A Method of Object Identification Based on Sea Image Processing

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Abstract—**Currently, the technological evolution has led to the birth of the image processing discipline which processes and analyzes images in different fields including marine image processing. Identifying a dolphin from a picture which has sea feature is difficult because the background of the picture is complex and has some similarities with the target. For this reason, we make a thorough research on the target segmentation and the existing identification algorithms used to solve this problem. In this paper, we will present a new segmentation algorithm based on clustering threshold in the RGB color space to process dolphin images. We will combine it with the SIFT algorithm for image post-processing feature extraction. Then we will present how to build a dolphin growth model to identify a dolphin.**

Keywords—dolphin identification; sea image processing; target image segmentation; growth model; SIFT feature matching algorithm

I. INTRODUCTION

In digital image processing, it is desired that the machine recognition is capable of recognizing the object effectively from the complicated image and make a judgment, same as the human eye discriminates. Therefore, research and application of image segmentation technology and image recognition technology are very significant. Now, image recognition technology has been applied in more and more fields, such as face recognition, medical image processing and ocean image processing. We are interested in the application of the image recognition technology in recognizing dolphins.

Dolphins are some of the world's animals that are at risk of extinction. When wild dolphins' conservation experts study the wild dolphin colonies, they often estimate the age of dolphins by the artificial method. The method is that they need to compare the photographs one by one to estimate the age and distinguish individual dolphins according to the characteristics of the surface of dolphins. For experienced maritime workers, the correct rate of recognition of dolphin is relatively high. However, in order to distinguish the dolphins accurately, young marine workers need to take a lot of time to learn. The artificial recognition method has a big workload and high error rate. Therefore, we need to explore a new method of image recognition to solve these problems.

Ma Yan et al. [1] proposed a new algorithm for automatic object segmentation in different color space. Gondra et al. [3] proposed a target segmentation algorithm based on machine learning. The gray image segmentation is highly efficient. The color image segmentation splits the image from different color spaces. Lowe [5][6] proposes a SIFT feature extraction algorithm with scale invariance. This algorithm is relatively stable in feature extraction and it can effectively deal with affine transformation and perspective transformation.

Each dolphin has its own characteristics, which can be used to distinguish different dolphins. In this paper, we improved the commonly used target segmentation algorithm and the identification algorithm and apply it to the field of dolphin image identification. We will present how to distinguish the identity of the dolphins through image recognition technology. We will present how to establish the identification model and the growth model of dolphins based on the surface characteristics of dolphins. We will also present an automatic management process of dolphins' image.

In Section 2, we will analyze dolphins target image segmentation. In Section 3, we will present image preprocessing and SIFT feature-matching algorithm. In Section 4, we will present our growth model. In Section 5, we will illustrate our experiments.

II. DOLPHINS TARGET IMAGE SEGMENTATION

In this paper, we need to segment the dolphins' targets from the background of sea image. However, there are a lot of waves on the ocean surface, which can lead to incorrect segmentation results. The color image segmentation divides the image from different color spaces, as in [3][4]. The image may be an image composed of multiple complex images, and the gray image segmentation may not divide the image, as in [1][2]. In this paper, we will propose two methods of using the color image segmentation:

 ISBN: 978-1-61208-520-3

1) Color image target segmentation;

2) Manual target segmentation.

The color image target segmentation technology uses an average clustering method. The dolphin image background is seen as a category and the dolphin target as another category. We used fuzzy C-means clustering methods to separate the dolphin image from the original color image. Then we obtained the dolphins' image target.

The implementation of the specific steps is as follows:

3) Determine the clustering center;

4) Adaptively determine the clustering center and classify the dolphins image according to the clustering strategy: sea background as class Ⅰ and dolphins target as class Ⅱ;

5) Separate class Ⅰ from the dolphin in the image to obtain the dolphins of target class Ⅱ.

We use the distribution of RGB color components as the scope of clustering in Figure 1. The integer value range of RGB three components is from 0 to 255. These points are contained within a quarter of the ball whose radius is 255; in Figure 1, the ordinate represents G component, the abscissa represents R component. Dolphin image pixel range is in the black line and blue line around the area. The scope of pixels of the water is in the red line and green line around the area.

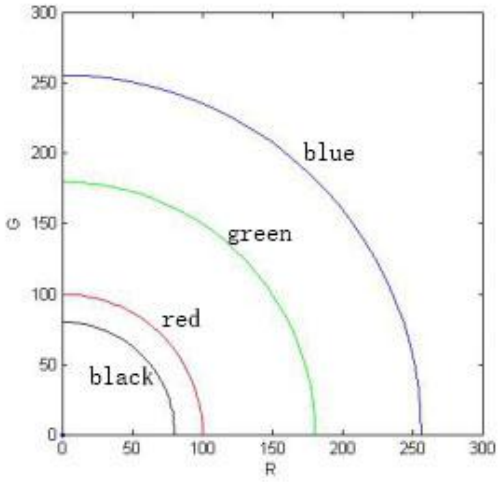

Figure 1. Scope of clustering

We calculated the maximum and the minimum Euclidean distances of each sampling matrix and the result is as follows:

$$L_{\max} i = \max(\mathrm{L}) \qquad L_{\min} i = \min(\mathrm{L}) \tag{1}$$

Calculate the maximum and minimum average distance:

$$\mu_{\max} = \frac{\sum_{i=1}^{8} L_{\max} i}{8} \qquad \mu_{\min} = \frac{\sum_{i=1}^{8} L_{\min} i}{8} \tag{2}$$

We also used the Euclidean distance to calculate the image color clustering center.

$$\mathrm{R}_0 = \frac{\sum_{i=1}^{8} \mu_i}{8} \tag{3}$$

Where μ_i is each sampling matrix average Euclidean distance.

After calculating the Euclidean distance of all the pixels in the image, and comparing it with the clustering range, we regard the area within the scope as the sea background and the pixel is set to 0; the area that is beyond the scope is to keep the original pixel distribution. The results are shown in Figure 2.

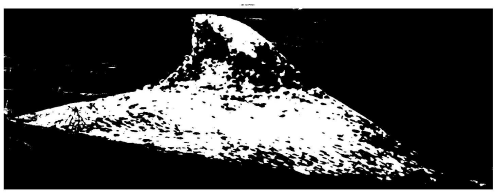

Figure 2. Image using color segmentation algorithm

Manual segmentation is done by manipulating the mouse on the image, as shown in Figure 3. The blue line in Figure 3a is the route of the mouse in manual segmentation. Figure 3b is the goal and Figure 3c is the result after the image segmentation. The steps of manual target segmentation are: Firstly, mark the needed segmented regions, and set the pixels of the image in the area to 1, the pixels of other areas of the image to 0. Then the template image of Figure 3b is obtained. Secondly, the result of the template image and original image multiplication is the target image after segmentation.

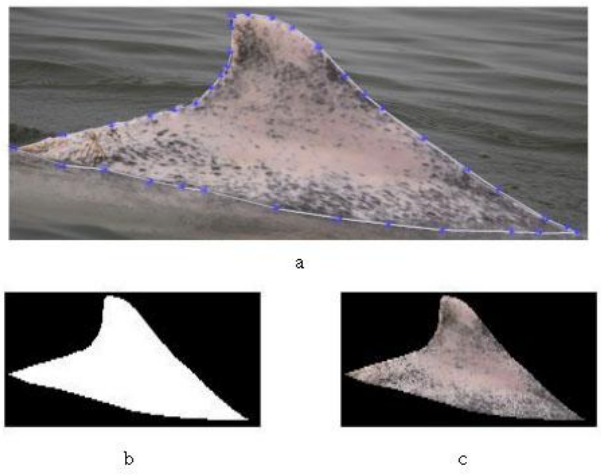

Figure 3. Manual target segmentation

Automatic target segmentation is more effective and has fewer human errors. But if the image quality is low and it

needs higher segmentation precision, it is better to use manual target segmentation.

III. IMAGE PREPROCESSING AND SIFT FEATURE MATCHING ALGORITHM

In this section, we obtain the distribution of the spots on the surface of dolphins by image preprocessing, and then we can calculate these spots and establish the growth model of dolphins.

A. Image pre-processing phase

The spots on the surface of the dolphin are the feature points of the dolphin identification. The spots on the surface of the dolphin are dense and vary in size, which will increase computation of spots extraction, and produce errors easily. So we have taken three steps to preprocess: remove the edge; spot inflation; spot polymerization.

In this paper, we used Prewitt edge detection algorithm to process the dolphin image that has been segmented, and accurately detected the dolphins' surface spots edge. At the same time, manual segmentation region contour edge was detected. These contours can produce unnecessary interference to identify the effect, so it needs to be removed.

We used 5*5 square matrix corrosion structure elements. The target shape of the corrosion has not been changed, and the image edge was removed.

Now, the dolphins' surface spots are accurately marked out. However, the spots very in size and are unevenly distributed, which makes the statistics and identification prone to error. We carry out the result by expansion processing these spots, and make some small spots together, as a new feature point. The structural elements of expansion which we use is: $\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$. We carried out on the spots three times in the expansion operation.

We can see from the picture that small spots formed together big spots, and features are more obvious.

B. SIFT feature matching algorithm

SIFT (Scale Invariant Feature Transform) features keep the invariance to image scaling, rotation, scale brightness unchanged, which is a very stable local l feature, as in [7], thus has very extensive application value.

SIFT feature matching algorithm is used to identify the matching function that can be divided into three phases. The first stage is the feature point detection. Extract all of the images for matching feature points. The second stage is the feature descriptor. Add a detailed description for the local feature of the extracted feature points. The third stage is to generate the feature vector and feature vector match. Find out the mutual matching feature points by comparing the original image and the target image feature points, thus we could establish the corresponding relationship between objects.

We have found the key points and have given them position, scale and direction information. However, we need a special set of key vector to describe the key points of the image and the key points that include not only the key, but also include the pixels around the key points for its contributions. Descriptor will be used as the basis of target matching.

We took the 8 * 8 window centered on key points. The squares of window are divided into groups with size of 4 * 4, using statistical methods to obtain the gradient direction and gradient magnitude in each group. In the end, the gradient and direction of these different groups form a set of vectors. This group can be used to describe the key point and the descriptor. Being generated according to pixel of the key points in the field, the descriptors have strong inhibition to noise.

IV. GROWTH MODEL

Jefferson et al. [8] had proposed to divide the Chinese white dolphin into six age groups, but the boundary was not clear. It was also not clear how to represent the ages. The recognition criteria are shown in table I according to the different age paragraphs.

TABLE I. STANDARD OF DIFFERENT AGES

age grades	description
childhood and early youth	childhood skin color is dark gray, no spots, body length smaller, body length is about 1/3 to 1/2 of adult; early youth individuals is grey or light grey, and occasionally has dark spots, and is significantly greater than childhood, body length is about two-thirds of the adult.
youth and sub-adult	Complexion is pale, general is pale pink or white, with more spots, occasional dark spots.
adult	pure white or pink, less or no spots.

The change of Chinese white dolphins' spots and the change rule of age are shown in Figure 4. The horizontal axis is the dolphins' age, unit is the month. The vertical axis is the number of feature points of the dolphins' image detected.

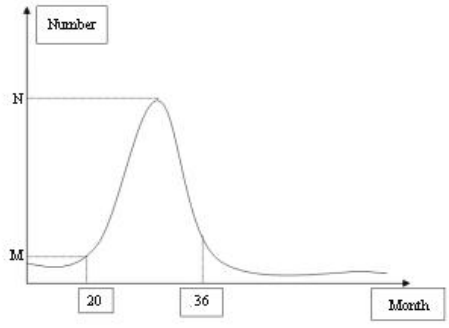

Figure 4. Dolphins spots variation

We can see that from born to 20 months old, the number of the dolphins' surface spots are sparse, and with the passage of time, the number of spots gradually increased. However, when dolphins are teenagers, there will be a substantial increase in growth of the number of spots. When the number of dolphins' surface spots reached a peak, the number of spots will decline rapidly. In the end, the spots of

 ISBN: 978-1-61208-520-3

dolphins disappear or there are only a few spots, which is the sign of the maturation of the dolphin. So we can complete statistics of dolphins' age through statistics of the number of their surface spots. But among the spots on the surface of the dolphins, some are big and some are small. Therefore, we expand the small spots in the image. The spots shape characteristics are not changed when the small spots get together. The size and number of the spots on the surface of a dolphin are both the mark of a dolphin's age and identity.

For the experimental part, we used 190 dolphin images provided by the Pearl River estuary Dolphin Conservation base. 100 images are randomly selected from these images. Then the selected images are processed automatically by object segmentation, image preprocessing, and feature point extraction. Thus their feature points distributions are obtained, and then we obtain the images corresponding to their age. The results are shown in Figure 5 which is the age distribution of dolphins.

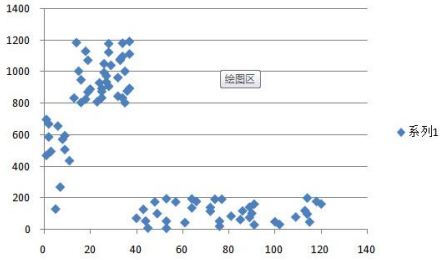

Figure 5. The age distribution of dolphins

There are three conclusions in Figure 5.

1) When the age of the dolphin is between 0 to 12 months old, the number of the key points detected on the dolphin's surface is between 200 and 760.

2) When the age of the dolphin is between 15 to 38 months old, the number of the key points detected on the dolphin's surface is between 800 and 1200.

3) When the dolphin's age is greater than 40 months, the number of the key points detected on the dolphin's surface is between 0 and 200.

V. EXPERIMENTS

In this paper, we used 190 images of the White Dolphin after artificial classification. Each image is attached with the age information. We use 90 images as the experimental object to verify the accuracy of the dolphins' growth model. 90 images were processed in order to extract the feature points, and to determine the age of dolphins according to the number of feature points. The results were compared with the results of the dolphin protection workers. Through the experiment, the correct rate using dolphins' growth model to estimate the age of the dolphins was 85%, the remaining 15% of the error rate is because there are some waves in the dolphins' image covering the key points. However, due to the high transparency of the waves, the human eye can see the spots on the surface of the dolphins through the spray, and identify the dolphin's age.

The matching strategy judges the dolphin's identity through key points. The dolphin's image matching experiment can be divided into three groups: normal image matching experiment, partial occlusion experiment, and rotating image experiment. Supposing the number of key points detected in the input image is M, the key points number of template is N, the number of the key to successfully match is K, and the matching rate is δ.

$$\delta = \frac{k}{N} * 100\% \tag{4}$$

A. Normal dolphin image matching

Figure 6. Normal dolphin image

The image needs to be identified as in Figure 6. The experiment selected 5 images as input image. The experimental results are shown in Table II.

TABLE II. EXPERIMENTAL RESULTS 1

Test image	M	N	K	δ	Recognition result
1	2759	3046	1797	0. 619	1
3	947	2054	76	0. 037	4
5	2896	3700	2176	0. 588	5
7	3315	4125	3110	0. 754	7
9	3689	2789	1706	0. 612	9

The matching rate of recognition is 80%.

B. partial occlusion experiment

Segmentation of the body surface features of a dolphin uses manual target segmentation. Then the segmented image is recognized. The segmented image is shown in Figure 7.

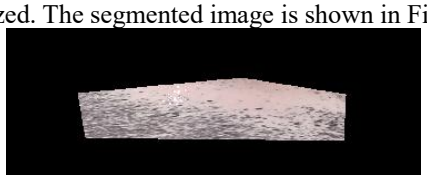

Figure 7. Partial occlusion of dolphin image

Partial target segmentation of pictures No. 1, 3, 5, 7, 9 images, experimental results are in Table III.

TABLE III. EXPERIMENTAL RESULTS 2

Test image	M	N	K	δ	Recognition result
1	446	3046	136	0. 305	4
3	987	2054	575	0. 583	3
5	1783	3700	1101	0. 621	5
7	2596	4125	477	0. 184	9
9	1865	2789	1108	0. 594	9

 ISBN: 978-1-61208-520-3

The experimental results show that the matching rate is 60%.

C. Rotation matching experiment

Rotate No. 1, 3, 5, 7, 9 and match recognition, as shown in Figure 8.

Figure 8. Rotating image

Experimental results are illustrated in Table IV.

TABLE IV. EXPERIMENTAL RESULTS 4

Test image	M	N	K	δ	Recognition result
1	2786	3046	1739	0. 571	1
3	1486	2054	1051	0. 512	3
5	3412	3700	1161	0. 314	7
7	3752	4125	2397	0. 581	7
9	2163	2789	1484	0. 533	9

The matching rate of the experimental result was 80%.

After more than three sets of experiments, it can be shown when the rotation, occlusion and other factors influence the image; the recognition rate is still higher than 60%. SIFT feature extraction algorithm is very effective in the use of dolphin identification.

VI. CONCLUSION

In this paper, we have studied the dolphin image segmentation, the image preprocessing, and key point detection. Then, we summed up the relationship between the key quantity and dolphin age, and the dolphin growth model. Through the experiment, we used a dolphin growth model to estimate the age of the dolphins and the correct rate was 85%. Finally, the key points can be used to accurately describe the characteristics of the image. The accuracy of the dolphin matching is measured, and the accuracy rate is above 60%. In this paper, the growth model of dolphins established by key points can estimate the age of dolphins by the number of key points. But when the part of the key points of dolphins' surface are covered, the result is not accurate. In the future, we will study how to use probability estimation to estimate the dolphin's age when the key points of the dolphin are covered.

ACKNOWLEDGMENT

This research is supported by (1) 2017-2020 The National Natural Science Fund (Project No. 51679058). (2) 2013-2016 China Higher Specialized Research Fund (PhD supervisor category) (20132304110018).

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 ISBN: 978-1-61208-520-3