Fish Recognition Method using Vector Quantization Histogram for Investigation of Fishery Resources

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***Abstract*—This paper proposed a novel approach to the kichiji rockfish recognition method for investigation of the fish biomass. This method does not depend on the size, position and attitude of the fish, because SIFT feature with rotation invariant is used and is represented by vector quantization histogram. The experiment results showed that our method detected 94 % of object which is the fish from 37 photographs and recognized 57 % of the fish from detected image. And our method was able to recognize kichiji rockfish from SIFT features of the fish head. However, if more than one object is piled up, our method is a possibility of mistaken recognition because features of object other than target are used for recognition**

***Keywords*—component; biomass invesitigation, kithicji rockfish, fish recognition method, AUV**

I. INTRODUCTION

Kichiji rockfish (*Sebastolobus macrochir*) are found on the Pacific side of the island of Hokkaido in Japan, and in the southwestern Sea of Okhotsk. The kichiji is an expensive and valuable resource, and consequently, overfishing has significantly decreased the population density of the fish. Regular surveys of kichiji rockfish biomass are necessary to manage the fishery [1]. Because benthic kichiji rockfish has difficulty to be found by acoustic sonar, the biomass of the fish is commonly investigated using a combination of trawl surveys and the swept-area method [2]. This approach, which can effectively survey a wide area, has a risk for that the habitant gets damage by contact with seafloor.

We proposed novel investigation method to the the investigation of kichiji rockfish biomass using the AUV Tuna-Sand shown in Fig.1. The AUV can take high-resolution photograph of the seafloor automatically at a low altitude using only mounted sensors and devices [3][4]. The AUV Tuna-Sand surveys the kichiji rockfish biomass in Kitami-Yamato bank off northern Japan in 2013. The AUV took approximately 5,300 photographs of the seafloor during five dives in the bank, and captured images of 37 kichiji rockfish ranging in length from 90 to 340 mm [5]. In the result, kichiji rockfish detection from more than 5,000 photographs was used someone's eyes and spent a lot of time.

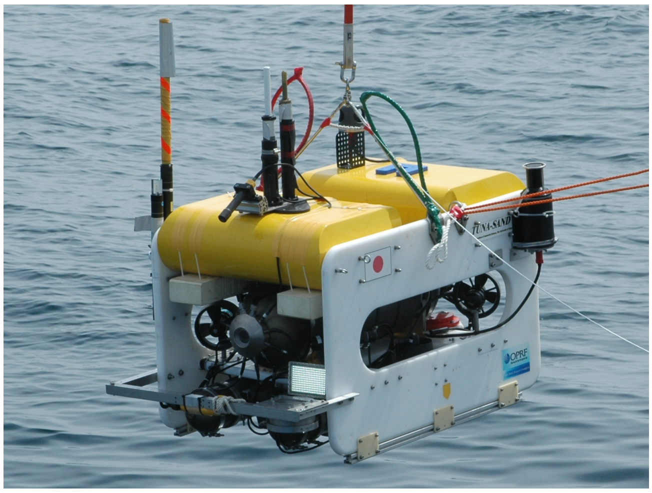


Fig.1 Hovering type AUV "Tuna-Sand"

This paper proposes kichiji rockfish recognition using bag-of-keepoints method [6][7] for survey of the fish biomass. The method robustly recognizes the fish from taken photograph due to use vector quantization histogram based on SIFT features [8] without potions between local features. The paper describes the experiment results using photographs taken in kichiji rockfish survey carried out in June 2013 in the Sea of Okhotsk off northern Japan.

II. RECOGNITION METHOD

A. Description of our method

This research developed image processing method which can detect sea-creature and recognize kichiji rockfish, from photographs taken by AUV Tuna-Sand. This image processing approach is shown in Fig.3. The photographs taken by the AUV require correction of luminance difference due to distance between the light source and target. First, the color and luminance in the photographs are corrected using the method proposed by Singh [9]. Sea-creature is easy to observe in the color corrected image because the saturation of sea-creature is higher than the seafloor. The second processing step extracts rotation-invariant SIFT features for the fish recognition and detects objects other seafloor by binarization process, from

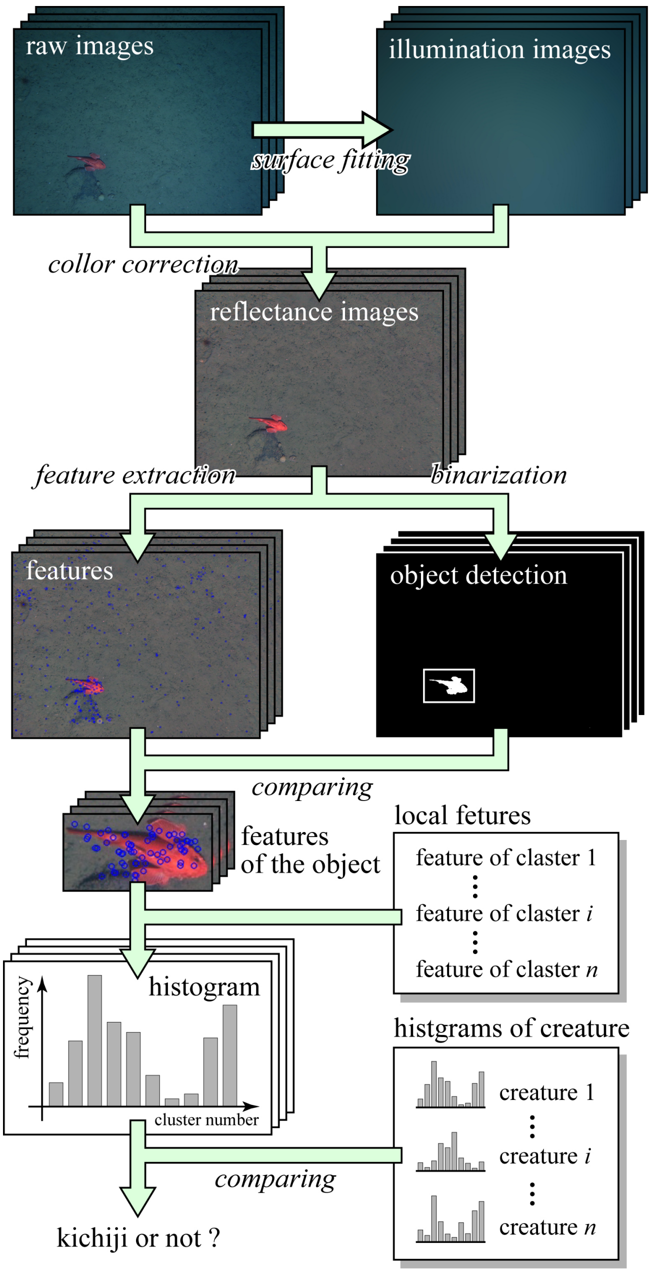


Fig.2 processing procedure of our fish recognition

corrected photographs. This approach research converts the color of photographs from RGB coordinates to HSV coordinates and binaries the photographs using the saturation threshold. Extracted SIFT features of the seafloor are deleted based on binarized images obtained. Third process step makes vector quantization histograms using bag-of-keypoints method to represent SIFT features of an object by one feature vector. The final processing step recognizes kichiji rockfish by comparing the quantization histograms of reference and target. Reference and target sea-creatures are easy to compare by using the histogram represent by one feature vector.

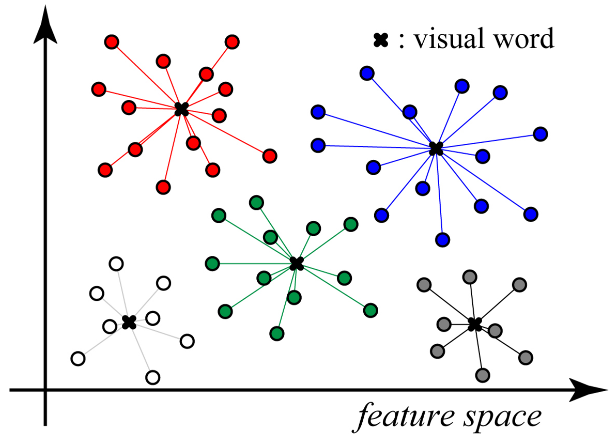


Fig.3 Visual words produced by vector quantization

B. Color correction

A downward-facing camera on AUV Tuna-Sand photographs the seafloor using a single strobe. This approach can be used to observe natural sea-creature on the seafloor, because the strobe light is less irritating to animals than other lights. Therefore, imaging surveys by the AUV with a still camera and strobe is an effective approach for biological research. Let input image F be expressed by reflection image R and Illumination image I and

$$F(x, y, \lambda) = I(x, y, \lambda)R(x, y, \lambda) \quad (1)$$

Where x and y denote the pixel coordinates and denotes the color channel. $I(x, y, \lambda)$ includes light evenness in $F(x, y, \lambda)$. Thus, we are able to obtain uniform brightness in the image if $I(x, y, \lambda)$ is removed from $F(x, y, \lambda)$. The logarithm of the illumination component formed by a single strobe in the water is represented by a fourth order polynomial of two variables as

$$I_L(x, y) \approx p_1x^4 + p_2x^3y + p_{14}y + p_{15} = \boldsymbol{SP} \quad (2)$$

Where $\boldsymbol{S}$ refers to surface fitting matrix for each pixel, and $\boldsymbol{P}$ is the Parameter vector. The last squares method estimates $\boldsymbol{P}$ from a color channel $F_L(x, y)$ represented by the logarithm of $F(x, y, \lambda)$. A clear image can be obtained by that $F_L(x, y)$ removed $I_L(x, y)$ is converted to linear scale. Note that $I_L(x, y)$ includes the low-frequency component of the seafloor and sea-creature in the photograph. Seafloor pixels occupy most of pixels in photographs taken by AUV, even if many sea-creatures inhabit on the seafloor in observation area. Therefore, most low-frequency component removed by color correction is the seafloor, and its saturation is lower than sea-creature in corrected photographs.

C. Vector quantization histogram

This research represents SIFT features of objects by the frequency of local features called visual word, and makes vector quantization histograms. The visual words denote representative vector of feature groups calculated clustering method as shown in Fig.3, and require to be generated as

(a) 10 Photographs with kichiji rockfish

(b) 7 Photographs with the fish other than kichiji rockfish

(c) 14 photographs with other sea-creature

Fig.4 Reference sea-creature images

follows before making the histograms. (1) Photographs with sea-creatures including kichiji are collected from pictures taken by AUV Tuna-Sand. (2) The color of the photographs is corrected by above method. (3) SIFT features are extracted from all photographs corrected. (4) K-means method calculated *n* representative vectors which are visual word. N-dimensional vector quantization histograms are calculated by voting to visual word which Euclidean distance between SIFT feature and itself is minimization. The histograms are normalized by feature number because extracted features depend on photograph.

D. Similarity of the histogram

Kichiji rockfish recognition requires similarity between vector quantization histograms of target object and reference sea-creature. This approach calculates the similarity between two histograms using histogram intersection proposed by Swain [10]. Let the similarity *S* be expressed by the frequency $h_1(i)$ and $h_2(i)$ of *i*-th visual word in *n*-dimensional histogram as

$$\alpha = \sum_{i=1}^{n} \min(h_1(i), h_2(i)) \tag{3}$$

α in eq.(3) depends on feature number of reference and target object, even if normalized histograms are used. This approach calculates the similarity normalized by feature number of object as

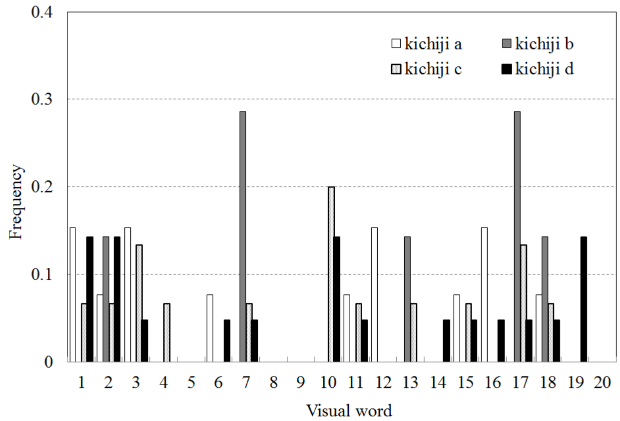


Fig.5 Vector quantization histogram of kichiji rockfishes

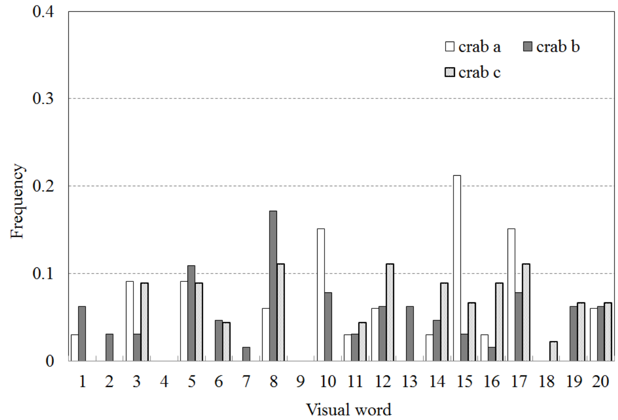


Fig.6 Vector quantization histogram of crabs

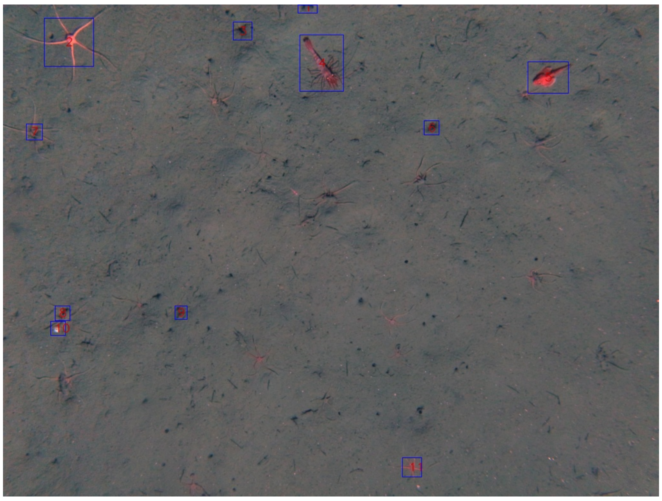
$$\alpha = \sum_{i=1}^{n} \min(h_1(i), h_2(i)) \Big/ \sum_{i=1}^{n} h_1(i) \tag{4}$$

The similarity represented by eq.(4) is the range between 0.0 and 1.0. Reference creature with the highest similarity is defined as the creature of target object. However, if target object has few features, α in eq.(4) is often 1.0. Therefore target object with scant features for calculating the similarity is defined as unknown creature.

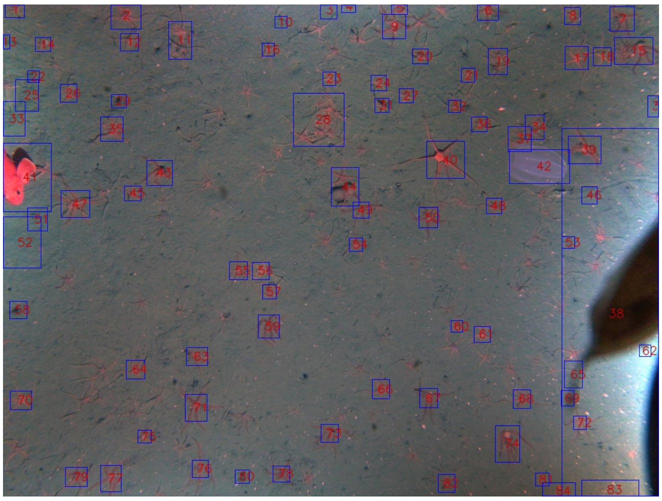
III. EXPERIMENT

A. Datasets for experiment

Our method cognized kichiji rockfish from photographs taken by AUV Tuna-Sand in Kimita-Yamato bank off northern Japan in June 2013 to verify the effectiveness of fish recognition method. 20 visual words is produced by k-means method based on SIFT features which are extracted from 606 photographs with sea-creature. Figure 4 shows color corrected images of reference sea-creature. 10 images with kichiji rockfish are used as recognition object, 7 images including eelpout and flatfish are used as the fish other than kichiji rockfish and 14 images including starfish, crab and squid are used as other sea-creatures. Representative vector quantization histograms of 4 kichiji rockfishes and 3 crabs are shown in Fig.5 and 6. The histograms of kichiji rockfishes have SIFT



(a) Photograph with a kichiji rockfish and few sea-creatures



(b) Photograph with a kichiji rockfish and many starfishes

Fig.7 Photographs recognized kichiji rockfish

features categorized in 2nd and 18th visual words, and have low type of visual words. The histograms of crabs have SIFT features categorized in 10 types of visual words such as 3rd, 5th, 8th, 11th, 12th, 14th, 15th, 16th, 17th and 20th.

B. Recognition results

We tried to detect and recognize kichiji rockfish from 37 photographs with the body and head of the fish using our method. The experiment results showed that our method detected 94 % of object which is the fish from 37 photographs and recognized 57 % of the fish from detected image. Figure 7 shows two photographs which our method recognized kichiji rockfish, and Fig.8 shows a photograph with error recognition. Blue squares mean detected object other than seafloor. Most sea-creatures other than very small starfishes were detected as shown in Fig.7, even if many sea-creatures stayed on seafloor in observation area. And our method was able to recognize kichiji rockfish from SIFT features of the fish head. However, if kichiji rockfish stayed on other object as shown in Fig.8, our method detected the fish and the object by one object and extracted SIFT features including the object. Our method had a mistaken recognition of kichiji rockfish.

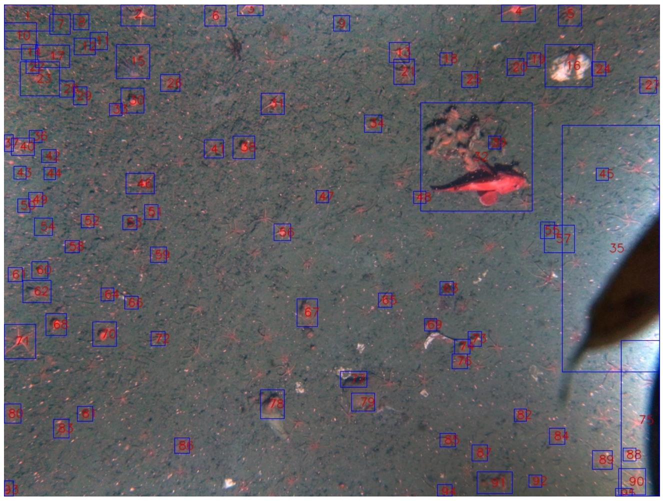


Fig.8 Photograph with error recognition

IV. CONCLUSIONS

This paper proposed a novel approach to the kichiji rockfish recognition method for investigation of the fish biomass. This method does not depend on the size, position and attitude of the fish, because SIFT feature with rotation invariant is used and is represented by vector quantization histogram. However, if more than one object is piled up, our method is a possibility of mistaken recognition because features of object other than target are used for recognition.

We will increase recognition accuracy of our method and develop a novel method which can recognize several sea-creatures at same time.

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