2014 Seventh International Symposium on Computational Intelligence and Design

A New Detection Method for Fish Freshness

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***Abstract*—Fish freshness is an important index of fishes and fish products which indicates their qualities. Rapid detection of fish freshness has very important guiding significance for processing, storage and marketing of fishes and fish products. Aiming at the disadvantages of fish freshness detection techniques at present, a rapid and nondestructive fish freshness detection method was proposed in this paper. We got the statistics features of gray values for eye iris image at first, and then the surface texture features of fish body were obtained and downsampled. Finally, the combined feature vectors by these two features were used to accomplish freshness detection. The method was verified by using carps randomly purchased and the detection accuracy rate got 86.3%. The experimental results show that the proposed method can achieve accurate fish freshness detection rapidly and nondestructively.**

Keywords- fish; freshness detection; support vector machine

I. INTRODUCTION

Fish meat is one of the main food sources in people's daily life, which has many advantages, such as high nutritional value, high protein, low fat, rich vitamin, rich mineral content, good taste, easy digestion and absorption, etc [1]. The stale fish meat is not only tasted bad, but also easy to cause poisoning after eaten. Therefore, fish freshness is an important index for the qualities of fishes and fish products. It is not only the indicator of the final qualities of fishes and fish products, but also closely related to the safety of them [2].

Study on the rapid detection of fish freshness has very important guiding significance for processing, storage and marketing of fishes and fish products. Mature methods for detection of fish freshness include sensory evaluation method, microbiological method, physical and chemical method, and so on [3]. But these methods are all not able to achieve rapid detection of fish freshness. Nowadays, there appear a series of methods for rapid detection of fish freshness, including electronic nose technology, electronic tongue technology, biological sensor technology, bio impedance technology, near infrared spectroscopy technology, etc. These methods have achieved satisfactory rapid detection under specific conditions, but they have their own different shortcomings. For example, electronic nose technology can only detect well when fishes have begun to corrupt, and cannot get accurate detection result before the corruption stage [4,5]. Electronic tongue technology requires the detection sample must be liquid one, so its detection range is limited. Meanwhile the sample must be dealt with a series of pretreatments before detection, and these pretreatments will affect the detection result [6,7]. Biological sensor technology has the shortcoming of cockamamie preparation, harsh detection condition, complex equipment maintenance. Because of its high selectivity, sometimes an index is not enough to measure fish freshness, so the detection result needs further verification [8]. Bio impedance technology cannot detect the fish samples with great different impedance characteristic [9]. Near infrared spectroscopy technology has relatively low sensitivity and great spectral fluctuation. Samples of different groups may have multiple peaks overlap in the same wave length, which leads to the complex data processing [10]. According to the testing standard of fish health and daily life experience, we know that in the storage process, some appearing characteristics of fishes which can be observed, such as fish eye iris color and surface texture characteristics, will change obviously with the decrease of fish freshness quality.

Given the above consideration, a new rapid detection method of fish freshness based on image processing was put forward in this paper. Aiming at the shot fish body image, we firstly extracted eye iris features and body surface texture features. And then the optimal feature combination was discussed and ascertained to constitute the feature vector. Finally we used support vector machine(SVM) classifier to accomplish fish freshness detection, and discussed the detection accuracy rates by using different numbers of training samples. The proposed method can realize the rapid and nondestructive detection of fish freshness.

II. FISH FRESHNESS FEATURES

A. Experimental data

The experimental materials were 100 live carps randomly bought from supermarket, which weighted between 500-800g. The fish surfaces were holonomic and nondestructive, and the fish meats were fresh. After bought back, the fishes were kept in refrigerator for 3 hours to suffocate to death, and then we acquired the images of their surfaces as the samples at the zeroth day. Afterwards, the fishes were gotten out respectively at the second, fourth, eighth and twelfth

978-1-4799-7005-6/14 $31.00 © 2014 IEEE
DOI 10.1109/ISCID.2014.153

days and were acquired images of their surfaces as the samples at the corresponding storage days. For each storage day, we randomly chose 65 fish images as training set and the remaining 35 images as test set. The size of acquired gray images was 1024×452. Image acquisition used the uniform illumination environment, and the experimental environment was same when the fish images at different storage days were acquired.

B. Eye iris features

According to daily life experience and experimental observation, eye iris of the fresh fish is white and clear. With the increase of storage time, the fish eye iris becomes red and dark and more and more turbid. The reflection of these changes in the gray image is that the pixel values become smaller and the pixel value differences become larger. Therefore, we can detect fish freshness according to these rules on the perspective of image processing. Based on the acquired gray image of fish surface, the fish head image intercepted down from the fish gill trailing edge was shown in Fig. 1.

Figure 1. The fish head image

The fish head image was binary processed using threshold method with the threshold value set to 128. The gotten binary image was shown in Fig. 2.

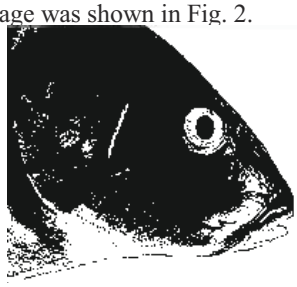

Figure 2. The binary image of fish head

By using region labeling algorithm, we labeled each obtained connected component respectively, and screened the eyeball region from these components using the circular degree index. Then, from all components in the binary image of fish head, we selected the region which area was the largest. The complement of this region was calculated. In all gotten complements, the one with the highest circular degree was the fish eyeball region. We fitted a minimum circumscribed circle on this eyeball periphery, then the intersection of the circular area and the complement of eyeball region is the iris region [11], as shown in Fig. 3.

Figure 3. The fish eye iris region

Making "&" operation with this eye iris region and the original fish head image, we obtained the gray image with only iris regions, as shown in Fig. 4.

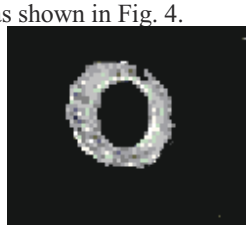

Figure 4. The gray image of iris regions

Because in gray image, the size and difference of pixel value in eye iris region could reflect the color of the iris, and ulteriorly the fish freshness, we extracted the mean and standard deviation of all pixel values in eye iris region as the features to detect fish freshness. In order to determine the effects of these two features, we compared the detection results using different feature set. Fisher linear classifier was used as classifier and the detection accuracy rates were listed in Table I.

TABLE I. THE DETECTION ACCURACY RATES USING DIFFERENT FEATURE SET IN EYE IRIS REGION(%)

storage days	mean	standard deviation	mean + standard deviation
0	74.3	65.7	77.1
2	54.3	57.1	68.6
4	60	48.6	54.3
8	62.9	60	65.7
12	60	54.3	62.9
ave	62.3	57.14	65.72

As could be seen from Table I, compared with using the mean or standard deviation individually, the integrated application of these two indexes could give us better detection results. Therefore, we selected the mean and standard deviation of all pixel values in eye iris region as the features to achieve fish freshness detection.

C. Body surface features

According to daily life experience and experimental observation, when fishes in the corruption process, their bodies gradually lose luster, and the interval shadings between scales are more and more low, and the intelligibilities decline. The reflection of these changes in the gray image is the obvious change of texture feature. Therefore, we can detect fish fresh by analyzing the fish

surface texture. The image was drawn a rectangle along the outer contour of the fish, and a 128×128 fish surface image with its center at the position of the outer rectangle center was intercepted. Gabor transform was used for the extraction of Gabor features to character the texture feature of changes of fish body surface details. Gabor transform is windowed Fourier transform, and Gabor function can extract the related feature in frequency domain of different scales and different orientations. In addition, Gabor function is similar with the biological role of human eye, so it is often used to identify the texture and has achieved good identification results. If we constitute Gabor feature vectors using the Gabor transform coefficients of all pixels in the image, the gotten vectors will be very high dimensional. So, in order to reduce the dimension of Gabor feature vectors, the gotten Gabor feature should be downsampled. In this paper, we downsampled it to 4×4. In addition, when Gabor feature is calculated, the values of scaleν and orientationμ of Gabor function should be determined. If ν and μ is too small, it can't reflect the advantage of multi resolutions and multi orientations of Gabor transform. If ν and μ is too large, it does not necessarily improve the accuracy rates and maybe leads to heavy workload. In this paper, the scale values were set to 3 and 5 respectively and the orientation values were set to 2, 4 and 8 respectively, and SVM was used as classifier, the gotten detection accuracy rates of fish freshness were shown in Table II.

TABLE II. DETECTION ACCURACY RATES OF DIFFERENT SCALES AND ORIENTATIONS(%)

storage days	ν =3			ν =5		
	μ =2	μ =4	μ =8	μ =2	μ =4	μ =8
0	71.4	80	80	74.3	80	82.9
2	65.7	71.4	74.3	68.6	71.4	71.4
4	74.3	77.1	74.3	74.3	71.4	68.6
8	65.7	65.7	62.9	68.6	62.9	71.4
12	71.4	68.6	71.4	65.7	74.3	68.6
ave	69.7	72.6	72.6	70.3	72.0	72.6

As we saw from Table II, when analyzing using Gabor features, it was necessary to select more than one orientation. In this experiment, with the stationary scale value, the accuracy rates with orientation value set to 2 were lower than with orientation value set to 4 or 8. This appearance showed that only using the vertical and horizontal orientations, we would lose the image texture features in the acclivitous orientation, thus affecting the detection accuracy rates. On the other hand, it was not the more the better for the choice of scale and orientation values. In this experiment, when the scale got 3 and the orientation got 4, the accuracy rate had reached the highest. Then, further increasing the value of scale and orientation cannot raise accuracy rate accordingly, but lead to heavy workload greatly. In conclusion, the scale value was set to 3 and the orientation value was set to 4 in this paper.

III. DETECTION RESULTS AND ANALYSIS

The above gotten eye iris features and fish surface texture features were combined together to constitute the feature vectors to represent fish freshness, and the constituted feature vectors were sent to the classifier to detect fish freshness. In order to select a suitable classifier, we used Fisher linear classifier and SVM classifier respectively to accomplish the detection. The basic idea of Fisher linear classifier is projection. For a point in p-dimensional space, a linear function which can reduce it to one-dimensional numerical is looked for. Then this linear function is used to transform all training and test samples in p-dimensional space to one-dimensional data. Lastly the test samples are judged whether they belong to which classes according to the closeness between them. This linear function can minimize the distances between samples in the same classes and maximize the distances between ones in the different classes after transforming all samples in p-dimensional space to one-dimensional space. So the high discriminant efficiency is obtained. SVM is established on the basis of VC dimension theory and structural risk minimization principle. It searches for the best compromise between the complexity of model and the learning capability according to the limited sample information in order to get the best generalization ability. SVM shows many special advantages in the pattern recognition of small samples, nonlinear samples and high dimensional samples, and it can be applied to other machine learning problems, such as function fitting. The usual Fisher classifier and SVM classifier are designed for binary class problems. When dealing with the multiclass problems, we need to construct a suitable multiclass classifier. In this paper, we used one-to-one method for multiclass classification. That is, one binary classifier was designed between every two classes. So if we wanted to make classification between k classes, *k(k-1)/2* binary classifier should be designed. When we judged whether a sample belonged to which class, the class with the most votes for this unknown sample was its final class. In this paper, we respectively used Fisher linear classifier and SVM classifier to accomplish fish freshness detection in the light of different numbers of training samples, the results obtained were shown in Fig. 5.

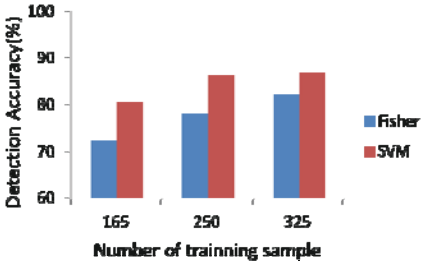

Figure 5. Detection results of different classifiers

As we could see from Fig. 5, Fisher linear classifier got its highest accuracy rate when training sample number is 325. While as for SVM classifier, the accuracy rate when training sample number is 250 had been close to the one when training sample number is 325. This phenomenon indicated that SVM classifier could obtain satisfactory detection accuracy rate with the less training samples, owning more practical significance. Therefore, we chose SVM classifier as

the classifier for fish freshness detection. The accuracy rate with 250 training samples were listed in Table III.

TABLE III. ACCURACY RATES OF FISH FRESHNESS DETECTION(%)

storage days	accuracy rate
0	94.3
2	85.7
4	77.1
8	88.6
12	85.7
ave	86.3

We could see from Table III, except for a few misjudgment for intermediate storage days, most actual storage days of test samples could be correctly predicted. It displayed that the proposed method owned good stability and high accuracy for fish freshness detection.

IV. CONCLUSIONS

Study on the rapid detection of fish freshness has very important guiding significance for processing, storage and marketing of fishes and fish products. In this paper, we analyzed the advantages and disadvantages of the present fish freshness detection techniques, and on this basis, a detection techniques based on image processing was put forward. The changes of eye iris gray value and fish body surface texture were combined to achieve the detection. The carps randomly purchased from supermarket were used to verify the method. The experimental results show that our method can achieve accurate fish freshness detection rapidly and nondestructively.

ACKNOWLEDGMENT

This work was supported by Program for Liaoning Excellent Talents in University (LR2012024) and the Research Projects of Liaoning Province (2011203005).

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