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Scallop Detection from Gravel-Seabed Images for Fishery Investigation

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Abstract

We propose a method of extracting scallop areas from gravel seabed images to assess fish resources, and developed an automatic system that measures their quantities, sizes, and states. Scallops feature different colors, fluted patterns and forms. The present study is described our method of extracting these features, and presented the results and its effectiveness.

1 Introduction

It is important that the quantity and state of fishery resources be known so that they can be sustained. It is also necessary to carry out these investigations non-invasively so that fishery resources are not affected. It becomes possible to obtain seabed images to effectively investigate fishery resources with direct techniques. However, there is no effective automatic technology to measure their numbers, sizes, or states (alive, dead, or diseased) from these images. Therefore, investigations into fish resources have not become more efficient or long-ranging. There are two main problems in automating these.

- The photography environment contains a high degree of noise with large differences in illumination. Sand, clay, and debris are also included.
- Investigation requires visual estimates of the state of fishery resources in addition to number counts.

We propose a method of extracting objects that are assumed to be scallops from gravel seabed images.

1.1 Design Consideration

Figure 1 shows a digital photograph of the seabed in gravel field (1536 × 1024pixels and in 24-bit color).

Figure 1: Seabed image.

In comparison to other areas, scallops have special features, such as being sepia or sienna in color and shaped like fans with a fluted pattern that radiates outward. This paper explains a method of extracting these scallop features from digital images by modeling them.

2 Preparation

From Fig.1, we can see these images have great differences in illumination due to the environment. Because of this, it is difficult to recognize color and form in the dark parts of these images when modeling the features of scallops. Therefore, they are extracted from areas where the features of scallops can be recognized.

2.1 Algorithm

Initially, localized regions are obtained by dividing to the original image into smaller areas of 32×32 pixels. The average lightness and variance are calculated from all of these smaller images. We can see the results in Fig. reffig:ave var.

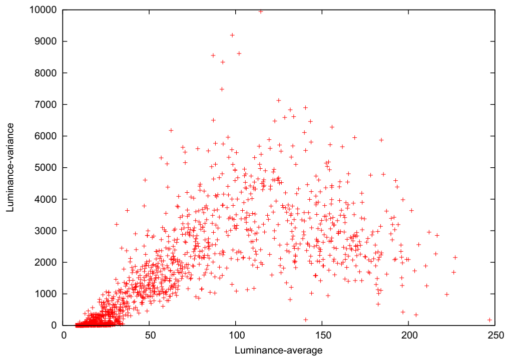


Figure 2: Distribution for average lightness and variance.

We can see the distribution is concentrated at low values from Fig.2. This is thought to be due to the influence of shadows around the images. Therefore, localized regions cancel out one another where the average lightness and variance are low. We set the threshold parameters to a mean of 100 and a variance of 2000.

The results for the extracted images are shown in Fig.3. The shadow regions were removed from the image of the scallop bed on the sea floor.

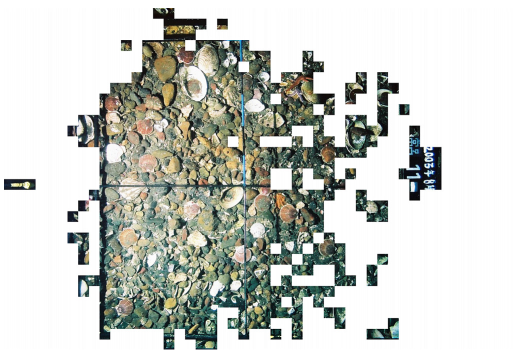


Figure 3: Results of extracting 32×32 pixel areas by using mean and variance of lightness

3 Modeling of Features

This section describes how we modeled all the features of the scallop areas.

3.1 Color Information

To clarify the color features of the scallops, we extracted 10,000 sample points from the original seabed image, and converted each R, G, and B element into hue, lightness, and saturation (HLS) color space. These were obtained as a histogram, and compared with the original image. From the results of this, we can see that the hue of the scallop area is concentrated in the peak ranging from $100 - 175$ angle (don't show results)[4]. However, we could not find the features from lightness and saturation.

Next, we extracted only the scallop area, and obtained 6 images. Here, we used the scallops area is not covered with sand or stone. We analyzed hue histogram, mean and standard deviation of scallop and other areas. Table 1 is shown these results.

Table 1: Result of hue mean and standard deviate about scallops and others area

Scallops	data1	data2	data3	data4	data5	data6
Mean (°)	139.1	139.1	133.2	156.1	152.9	164.5
SD	14.6	7.3	10.7	18.1	17.5	31.0

(a) Scallop areas

Others	data1	data2	data3	data4	data5	data6
Mean(°)	208.4	230.9	174.8	175.4	180.5	174.1
SD	59.0	50.7	15.7	33.6	14.3	18.9

(b) Other areas

The hue mean of the scallop area is settled from about $130 - 170$ angle in Table 1. And, standard deviates of scallop areas are lower than other areas. Here, we can define the color feature as hue mean is $125 - 175$ angle and standard deviate is lowest when there are some areas.

3.2 Striped Pattern

The surface of scallop shells has a pattern that is fluted and radiates outward like a fan. We extracted these features by edge detection and modeled them by spatial frequency analysis.

3.2.1 Extraction of Fluted and Radiating Patterns

In image f, the edge gradient of coordinate $f(x, y)$ is

$$\nabla f(x, y) = (\frac{\partial}{\partial x} f(x, y), \frac{\partial}{\partial y} f(x, y))^T. \tag{1}$$

Then, edge strength $|f(x, y)|$ and direction θ are

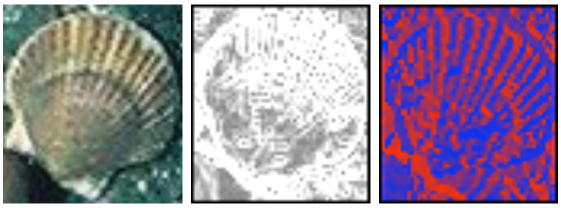
$$|f(x, y)| = \sqrt{(\frac{\partial}{\partial x} f(x, y))^2 + (\frac{\partial}{\partial y} f(x, y))^2} \tag{2}$$

$$\theta = \arctan(\frac{\partial f(x, y)}{\partial y} / \frac{\partial f(x, y)}{\partial x}). \tag{3}$$

The results from treating edges are presented in Fig.4. Weak radiating patterns were extracted by the edge direction, because edge detection was not influenced by the edge strength. Here, we used the edge direction to extract the patterns.

3.2.2 Analysis and Modeling

We analyze an image of edge direction, and modeled.



(a) (b) (c)

Figure 4: Results of edge treatment : (a) Object image. (b) Image of edge strength. (c) Image of edge direction.

The number of pixels is $M \times N$, the two-dimensional image is $f(m,n)$, and then the two-dimensional Fourier transform is

$$F(u,v) = \frac{1}{MN} \sum_{n=0}^{N-1} \sum_{m=0}^{M-1} f(m,n) W_1^{mu} W_2^{nv}, \qquad (4)$$

where $W_1 and W_2$ are

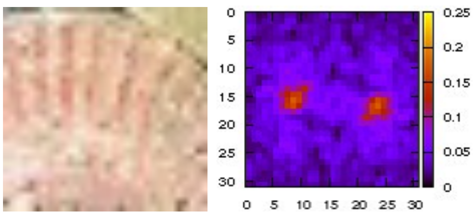
$$W_1 = e^{-j\frac{2\pi}{M}}, \quad W_2 = e^{-j\frac{2\pi}{N}}.$$

When the power spectrum distribution of $P(\theta, r)$ is normalized. $P(r)$ is defined as

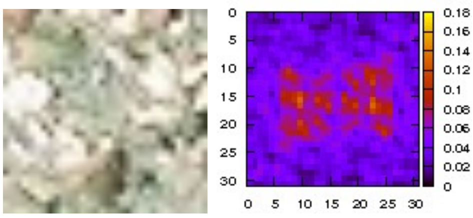
$$P(r) = 2 \sum_{\theta=0}^{\pi} P(\theta, r). \qquad (5)$$

$P(r)$ expresses the sum of the power spectrum around the concentric area around the original point in power spectrum space.

The scallop and other areas were compared by using the following processing. All areas were reduced to 32×32pixels and the edges were detected from the images. These images were obtained as $P(r)$. The results from comparing the spatial frequency spectra are presented in Fig.5 and $P(r)$ is presented it Fig.6.



(a) Scallop area



(b) Other area

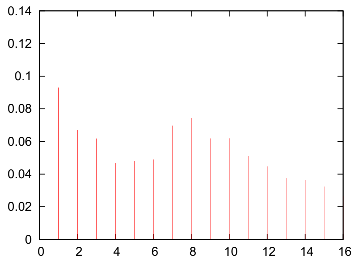
Figure 5: Object images and results of frequency analysis

As shown in Fig.6, the other area does not have features, but the $P(r)$ of the scallop area is concentrated in the range of $7-9_{Hz}$. This result suggests a radiating fluted pattern is reflected.

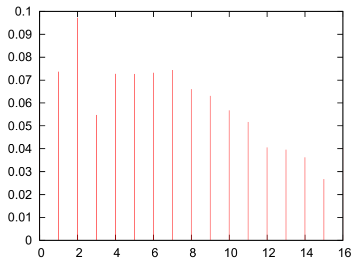
Therefore, we modeled this as follows. In the image of edge detection, the local area of 32×32 is defined as $L(x,y)$. The $P_L(r)$ is the r element of space frequency in the power spectrum. When the sum of the specific range of $P(r)$ is defined as A,

$$A = \sum_{r=k_{min}}^{k_{max}} P'_L(r), \qquad (6)$$

where $k_{min} and k_{max}$ satisfy $0 \leq k_{min} \leq r \leq k_{max} \leq 16$. In this paper, we have set $k_{min} = 7, k_{max} = 9$. If A is more than the threshold. T_A, then we assume it is a candidate point for the scallop area. This processing is performed for the whole image.



(a) Scallop area



(b) Other area

Figure 6: Results of P(r)

3.3 Shape of Scallop Shell

The shape of the scallop shell is detected as an ellipse with a Hough transform.

3.3.1 Preparation

The shape of the scallop shell determines how clearly its edge is detected. Therefore, only strong edge shapes are extracted by the Sobel edge operator. Here, we use an edge strength value of 180. The obtained photograph was processed by thinning. The results are presented in Fig.7.

Figure 7: Object image and edge image

3.3.2 Detection of Shape

An ellipse is described by 5 parameters: the center point (x, y), two semi-axes ($\alpha and \beta$), and orientation ϕ. The shape of the scallop shell was detected from an edge image by using Hough transform.

4 Experiment

4.1 Method

We tried to extracted the scallop area by using two processes: 1 detecting ellipse by the shape feature, 2 selecting a ellipse area that included the color feature of scallops or their fluted radiating pattern. We defined the area of ellipses that was detected in a fluted radiating pattern of process 2 as S_e, and this area contained a fluted radiating pattern of S_p. We let the ratio of these areas equal $R = S_p/S_e$. The scallop area was defined as being R more than threshold T_R.

4.2 Results

The sample of experiment results are presented in Fig.??. As can be seen from these, the scallop area was extracted by combining its features, but not extracted with only the shape feature. Table 2 shows the entire results of experiment. Here, error is non detection or false detection. This experiment provided adequate results. In process 2, the color feature of scallops is better than their fluted radiating pattern, because the color information is obtained stable.

(a) (b) (c)

Figure 8: Actual process : (a) Original image (b) Detection of ellipse (c) Selection scallop area in detected ellipse

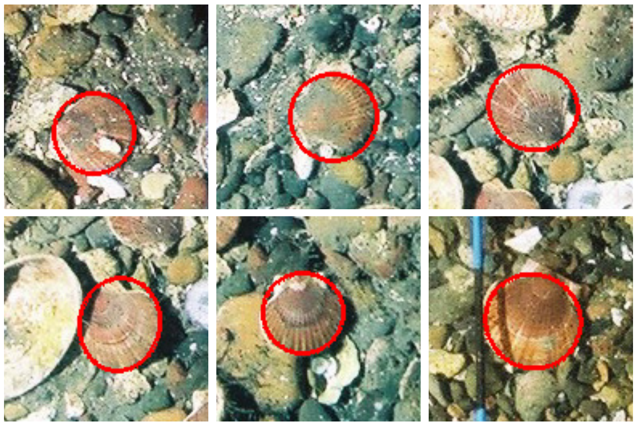


Figure 9: Samples of the experiment result

Table 2: Result of hue-mean and standard deviation about scallops and others area

	Scallops	Others
Total images	28	104
Num of scallop	29	0
True	25 (86%)	86 (83%)
Error	4 (14%)	18 (17%)

5 Conclusion

We proposed a method of extracting an area with scallops from seabed images. We tried to improve the accuracy of this method of using the features of scallops by integrating color, fluted radiating patterns, and shapes. In future work we intend to improve the precision of extraction more, and the photographic environment itself to obtain the images.

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