Feasibility Study on An Automated Intruder Detection for Tropical Fish Farm

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***Abstract*—In this paper, an automated intruder detection system for sea cage fish farm is introduced. Optical imaging method is used to detect possible predator or theft invasion in the fish net area or in the vicinity. In order to accurately alert the operator on an invasion event from tens of camera installed around the feeding nets, an high speed rule based algorithm is tested to identify possible intruders that trespass into the sea cage net area of a local fish farm. A camera system will be installed below the net level of the feeding area. In the early stage, a recorded mode camera system is used to record down the images captured for analysis purpose. The objective is to identify predator, non-fish and the fish categories from looking down position. We employ rule based algorithm that show high tolerances to in-plane rotation, scale variation and out of plane rotation. Various testing images from different scenarios are used in the experiment. The results show that low cost system can be installed using this algorithm to identify the targets in least image processing resources.**

***Keywords*— rule based intruder detection, image processing, fish identifications.**

I. INTRODUCTION

Pollution and extensive fishing over the years have caused significant reduction in seafood catching and fishing volumes. Thus, fish farming using sea cages floating on the coastal water area becomes an increasing seafood sources to satisfy world's seafood demands. Coastal Malaysia water is suitable for sea cages fish farming due to its warm temperature and relatively calm water in the protected straits of Malacca. However, the fish farmers are still suffered from various causes of economics losses due to predators (such as: sea otters, alligators, jelly fish, birds etc) and theft (humans), especially during the harvesting seasons.

Figure 1 depicts a typical fish farm constructed on the coastal sea area. Optical means are preferred in the application compared to sonar [1] because the sonar might create noise pollution to the fish stock and other sea creatures [2]. Nevertheless, the optical imaging method is most suited for detection range of 2 meters with high resolution data [3][4][5]. The multiple camera system was hanged below the fish farm structure. Each cage will need 2-4 cameras in order to give full field of view below the net area. We anticipate the predators or theft will come from any direction below sea water level. Above sea water level, animals are fed on the fish farm to chase away birds or human intruder. Figure 2 indicating the camera position relative to the fish farm and feeding net area.

Figure 1. Tropical fish farm in construction phase. Each compartment is an individual fish cage.

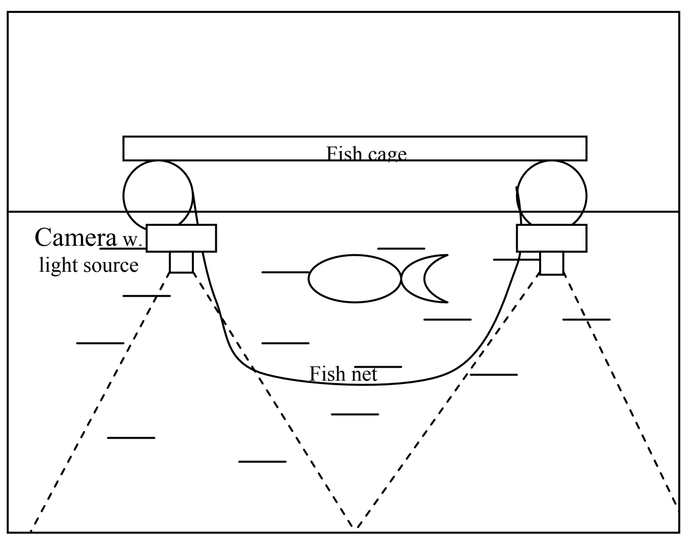

Figure 2. Tentative design for the fish farm intruder detection system (Not to Scale)

Section III laid out the preliminary study using the high speed classifier to detect the "Non-fish" and predator images. Section IV discusses the results.

II. System Description

This project is initiated based on the specifications given by a local fish cage farmer that suffers from various sea predators and human theft problem in the region. First, the predators are described to carry out their attacks in just less than 10 seconds period, if the central processor scanning time takes longer than 0.1s for the image processing from each camera, it might miss to trigger the alarm system. Second, the predators normally have sizes larger than the fish size in near camera position. Third, the predators usually can be identified using color segmentation technique[6][7] if illuminated under clear sun light. Thus, the rapid motion, color and size of the predator become the key features in the intruder detection system design. In the mean time, the cost of the whole system should be lower than employing full times working personnel to monitor the cages 24 hours a day for 365 days a year. In this case, the system can only used 1 centralized processor (normal PC) for all camera installed on the fish farm in the initial stage.

The key component in the detection is a real time imaging system that can process hundred of images per second, and recognize the right pattern from various underwater imaging and background conditions, such as: sea lighting, rubbish, visibility, other non-predator fishes etc. The main challenge of the system is to sound an early alarm immediately whenever there is a possible predator approaching or in the vicinity of the fish net. Thus, a high speed detection algorithm based on geometrical features is proposed to classify non-predator and predator images. The processing speed is the key concern in this application, since there are at least 2 cameras for each cage for over 50 cages in a typical fish farm.

The preliminary algorithm in the intruder detection system is shown in Figure 3. First, fishes / non-predators are detected from image. If fishes are not detected, then predator verification is performed to check whether predators appear in the image or not. Once the predators are verified, the alarm is generated.

The development is to introduce the fish detection algorithm before the predator detection and verification is based on the assumption that when fishes are detected in the image, the predators will not appear, due the fact that fishes will run-away or disappear when predators come. Since the predator verification is more difficult than fish detection, it is done only when the fishes are not detected. Therefore using the proposed approach, the predator verification process could be done in the effective way.

The common method to extract objects from the background is using an image segmentation based on color/intensity threshold. This method extracts objects if the color/intensity falls in a certain range. It is simple and fast method. However, from a few observations, the color threshold technique could not be adopted in the application.

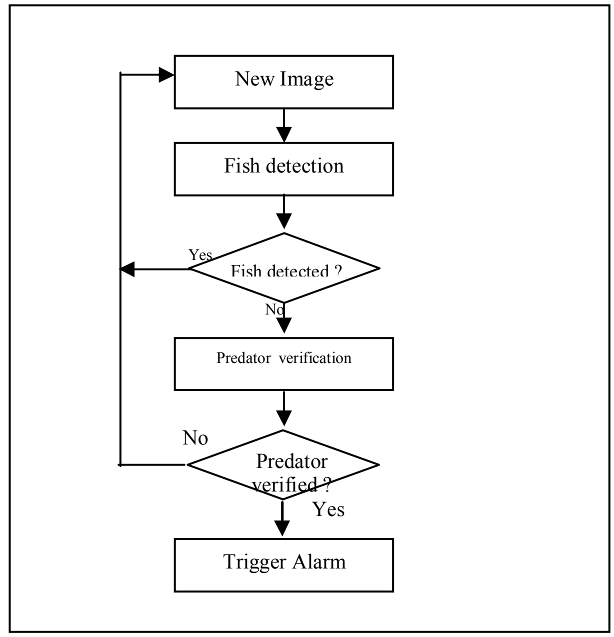

Figure 3. Image processing algorithm for intruder detection

Therefore, a novel method based on edge detection is used to extract objects from the background. In the fish detection stage, a simple and fast technique by utilizing the ratio of fish's length and width is employed. Using the method, fishes could be detected from the image easily.

We use 8-connected pixels detection to label each feature appears in the FOV. For each target feature, the centroid is normalized and its major and minor axial ratio can be calculated by its moment:

$$U_x = \sum x_i^2/N \quad (1)$$

$$U_y = \sum y_i^2/N \quad (2)$$

$$U_{xy} = \sum x_i y_i/N \quad (3)$$

$$C = \mathrm{sqrt}((U_x - U_y)^2 + 4U_{xy}^2) \quad (4)$$

The Major Axis Length,

$$Ma = 2*\mathrm{sqrt}(2)*\mathrm{sqrt}(U_x+U_y+C) \quad (5)$$

The Minor Axis Length,

$$Mi = 2*\mathrm{sqrt}(2)*\mathrm{sqrt}(U_x+U_y-C) \quad (6)$$

In the predator verification stage, the rapid motion comparator is used to check if the object in target is moving faster than the background movement. If it is positive, the size and the color of the target feature will be compared to the previous fish images recorded/detected. If the size is bigger than the previous fish size, the predator verification will identify the categories of the predator (recorded for future analysis) and trigger the alarm.

III. PRELIMINARY TESTING RESULTS

3.1 Pre-processing

Pre-processing stage is used to extract objects from the background. To extract objects, an edge detection method is employed. Edge detection method finds edges of objects by computing the gradient of pixel's intensities. A pixel is assigned as an edge when the changes of the intensity to the neighbor pixels are greater than a threshold. After edge detection is applied to the image, boundary of objects could be determined. Then a blob, i.e. binary image representing an extracted object is created by filling in the area inside the boundary. The blobs are further processed in the fish detection stages to identify them as fishes or not.

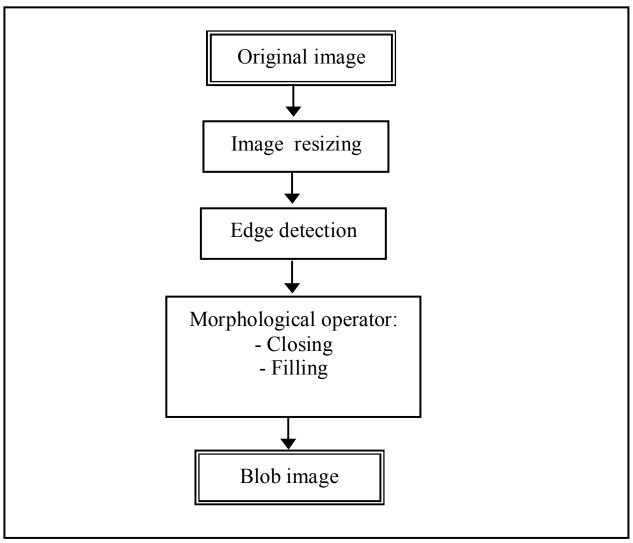

Figure 4. Pre-processing of captured images

Figure 4 depicts the pre-processing stage. First, image is resized into 120 x 160 pixels for two reasons: a) to reduce the computation time; b) by resizing image, object becomes solid, thus edge of the object will form a connected line (or almost connected). After resizing, a Sobel edge detector is applied to the image to extract edge. Then a morphological operator "close" is used to connect the edge pixels to form a boundary of the object. Finally, area inside the boundary is filled to create a blob.

3.2 Fish detection

In the fish detection stage, blobs extracted in the pre-processing stage are identified as fish or not using the geometry feature. First, a fast ellipse fitting based on the moment (second order moments) is used to fit an ellipse of the blob/object.

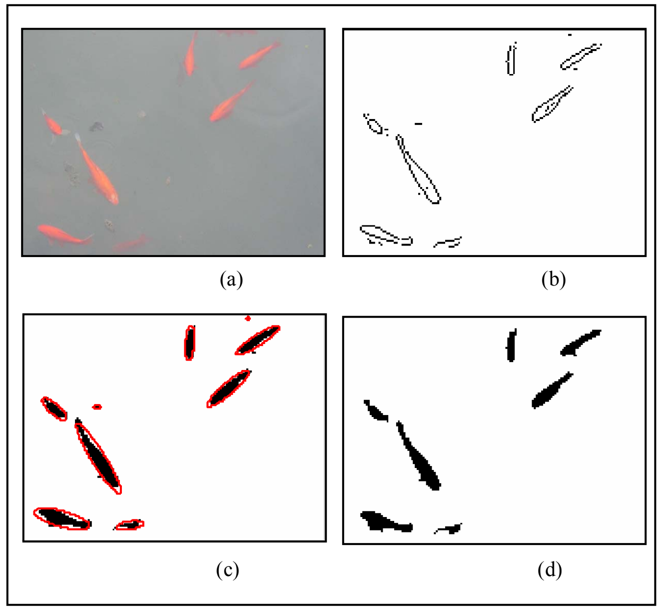

Figure 5. (a) Original image; (b) Edge image; (c) Blob image and the fitted ellipses drawn with red color; (d) Detected fishes

After ellipse is extracted from an object, the major-axis and minor-axis of the ellipse are used to verify the object as a fish or not. An object is identified as a fish if it satisfies the following rule:

IF (blob's size > Lo_threshold) AND (blob's size < Hi_threshold) AND (Major-axis/Minor-axis > Ratio_threshold) THEN object is fish AND (blob_ matched_ ratio > BM_ratio), where Lo_threshold, Hi_threshold,Ratio_threshold, BM_ratio are the system's parameters. The blob_matched_ratio is defined as

$$R = \sum N_i / A_i \tag{7}$$

Where R is the blob matched ratio, N_i is the blob's pixels and A_i is the ellipse's area

The blob_matched_ratio is introduced to overcome the following problem. Ellipse fitting method fits object/blob to an ellipse shape. In some cases, ellipse detected from non ellipse object might be identified as a fish using blob's size and ratio of major axis and minor axis. However, by introducing the blob_matched_ratio, our algorithm could avoid mis-detection caused by such problem.

Figure 5 shows the results of each step in the pre-processing and fish detection stages. In Figure 6, a non fish object appears in the image. Due to the shadows on sea water, they are detected as blobs, thus many ellipses are extracted from those blobs. However by verifying using rule in ( ), we could remove all non fish objects as indicated by empty figure (means no fish detected) in Figure 6(d).

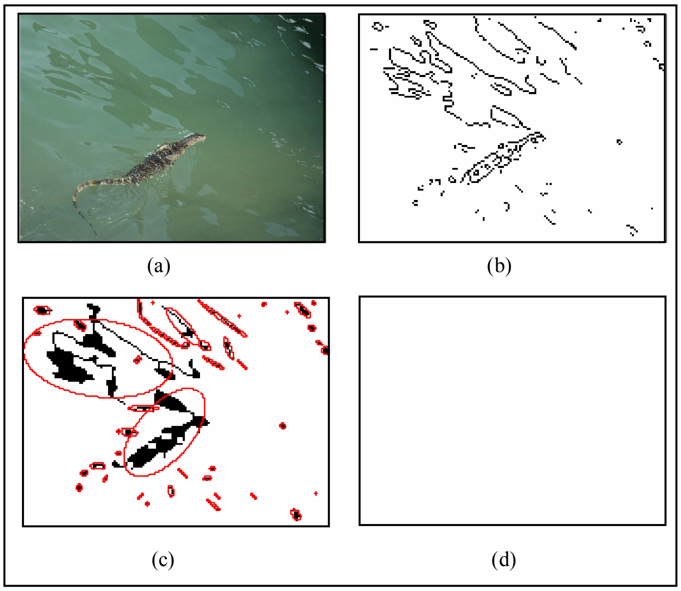

Figure 6. Non-Fish detection : (a) Original image; (b) Edge image; (c) Blob image and the fitted ellipses drawn with red color; (d) No detected fishes.

Further we tested our algorithm to detect fish from images taken from side-view in under sea-water as shown in Figure 7. Since the fish color is almost similar to the sea-water, color segmentation is ineffective. However, our method by combining edge detection, morphological operator, ellipse detection, and verification rule is able to detect the fish properly.

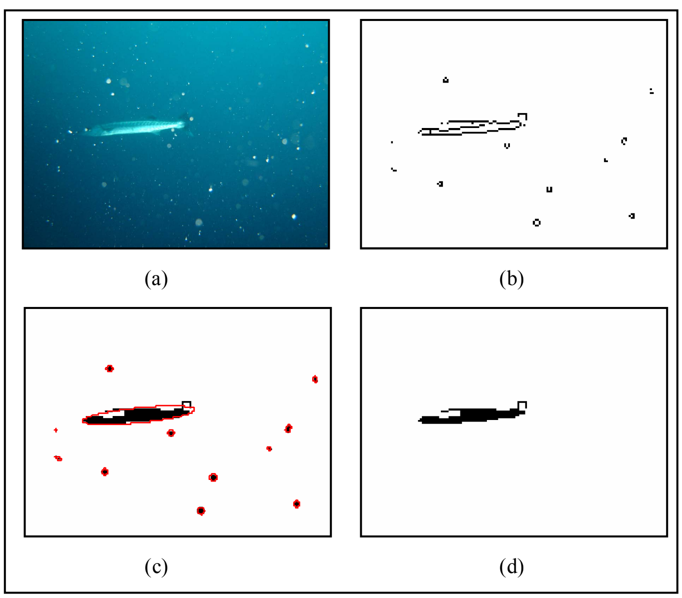

Figure 7. Fish detection taken from side-view : (a) Original image; (b) Edge image; (c) Blob image and the fitted ellipses drawn with red color; (d Detected fish.

Our algorithm might encounter problems when fishes form in a group whose distances are very close each others. In this case, all detected blobs might be connected, thus produces a big blob which is considered as a non fish by our verification rule. It becomes a challenging problem will be addressed for further research.

3.3 Predator verification

First, the algorithm will detect the predator using a gradient based optical flow detector [8]. If the target is moving more rapidly than the background current movement, it is verified as the non-fish categories in the verification stage.

Second, the size of the target is quantified. Generally, the predator, such as: sea otter, human, alligators are larger the fish sizes. By comparing the size of the target to the previous recorded fish images, a predator category is identified. An alarm should be trigger in this stage. While doing that, the algorithm proceeds to identify the predator category for future research purposes.

Third, the shapes and colors of human diver, jelly fish are easier to identify compared to sea otter and alligator. Thus, further specific algorithm are needed for this identifications.

IV. DISCUSSION

In this preliminary stage, we can only test with existing images available. A field trip should be carried out to capture images in the region. This should includes fish, non-fish, and predator images. We are confidence on the project outcome based on the successful identified fish images. Of course, we still need to proceed to second stage of investment and funding in order to installed proper system and testing rig on the fish farm.

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REFERENCES

[1] Lecornu, L. Burdin, V. Scalabrin, and C. Hamitouche , “Fish school analysis from multibeam sonar image processing,” IEEE Ocean 1998, Volume 1, pp. 587-591.

[2] http://www.nrdc.org/wildlife/marine/sonar.asp

[3] J. A. Lines, R. D. Tillett, L. G. Ross, D. Chan, S. Hockaday and N. J. B. McFarlane, “An automatic image-based system for estimating the mass of free-swimming fish,” Computers and Electronics in Agriculture Volume 31, Issue 2, April 2001, Pages 151-168.

[4] Wu GuanHao and Zeng LiJiang, “Video tracking method for three-dimensional measurement of a free-swimming fish,” Science in China Series G: Physics Mechanics and Astronomy, Volume 50, Number 6, pp. 779-786, 2007.

[5] N. J. C. Strachan, P. Nesvadba, and A. R. Allen, “Fish species recognition by shape analysis of images,” Pattern Recognition, Volume 23 , Issue 5, pp. 539-544, 1990.

[6] Fablet, R., Bouyhemy, P., Gelgon, M., “Moving object detection in color image sequences using region-levelgraph labeling,” ICIP Proceedings. 1999 International Conference on Volume 2, pp.939 – 943, 1999.

[7] X. H. Fang, W. Xiong, B. J. Hu and L. T. Wang, “A Moving Object Detection Algorithm Based on Color Information,” International Symposium on Instrumentation Science and Technology, Journal of Physics: Conference Series **48, pp.** 384–387, 2006.

[8] Yokoyama, M. and T. Poggio., “A Contour-Based Moving Object Detection and Tracking,” Proceedings of Second Joint IEEE International Workshop on Visual Surveillance and Performance Evaluation of Tracking and Surveillance (in conjunction with ICCV 2005), Beijing, China, pp. 271 – 276, October 15-16, 2005.