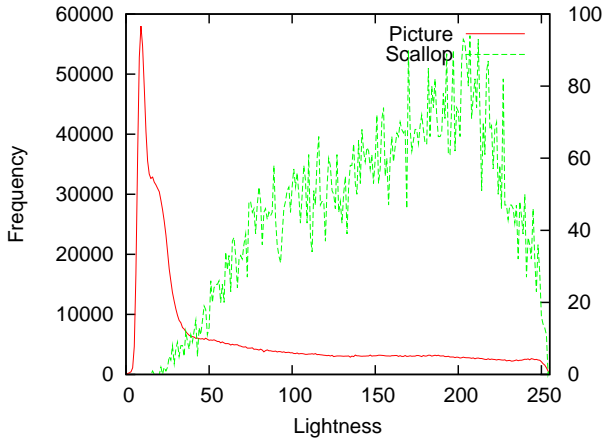


Fig. 3: Comparison between whole image and scallop area: lightness.

We were not able to find characteristics in the graphs of saturation and lightness, but can find the characteristics of hue, whose values concentrate from about 100 degrees (H_{min}) to 160 degrees (H_{max}). Therefore, we derived the following equation to extract scallop areas:

$$O_{hue}(x, y) = \begin{cases} SA & \text{if } H_{min} < H(x, y) < H_{max} \\ NSA & \text{others} \end{cases} \quad (1b)$$

where $O_{hue}(x, y)$ indicates the operator on the (x, y) coordinates, and $H(x, y)$ refers to hue data on the (x, y)

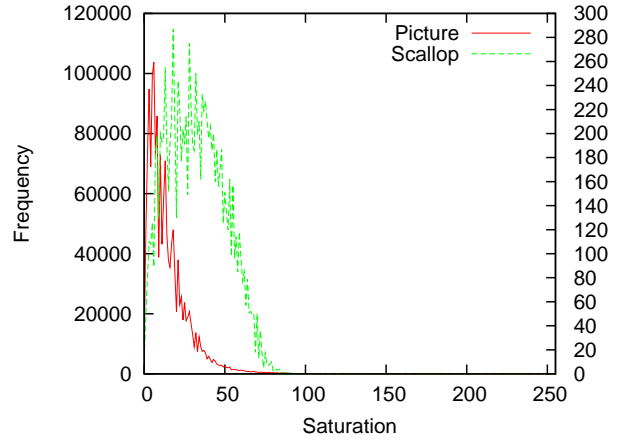


Fig. 4: Comparison between whole image and scallop area: saturation.

coordinates. 'SA' means 'scallop area,' and 'NSA' means 'NOT scallop area'.

4. MODELING OF SCALLOP AREA BASED ON STRIPED PATTERN

The scallop shell has a peculiar, radial striped pattern. We tried modeling this characteristic using gradient information and space-frequency analysis.

4.1 Extraction of radial striped patterns using gradient information

To extract striped patterns, we focused on the gradient information of the image. The gradient vector at coordinate (x, y) in the image $f(x, y)$ is defined by equation (2).

$$\nabla f(x, y) = \left(\frac{\partial}{\partial x} f(x, y), \frac{\partial}{\partial y} f(x, y) \right)^T \quad (2)$$

Then the magnitude of the gradient vector, $|\nabla f(x, y)|$, and the direction of the gradient, (x, y) , are also defined as equations (3) and (4).

$$|\nabla f(x, y)| = \sqrt{\left(\frac{\partial}{\partial x} f(x, y) \right)^2 + \left(\frac{\partial}{\partial y} f(x, y) \right)^2} \quad (3)$$

$$(x, y) = \arctan\left(\frac{\frac{\partial f(x, y)}{\partial y}}{\frac{\partial f(x, y)}{\partial x}} \right) \quad (4)$$

Fig. 5 shows an original image of a scallop shell taken in the scallop area. Fig. 6 shows the distribution of the magnitude of the gradient vector from the original image, and Fig. 7 shows the distribution of the direction of the gradient vector from the original image.

We can see the striped patterns in Fig. 7, so we obtained information on the direction of the gradient vector.



Fig. 5: Original image of scallop taken in scallop area.



Fig. 6: Gradient vector magnitude distribution.

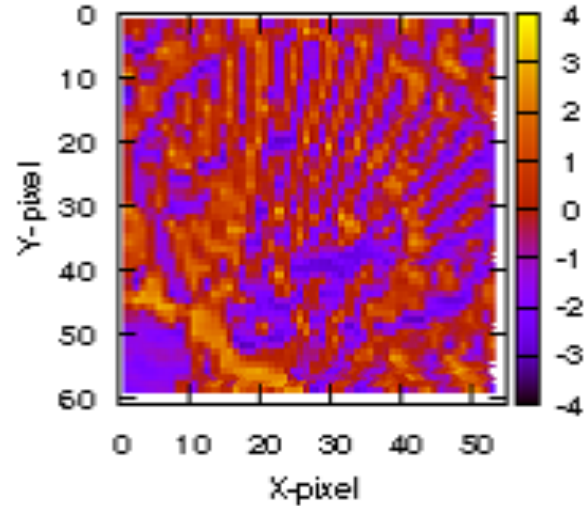


Fig. 7: Gradient vector direction distribution.

4.2 Space-frequency characteristics of radial striped pattern and its modeling

We consider that striped patterns have specific space-frequency characteristics, so we conducted a space-frequency analysis of the striped patterns described in section 4.1.

The two-dimensional discrete Fourier transform (DFT) of an image $f(m, n)$, in which the number of pixels is given by $M \times N$, is expressed by equation (5).

$$F(u, v) = \frac{1}{MN} \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} f(m, n) W_1^{um} W_2^{vn} \quad (5)$$

where

$$\begin{aligned} W_1 &= e^{-j\frac{2\pi}{M}} \\ W_2 &= e^{-j\frac{2\pi}{N}} \end{aligned}$$

The power spectrum, $P(u, v)$ of $F(u, v)$ is defined by equation (6).

$$P(u, v) = |F(u, v)|^2 \quad (6)$$

$P(r, \theta)$ is the polar coordinate conversion of $P(u, v)$ by distance r and direction θ from origin $(u, v) = (0, 0)$. Then $P(r)$ is obtained by equation (7).

$$P(r) = \sum_{\theta=0}^{\pi} P(r, \theta) \quad (7)$$

Here, $P(r)$ means the total sum of the power spectra in the concentric circle whose center is the origin $(0, 0)$, and which shows the degree of roughness of the striped patterns.

We tried to apply these operations (space-frequency analysis) to the image of the direction of the gradient that was acquired in section (4.1). A scallop area with the size of 32

32 pixels was extracted manually, and an image showing the direction of the gradient was obtained. Then we carried out two-dimensional DFT on the gradient direction image and obtained the power spectrum $(P(u, v))$, and the polar coordinate conversion of $P(u, v)$ ($P_s(r, \theta)$), and $P_e(r)$ calculated in expression (7). We also did the same procedure with an image that did not have a scallop area, and obtained $P_{es}(r, \theta)$, and $P_{es}(r)$. After these procedures, we compared $P_s(r, \theta)$ of the area with a scallop and $P_{es}(r, \theta)$ of the area without it.

The original images are shown in Fig. 8, and the images of $P_s(r, \theta)$ and $P_{es}(r, \theta)$ are shown in Figs. 9 and 10. The distributions of $P_s(r)$ and $P_{es}(r)$ are shown in Figs. 11 and 12.

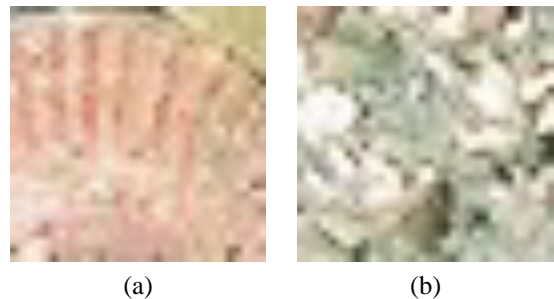


Fig. 8: (a) Scallop area, (b) Area without scallops

We cannot see the pattern characteristics in Fig. 10. However, we can find a specific concentration in Fig. 9. We also see the characteristics in Fig. 11; that is, the ratio of P_r around $r = 8$ is characteristically high.

In order to extract a scallop area using this characteris-

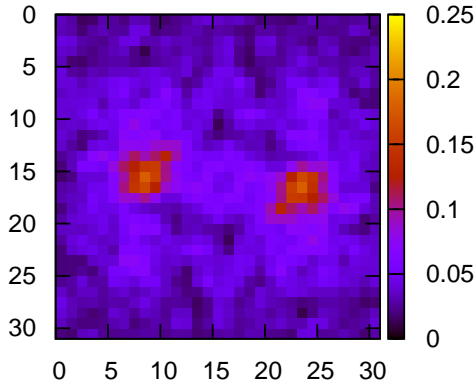


Fig. 9: Results of space-frequency analysis : scallop area.

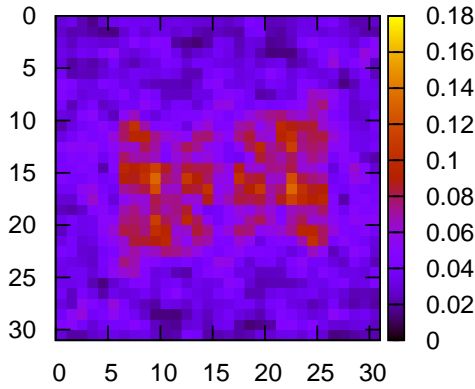


Fig. 10: Results of space-frequency analysis : area without scallops

tic, S is calculated by equation (8).

$$S = \sum_{r=k_{min}}^{k_{max}} P(r) \quad (8)$$

S is the sum of $P(r)$ with a particular r . In this research, k_{min} was set to 7, and k_{max} was set to 9 from the experimental results. When the value S is more than the threshold value T , the center of a small area sized 32×32 pixels is regarded as a scallop area. We can extract scallop areas by using this procedure on the whole image.

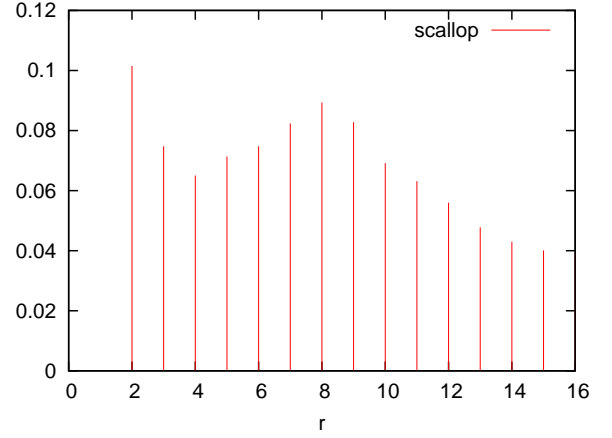


Fig. 11: Distribution of $P_s(r)$, a scallop area.

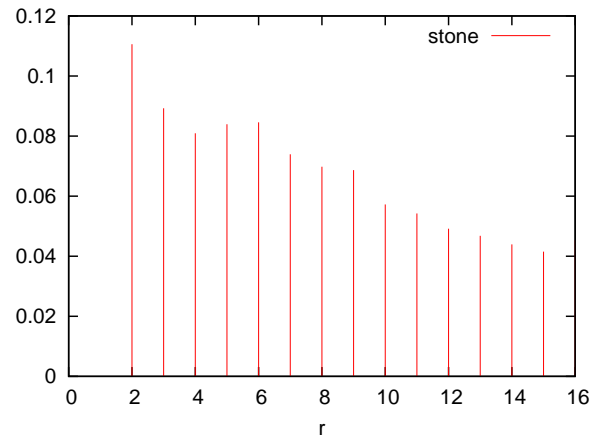


Fig. 12: Distribution of $P_{es}(r)$, an area without scallops

5. MODELING OF SCALLOP AREA BASED ON SHAPE INFORMATION

The shape of the scallop shell is like a fan, and characteristic. We tried to extract a scallop area using the shape information.

5.1 Extraction of shape information using edge detection procedure

We extracted edges of the scallop shell using the Canny filtering algorithm. The original image is shown in Fig.13(a), and Fig.13(b) shows the distribution of edges of the scallop shell.

5.2 Extraction of shape patterns using Hough transform

We consider the shape of the scallop shell approximately as the ellipse. To extract ellipses, we operated the Hough transform to the distribution of edges. That is to say, the ellipse is defined by five parameters (the coordinate of a center (x, y) , a long radius α , a short radius β , a lean of a long radius θ), and we tried to extract ellipses using the five dimension Hough transform algorithm. A long radius and a



(a) Original image.



(b) Distribution of edges.

Fig. 13: Distribution of Edges using Canny filtering algorithm.

short radius are $22 \bullet \alpha$ and $\beta \bullet 28$ because of the scallop size restriction.

Fig.14 shows the experimental result of ellipse extraction.

6. EXPERIMENTAL RESULTS

Fig. 15 shows the original image, and Fig. 16 show the experimental result using only an operator based on hue information. Fig. ?? show the experimental result using only an operator based on shape information by the Hough transform, and Fig. 18 shows experimental results using operators based on hue information, space-frequency analysis and shape information.

7. CONCLUSION

In this study, we proposed a method to automatically extract areas with scallops in order to construct a system that can measure automatically the number, size, and state of fishery resources, especially of scallops, by analyzing seabed images. Our algorithm uses hue information, the characteristic striped pattern information, and the shape information of scallops. The effectiveness of the proposed method was illustrated through the experiment.



Fig. 14: Experimental result of ellipse extraction using the Hough transform.



Fig. 15: Original image.

Acknowledgment

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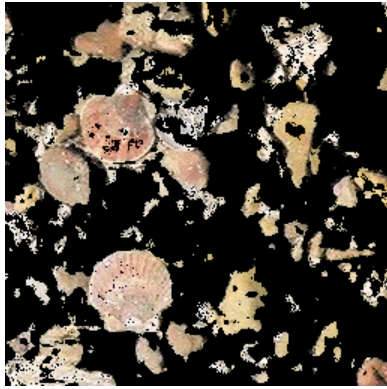


Fig. 16: Experimental result using an operator based on hue information.



Fig. 17: Experimental result using only an operator based on shape information.

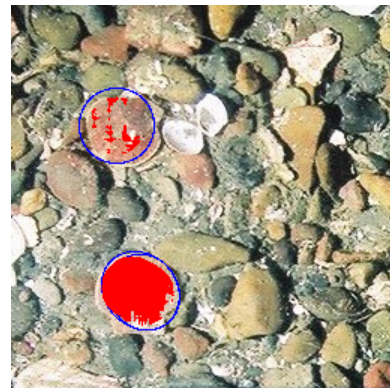


Fig. 18: Experimental results using operators based on hue information, space-frequency analysis and shape information.

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