Boundary Tracing of Fish Image

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ABSTRACT

There are several techniques to obtain boundary of an object in a digital image. Some of the well known techniques are contour tracing and edge detection technique. The result of this boundary tracing is used for analyzing an object in the image. This result is critical for some certain image analysis. In this study, the techniques will be used for obtaining the fish boundary from a digital image. The study will evaluate the suitable approach to get the fish boundary. This study is important for the next study on analyzing the physical characteristic of the fish.

Keywords

Image processing, boundary tracing, edge detection, contour tracing.

1. INTRODUCTION

Oceanic fish is one of the food resources that contain amounts of protein for human. Many scientists are conducting researches in fisheries to understand the fish life. This is important to raise the food quality for human being and also to keep the fish population from extinction. The scientists try to scientifically get the fish information to improve their knowledge about fish life history, physical characteristics and its essential fish habitat. Many ways have been tried by them, including to use technology.

Nowadays, digital imaging can contribute to enhance scientific research in oceanic fish. By using the digital image processing techniques, the fish information can be obtained to help the research. Tou et al. (1982) showed that different fish species could be discriminated from one another by using computer vision. In order to be able to discriminate sea fish species, Strachan (1993) developed algorithms to generate descriptors for shape and colour. The descriptors were functional even if the fish was taken picture in a deformed position. With this computer vision algorithm, 18 species of demersal and five species of pelagic fish could be sorted with 98-100% reliability. Jia et al. (1996) developed computer vision algorithms for automated processing of ‘channel catfish’ (Ictalurus punctatus) including the detection for fish orientation, identification of head and different fins. So and Wheaton (1996) used computer vision regarding automated opening of oysters. Gunnlaugsson (1997) made a review on how computer vision technology could be used in fish processing plants. For automated classification of fresh water fish, Zion et al. (1999) developed a computer vision algorithm based on the moment invariants and geometrical parameters. This algorithm could sort three different species from one another. Computer vision in fish has also been used for grading herring row (Hu et al., 1998) and determination of the fat and connective tissue amounts in salmon fillets (Borderias et al, 1999). Although Borderias et al. did not achieve a good correlation in their work (R=0.44), Misimi (2007) concluded that this method could be applied for on-line quality control of salmon (at least rough grading in different fat classes). Recently Marty-Mahè et al. (2004) have estimated the brown trout cutlet fat contents by automated colour image analysis in the CIELab colour space, while Stien et al. (2005, 2006) have used image analysis to study the colour composition as well as the rigor development of rainbow trout fillet.

The vast amount of work done in applications described one of fundamental aspect of fish research is to understand the physical characteristic of the fish. This physical characteristic of fish includes the color, length, height and the size of fish body. From this information the researcher can identify the life history of the fish.

2. RELATED WORK

There are some image processing researches conducted on the physical characteristic of oceanic fish. Some scientists try to understand the color of the fishes. A variety of fish colors contains valuable information. Any color changes in fish provide significant information about their state which then can be studied and interpreted. The research was focused on the study of color and its characteristics in fish research. The object of the study was a species of fish called Arctic char (Salvelinus alpinus). Arctic char was considered an endangered species in Finland and studied by the biology scientists to restore this population of fish. A red coloration of this fish was carotenoids-based coloration.

It was assumed to be a factor defining the sexual behavior of fish during spawning period [Shatilova 2008]. The high level of carotenoids in fish skin may be indicator on male attractiveness, activity and ability to produce health posteriority [Lozano, 1994]. Knowledge about carotenoids content is critical in biological research for determination health state, social and sexual contexts of fish. The relationships between carotenoids in the integument, level of immune-system function and sexual attractiveness were tested and a positive correlation has been revealed [Grether et al., 2004].
The objective of the study was to develop affordable method for determination of an approximation of carotenoids amount of Arctic charr to help the biological research of this fish. The algorithm proposed to approximate the carotenoids amount in Artic charr’s skin based on RGB image is shown in figure 2.

To measure the size of fish body, White et. al. (2006) constructed a special computer vision equipment called as Catch Meter system. They built the machine with conveyor belt, backlight, and camera that attached with a computer. They use backlight to increase the contrast of the silhouette of fish enabled Freeman (1974) chain code to be used. By using the machine, the size of the fish can be extracted thorough several processes, like calibration, find region of interest (including edge detection), find orientation, calculate parameters, and species decision.

The system that is used to get the boundary image of fish by Lee et. al. (2004) was little bit different, because they want to get the image from living fish. They try to recognize the population and migration of the fishes by recognizing the contour of the fish body. They built the system with camera attached to a computer.

The first and most important step in the system is image acquisition. The image for analysis must be in a high quality, therefore the selection of the camera is very important. After the system detects the presence of an object, then it will extract the contour of the fish and identify them if the object is indeed a fish. When an image of the whole fish can be acquired, the analysis process will be started. Whole fish features including fish contour and significant landmark points can then be extracted for analysis. Shape-based recognition can be performed to obtain size and species information (figure 4).
The system now is being used in Prosser dam on the Yakima River in Prosser, Washington.

3. EDGE DETECTION AND BOUNDARY TRACING METHOD

Image segmentation is an important part of the automatic image analysis. The result of this segmentation is used more in the pre-processing of an image to identify the object in the image. The output of this segmentation process will be used as the input for the next process higher process such as image classification process or object identification process, etc. There are some techniques that commonly used in image segmentation process based on discontinuity and similarity of pixels, such as edge detection and thresholding.

Edge detection is one of the image segmentation based on discontinuity. It is similar with spatial domain filtering, but usually uses different kernel values [Matteson, 1995]. Several different kernels can be used in one process, and the results are combined to provide the edges. Various filter kernels have been developed for doing edge extraction. Filter kernels that are more sensitive to horizontal, vertical, or diagonal edges are the Roberts, Prewitt, and Sobel operators, as shown below.

- **Roberts**:
  
  \[
  h_{r1}(x, y) = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}
  \]

  \[
  h_{r2}(x, y) = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}
  \]

- **Prewitt**:
  
  \[
  h_{p1}(x, y) = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{pmatrix}
  \]

  \[
  h_{p2}(x, y) = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{pmatrix}
  \]

- **Sobel**:
  
  \[
  h_{s1}(x, y) = \begin{pmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{pmatrix}
  \]

  \[
  h_{s2}(x, y) = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}
  \]

Thresholding is an image segmentation technique based on similarity. It is finding the regions by grouping pixels with similar gray-values. There are two kind of thresholding which is fixed thresholding

\[
 f_{sk}(i, j) = \begin{cases} 
 1 & \text{if } f(i, j) \geq T_N \\
 0 & \text{otherwise}
\end{cases}
\]

and adaptive thresholding with

\[
 f_{sk}(i, j) = \begin{cases} 
 1 & \text{if } f(i, j) \geq T_N \\
 0 & \text{otherwise}
\end{cases}
\]
where \( TN = kT + (1 - k)f_{1(i,j)} \), \( 0 \leq k \leq 1.0 \)

In boundary tracing, selecting the starting point and the direction are critical for certain objects, especially the object that has some holes inside. But this problem can be eliminated by erasing the holes inside the body.

Figure 5 shows the pixels traced clockwise from the north point of the object. The boundary tracing is started with selecting the starting point \( P_0 \). After the starting point is defined then define the direction of tracing \( \text{dir} \), \( \text{dir} = 7 \) for 8-connectivity. The first pixel found with the same value as the current pixel is a new boundary element \( P_n \). The tracing will repeat for searching pixels until the current pixel \( P_n \) found the pixel \( P_0 \). This boundary tracing result can be used for other image analysis such as estimating the area of the object or represent it in code by using chain code method.

**4. RESULT AND TESTING**

In this experiment, some techniques are used to obtain a boundary of a fish image. The steps are started with detecting the edge of the fish body.
The figures above are the result of some edge detection techniques. Figure 8 is the result of Sobel edge detection technique, while the figures 9 and 10 are the result of Robert and Prewitt. The edge detection technique that is used in this study is Sobel technique, because the result in figure 8 shows that this technique gives a clearer edge of the fish.

After detecting the edge, the fish image needs to be sharpened to give a strong line of the edges. The result of sharpened image is thresholded to and filtered remove the pixels that is not used, and convert it into binary data.

After that, the image needs to be closed to link the pixels inside the fish body. After closing the image, the fish body still has some uncovered areas. By using the flood fill technique, the image will appear as a complete fish shape.

After these steps are done, now the boundary of the fish image can be traced.

Figure 13 shows the result of boundary tracing by following the steps using some techniques including the edge detection technique. The result shows that the edge detection technique is needed in tracing the boundary of the fish. The edge detection technique helps to detect a fish object inside an image, especially when the object has a quite similar color with the background.

5. CONCLUSION

The boundary of fish’s body is one of the important information that is needed in a fish analysis. This preliminary study has shown that the boundary tracing for fish analysis is still an open field of research. The study tries to find the suitable approach to get the fish boundary by applying and combining some techniques. As expected, the techniques that are used can give the fish image boundary.

6. FUTURE WORK

Future work from this study is as follow:

i. Study some approach that can be implemented in some robust areas.

ii. Evaluate the fish boundary with some physical measurement.

iii. Review and improve the approach to get the fish boundary.

7. ACKNOWLEDGMENTS

The Authors would like to thank Dr. Ismail Mat Amin, Mr. Muhammad Zaidi bin Zakaria and the fisheries experts from Universiti Malaysia Terengganu for their help and comments regarding this work. The Ministry of Science, Technology and Innovation Malaysia that support this research under Vot.78365.

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