MVA '98 IAPR Workshop on Machine Vision Applications, Nov. 17-19, 1998, Makuhari, Chiba, Japan

8—17 A Morphological Approach to Fish Discrimination

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Abstract

In this paper, we propose a new method of the feature extraction for fish discrimination using mathematical morphology. The conventional research of fish discrimination used parameters which relied upon the physical characteristics of shape, contour and colour. But these methods were insufficient for practical application system. Other physical parameters include the colouring patterns, speckles and the scale forms of the fish. We focused on the speckle patterns and scale forms of fish as significant identification features. We tried to extract the features of Japanese Horse Mackerel (ma-aji), Pilchard Sardine (ma-iwashi) and Common Mackerel (ma-saba) by implementing newly designed morphological filters and algorithms. The discrimination system was implemented on the distributed parallel image processing system. Experimental results show the discrimination performance is superior to the conventional methods.

1 Introduction

Japanese consume large quantities of common fish like Pilchard Sardine and Japanese Horse Mackerel. Because the working conditions and the labor environment is hard at fish market, a good automation system and labor saving device is very desirable. Most especially, the development of a fish discrimination and sorting system is expected to enhance the marketing for many fresh fishes. In the past, the methods of discrimination fish species have relied upon the physical characteristics of shape and contour[1]. Physical parameters were mainly used in regard to body length, depth of body, perimeter, area, and their ratio. In spite of using above ten parameters, this method was insufficient for same species. Then another method was used to analyze the texture analysis of small regions of colour along the center of the lateral body[2]. This method cannot recognize the fish species when the analysis region is influenced by uneven colour. The integration method of colour and shape recognizes the fish species semi-automatically[3]-[4]. Other physical parameters include the colouring patterns, speckles and the scale forms of the fish. We focused on the speckle patterns and scale forms as significant identification features. We employed newly designed morphological filters and algorithms, which proved to be an efficient tool to extract features. The remainder of this paper is organized as follows: In section 2, the morphological filters are designed; section 3 gives feature extraction methods and discrimination process; section 4 describes experimental results and discussions; and the concluding remarks in section 5.

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2 Morphological Filters

(1)The Japanese Horse Mackerel is shown in Fig.1. It has about seventy placoid scales along the center line of the lateral body, as shown by the inset box in Fig.1. The placoid scales is an important feature for fish discrimination. At first, the new morphological filter were designed in order to eliminate the vertical direction parts such as placoid scales. The filter size was designed to be less than the width of a placoid scale according to use of the selective smoothing method[5]. The morphological filter is designed to 3×1 horizontal bar. The 1×5 vertical bar filter was determined in order to erode the placoid scales.

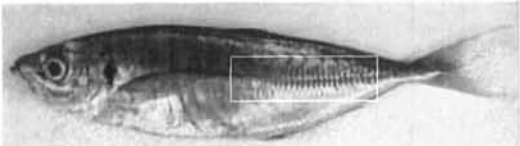

Fig.1 Example of Japanese Horse Mackerel Image

(2)The Pilchard Sardine is shown in Fig.4. It has many black dots that form a queue along the center of the lateral body, as shown by the inset box in Fig.2.

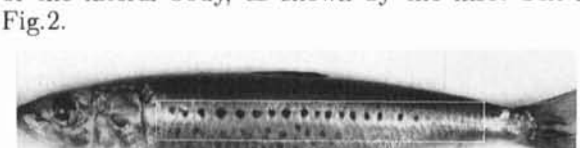

Fig.2 Example of Pilchard Sardine Image

The black dots are an important feature for Pilchard Sardine. We designed the new morphological filters according to the size of black dots.

The filter size was designed to be smaller than the black dots in order to decrease the processing time by multi-scale filtering methods[6]. The gray-scale disk filter is shown in Fig.3. This filter is used to sharpen the feature extraction. The binary scale disk filter is shown in Fig.4. This filter was used to eliminate noise elements.

1	3	1
3	5	3
1	3	1

Fig.3 Gray-scale Disk Filter

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•	•	•
	•	

Fig.4 Binary Disk Filter

(3)The Common Mackerel is shown in Fig.5. It has pale and dark speckle patterns on the back of the body. We designed the 1×7 filter to extract the speckles. The size of the speckles is longer than the placoid scales.

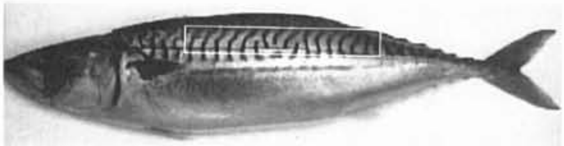


Fig.5 Example of Common Mackerel Image

3 Feature Extraction and Discrimi-naion

3.1 Japanese Horse Mackerel

(1a) Image data was acquired by CCD-camera with a size of 512×480 pixels. The feature patterns are extracted from full scale image data in order to reduce the processing time.

(2a) Since the placoid scales are similar to the vertical bar, we tried to eliminate the vertical parts using a opening operation which was made possible by implementing the newly designed horizontal bar filter. The placoid scales are extracted by subtracting the resulting image from original Japanese Horse Mackerel image data.

(3a)The image is binarized and the closing operation is processed using the binary disk filter. The placoid scales image is eroded by the 1×5 vertical bar filter.

(4a) To recognize the Japanese Horse Mackerel, an auto-correlation function was calculated in order to confirm the periodicity of placoid scales. The fish species was recognized by the number of the peaks.

3.2 Pilchard Sardine

(1b) The region of black dots is detected utilizing the same method as (1a).

(2b) To eliminate the black dot patterns, the original image is processed by dilation four times, using the newly designed gray-scale disk filter. Erosion of the dilation image is implemented four times, using the same filter. The black dot pattern is extracted by the subtraction of the resulting image from original image data.

(3b) The gray-scale image is changed to the binary image data considering threshold level. The closing operation is processed to eliminate noise using binary disk filter.

(4b) Labeling operation is executed and white clusters in the image are extracted. The number of dots along the center of the lateral body and those area and shapes were examined. The Pilchard Sardine is recognized from the other species.

3.3 Common Mackerel

(1c) The region of striped pattern on the Common Mackerel is detected utilizing the same method as (1a).

(2c)To separate the pale and dark stripes, the closing operation was processed using a vertical bar filter.

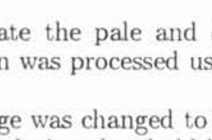
(3c) The image was changed to the binary image by the auto-calculating threshold level. The striped pattern is eroded to be extracted using the 1×7 filter.

(4c) The extracted results indicated a clear pattern of periodical stripes. To recognize the Common Mackerel, the number of same-sized ratio were calculated as areas, then divided by perimeter, and totalled.

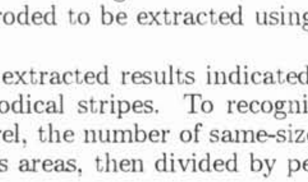
4 Experiment and Results

4.1 Japanese Horse Mackerel

The placoid scale is eliminated by the horizontal bar filter using selective smoothing method. Upon inspection, the feature extraction results are obvious but not completely clear(Fig.6(a)).



(a) Sample of Feature Extraction



(b) Result of Feature Extraction

Fig.6 Result of Japanese Horse Mackerel

It is necessary to erode the placoid scales and eliminate noise in order to calculate the auto-correlation function. We obtained good extraction results when the newly designed bar filters were used. The final feature extraction result is shown in Fig.6(b). The feature of placoid scales are formed by many vertical scales at periodic intervals. To recognize the Japanese Horse Mackerel, an auto-correlation function was calculated to extract the periodicity of placoid scales. The auto-correlation function of placoid scales is shown in Fig.7. The results of auto-correlation is indicated from the peaks of two dot to five dot intervals. We tested twenty-five Japanese Horse Mackerels for these experiments. The percentage of discrimination among the same species was about 94%.

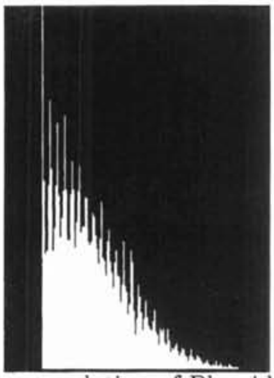
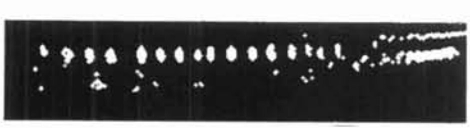


Fig.7 Auto-correlation of Placoid Scales

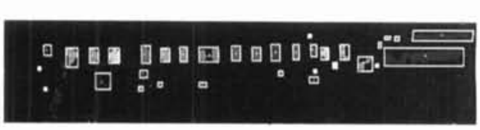
The reason for the discrimination errors is thought to be caused by the blurred placoid scales. It will be necessary to improve the lighting. The periodicity of placoid scales was determined when the number of peaks was more than five. The time of feature extraction was 792ms. The high speed technique will be necessary to improve for practical application.

4.2 Pilchard Sardine

The black dots are eliminated using multi-scale morphological filtering method. The black dots are extracted by the subtraction from original image(Fig.8(a)). A feature extraction result after the labeling operation is shown in Fig.8(b).



(a) Example of Feature Extraction



(b) Example of Feature Extraction with Labeling
Fig.8 Result of Pilchard Sardine

The discrimination of the Pilchard Sardine is based on the dot queue along the center of the lateral body.The range of dots were within an area of five to fifty. We tested thirty Pilchard Sardines for these experiments. The percentage of discrimination among the same species was about 95% using a judgement of more than four dots. The result were superior to any conventional discrimination methods. The 5% discrimination error is caused by the lack of black dot numbers.

The time of feature extraction was 982ms. The reason for the long processing time was due to repeating the morphological calculations. It will be necessary to investigate the higher processing techniques applying to the pipe-lined parallel processing.

4.3 Common Mackerel

The original image was changed to the binary image using calculated threshold level(Fig.9(a)). A feature extraction result is shown in Fig.9(b).

(a) Example of Feature Extraction

(b) Example of Feature Extraction with Labeling
Fig.9 Result of Common Mackerel

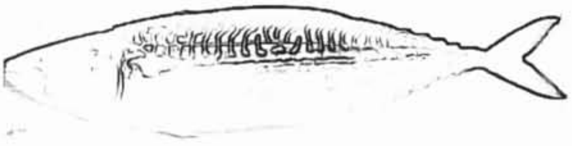
The labeling operation of Common Mackerel was calculated using the stripes of area and perimeter and its ratio. The range of stripes was decided by the number of a ratio from about one to four. The gravity interval on each stripe is calculated on a number of ten to fifteen. We tested twenty Common Mackerel for these experiments. The percentage of discrimination among the same species was about 92%. The ratio of discrimination error was due to the blurred feature area. The surface of the Common Mackerel has a tendency to be very light reflective. The time of feature extraction was 610ms.

4.4 Discussions

The results of experiments for fish discrimination using morphological filter were interesting. The effeciency of the morphological filter is dependent upon the morphological filter shape and size. In this study, the morphological filters design are based on the placoid scale, black dots and stripes. The extraction results using only morphological filters were quite clear. This effectual method is discussed by comparing another feature extraction method by the edge detection using the sobel filter(Fig.10). The edge detection results as applied to the Japanese Horse Mackerel did not always produce a clear image. As a result, the calculation of the auto-correlation function was not possible. The black dots of the Pilchard Sardine was detected using the sobel filter, however the noise elements remained on the image. Under these circumstances, it is not easy to operate the labeling of black dots in order to distinguish fish species.

(a) Example of Japanese Horse Mackerel

(b) Example of Pilchard Sardine



(c) Example of Common Mackerel
Fig.10 Result of Sobel Operation

The sobel operated image of the Common Mackerel was extracted clearly, but the horizontal line in the center of stripes connected mutually, and the top part of stripes is deleted. This is not conducive for accurate discrimination.

To decrease the processing time, another simple morphological operation was tested in regard to Japanese Horse Mackerel and Pilchard Sardine. At first, the region of placoid scales and black dots is detected by the same method as section 3. The closing operation using 3×1 horizontal bar filter is processed. The resultant image subtract original image in order to extract the feature. Suppose the threshold level of judgement as Pilchard Sardine was 100, we examined eighteen fishes. The percentage of discrimination was about 90 %. In the case of Japanese Horse Mackerel, the percentage of discrimination was about 88 %. The discrimination time of the simple method was about 685ms. This method is faster than original method, but it is necessary to improve the performance.

5 Conclusions

As noted previously, the development of a fish discrimination and sorting system is expected to significantly enhance the marketing of many fresh fishes. We studied a new method of feature extraction for fish discrimination using morphological filters. We focused on the speckle patterns and scale forms on the fish as significant identification features. We tested to extract the features of Japanese Horse Mackerel, Pilchard Sardine, and Common Mackerel by implementing the newly designed morphological filters and algorithms. The morphological filters were dependent upon the shapes of the placoid scales, black dots, and pale and dark stripes. The extraction results using only morphological filters were very successful. Experimental results of fish discrimination showed better performance than conventional methods which use the physical characteristics of shape, contour and colour.

This method will be advanced through incorporating the physical characteristics and also implementing parallel algorithms for quicker processing and load balance.

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