Chapter 25
The Development of a Fish Counting Monitoring System Using Image Processing

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Abstract The ability to accurately quantify the survival of fish in culture systems has been a challenge for the fish-farming aquaculture industry for many years. The fish hatcheries in many developing countries still rely on manual and volumetric counting to enumerate the post-larvae (PL) for sale to customers and used a lot of manpower whilst performing the task. Thus, this research reviews on the image processing technology in aquaculture that could be promoted in fish farming and hatcheries for the application of monitoring purposes. The fish counting monitoring system used the Arduino module to detect the post-larvae and capture the image through the IR sensor module. Arduino's information will be displayed on the LCD screen in which the farmer could monitor the fish counting via the system. MATLAB processes the captured image by implementing the image processing system. It is expected that the system will be able to count the post-larvae (PLs) with small mean absolute error, for large and small PLs, and the system has the potential for faster counting as compared to the conventional methods. Furthermore, it will open up possibilities for counting other small aquatic animals such as shrimp, crab, oysters in their nursery process. As for the recommendation, a colour sensor could be applied in the system to improve the readability on the LCD display screen.

Keywords Artificial intelligence · Image processing · Aquaculture · Fish hatcheries · Post-larvae

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A. Ismail et al. (eds.), *Advanced Materials and Engineering Technologies*,
Advanced Structured Materials 162,
https://doi.org/10.1007/978-3-030-92964-0_25

25.1 Introduction

Malaysia has 4055 km of coastline, 1640 km of which are in Peninsular Malaysia, and 2415 km of which are in Sabah and Sarawak. With the creation of a 200-mile exclusive economic zone (EEZ), Malaysia has spent a total fishing area of 160,000 square nautical miles. In spite of this large fishing sector, fishing is an important sector in the Malaysian economy. In 2003, 1.5 million mt of fish priced at approximately RM5 B was produced by the industry.

The production of marine fisheries at RM4 B was estimated at 1.3 million mt, representing 1.4% of gross domestic product (GDP). Aquaculture production was estimated at 196,874 mt above RM1.2 B, representing just 13 per cent of the overall production of fisheries. Though cockles (*Anadara granosa*) are the dominant crop in aquaculture, 37% of total aquaculture production is accounted for. Approximately, 89,400 fishermen and 21,100 aquaculture employees are working in the fishery sector, with 110,500 people in total. Traditionally, both in terms of growth and socio-economic considerations, Malaysian fisheries' principal or backbone is the inshore subsector. Nonetheless the inshore sub-sector has entered a saturation point, as seen by the increasing capture rate in recent years. This is coupled with the significant fishery opportunities in Malaysia's EEZ waters and the country's large potential for aquaculture production [1].

Fish farming is one of the important industry that anticipates tremendous growth in the coming years. New technology or method to increase fish production has been integrated commercially into the world's best practise on-farm management production systems to overcome most of the regulatory hurdles that have limited local development. The farmers, however, use many ways to count the number of fish, but it obviously took some time, and some methods are unreliable.

A traditional method is used to count the number of fishes, catch and weigh multiple fishes, estimating the total number of fishes in the pond. Thus, a new mechanism is needed to help the working environment and ease the farmer's day-to-day work.

Monitoring the production of fish population using image processing is one of the latest approaches proposed to reduce the inaccuracy of counting the number of fishes in a field. The system will reduce the time for the customer to count the number of fishes which in turn, will have a positive impact on the farmer, such as lowering their stress levels whilst raising productivity.

The research for fingerling counting algorithm also utilising the digital picture technique. To achieve this aim, a robust segmentation method, feature extraction approach and machine learning algorithm for fingerling classification and counting are formulated. At the completion of this research, the proposed method is predicted to count different sizes of fingerlings with great accuracy [2].

A catfish recognition and counting method using detection before counting consist of six steps which are picture capture, pre-processing, segmentation, feature extraction, recognition and counting. The images were captured and pre-processed, whilst the segmentation was conducted using picture binarization using Otsu thresholding, morphological operations utilising fill hole, dilation and opening operations and boundary segmentation using edge detection. The boundary features are used to train an artificial neural network (ANN) to conduct the recognition. The new counting approach was employed to determine the number of fish of any size. The proposed counting algorithm achieved 100% accuracy [3].

The combination of image processing techniques consists of image enhancement, edge detection and thresholding process are implemented to count the Nile Tilapia (*Oreochromis niloticus*). The samples data set is divided into three parts which are small data set, medium data set and large data set. The performance of the proposed method and the manual approach method is compared based on the number of fish. The results of the experiment show that the proposed method is outperformed compared to the manual counting due to the number of fish larvae measurement is similar [4].

The techniques based on machine learning to measure the number of shrimp larvae and juvenile on increasing population are proposed in [5]. Numerous image processing techniques were applied such as thresholding process, edge detection and morphological operator.

Due to the widely used image processing in developing the fish larvae counting system that gives high potential in fisheries area, therefore, this research aims to create the image processing system for counting the number of fish to reduce the time consumption and manpower utilisation in counting the number of fish. Therefore, the key scope is to create a prototype of a fish counting method that can be applied in many fish-farming areas to obtain the data and the results. This device is capable of detecting the number of fish in a given area using two infrared sensors mounted on the tube where the sensors can detect the presence of fish flowing through it and then use an image processing method to compare the number of fish. Therefore, this project could reduce the problem of time consumption caused by the abundance of fish that traditionally need to be counted, which consumes a lot of energy and time.

25.2 Methodology

The entire system consists of two IR sensors as the system input. The camera and seven-segment display are the system output. All of the input and output are interfaced to the Arduino as shown in Fig. 25.1.

The IR sensor module is mounted at the centre of the prototype is used to detect the presence of the fish through the transparent tube. The camera is used to capture the image of the object. Thus, the captured image could be further analysed to identify the correct image of the fish using a MATLAB software. The LCD display is used to display the quantity of the captured image of the fish that passes through the tube.

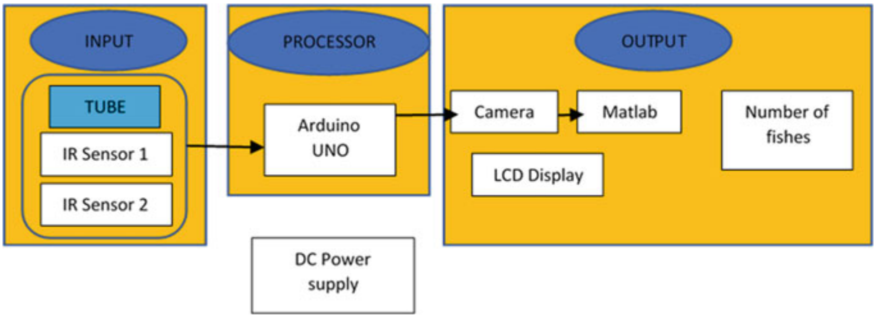

Fig. 25.1 Block diagram of the development of a fish counting monitoring system using image processing

The overall project block diagram as shown in Fig. 25.1 consists of several parts such as the sensor for the IR module, Arduino Uno, ring light, LCD display, tube, container and the camera.

The flowchart in Fig. 25.2 shows the whole process of the system starting from initialisation of the system until the process of image processing using MATLAB.

The IR sensor module used in this project is shown in Fig. 25.3. This sensor is able to detect the object's presence accurately. The time gap in coding that is relevant to 1 s in real time to detect the presence of the object is delayed by 1000. These sensors work well during testing, and the presence of fish moving through the tube can be detected without causing any errors on the LCD display. Three types of experiments have been conducted to assess this sensor's capabilities and to detect the presence of the object that passes through it. The following are the list of experiments on this sensor that have been carried out.

These are the three experiments that have been carried out.

1. To test the ability to detect the present of the fish that are passing through the tube when the time of the sensor detection is delayed for 0.5 s.
2. To test the ability to detect the present of the fish that are passing through the tube when the time of the sensor detection is delayed for 1 s.
3. To test the ability to detect the present of the fish that are passing through the tube when the time of the sensor detection is delayed for 2 s.

25.3 Results and Discussion

Table 25.1 shows the sensor's working state. The sensor time delay is set at 0.5 s, 1 s and 2 s, respectively. During the test, the number of fish is measured, and the sensitivity is being identified. The result shows that when the delayed period is set to 0.5 s, 1 s and 2 s, the exact number of fish detected on the LCD display is 10, 5 and 3, respectively. With a delay of 1000, which is equal to 1 s, this IR sensor module can detect the presence of any object that passes through the tube. Then, the LCD

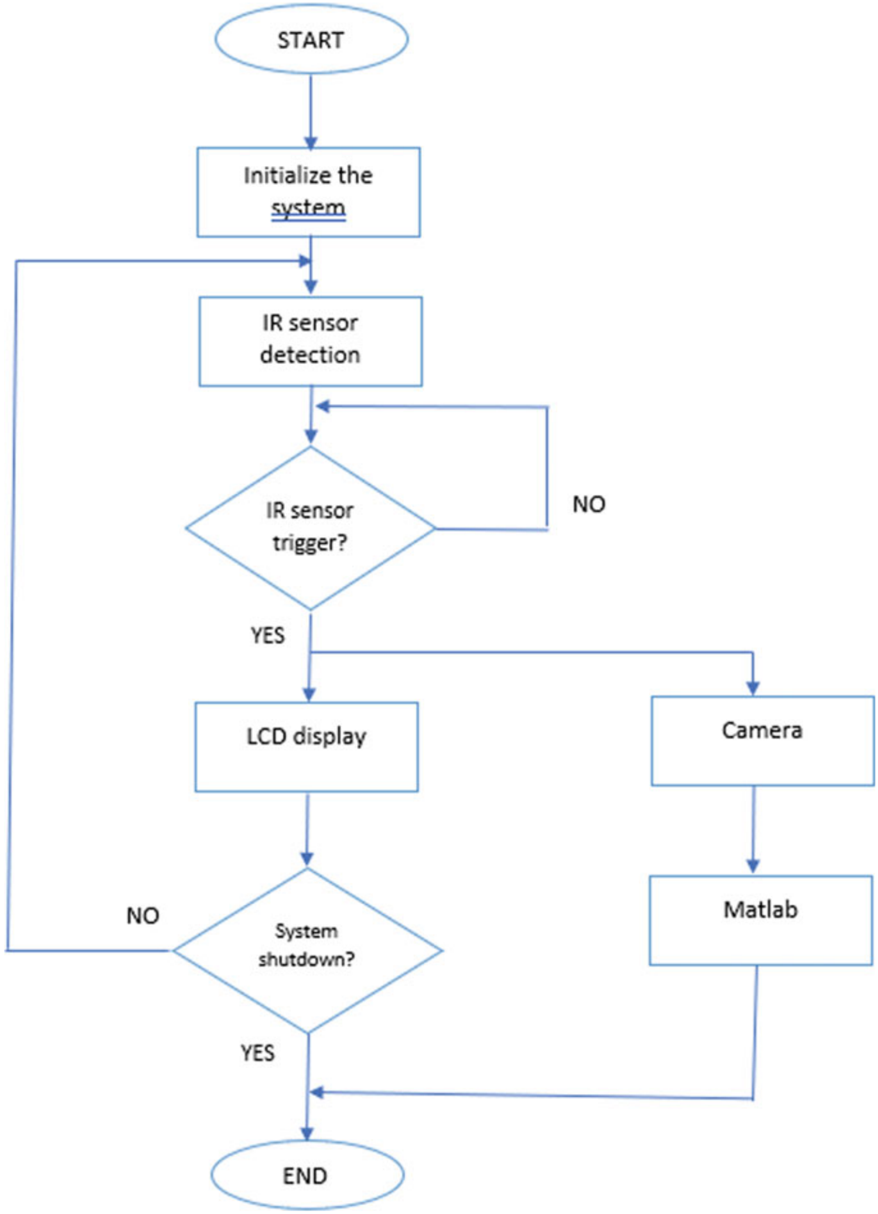

Fig. 25.2 Flowchart of the development of a fish counting monitoring system using image processing

Fig. 25.3 Prototype of the development of a fish counting monitoring system using image processing

Table 25.1 Result for operation condition of the IR sensor module

No.	Sensor’s delayed time (s)	Number of fish tested	Sensitivity of the of the sensor’s range (cm)	Number of fish counted (LCD display)
1	0.5	5	10	10
2	1	5	10	5
3	2	5	10	3

monitor will indicate the number of objects on the screen that the IR sensor module has detected. The effect displayed on the screen will later be compared to the image processing outcome.

The image processing method can be seen in Fig. 25.4. The camera, via the laptop, transfers the image to MATLAB. The original image that is in RGB image will be received by MATLAB and transformed into greyscale image. The last step is to transform the greyscale frame to binary image. The background becomes black and the fish in the foreground becomes white as the number is equal to the number of white images in the final step of image processing, which is the binary image.

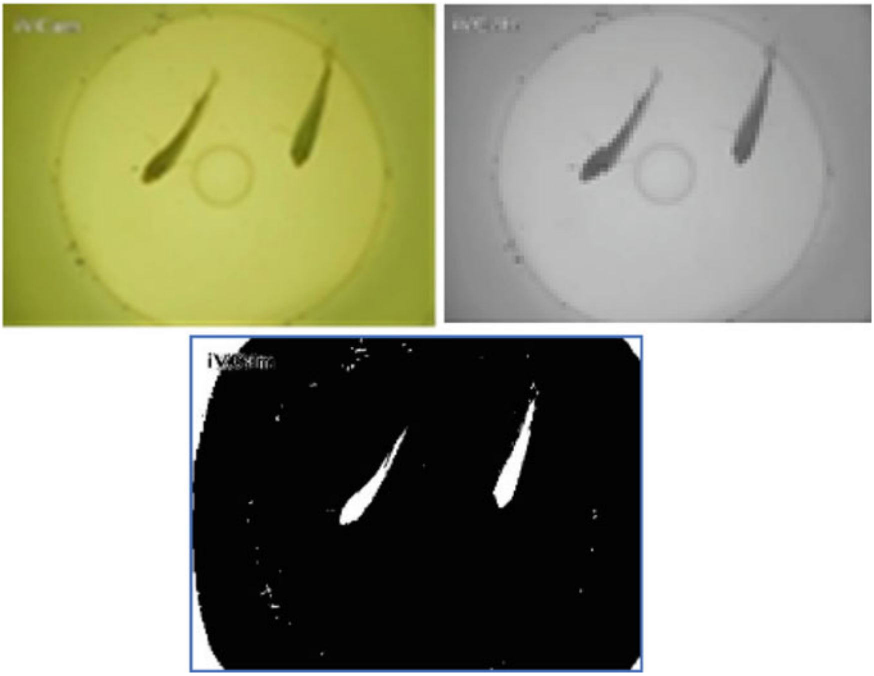

Fig. 25.4 Result in greyscale and binary image

The camera, via the laptop, transferred the image to the MATLAB. The original image that is RGB image will be received by MATLAB and transformed into the greyscale image. Greyscale is a monochromatic array of colours ranging from black to white. With multiple picture editing applications, it could convert a colour image to black and white or greyscale. This method extracts all colour details and leaves only the luminance of each pixel. The optical pictures show a mixture of red, green and blue colours in each pixel, which has three distinct values. Consequently, these three values should be merged into a single value when extracting the colour from an image. In order to differentiate between a picture object and the background, binary photos are often created by keeping down a greyscale or colour snapshot. The last step is to transform the greyscale frame to binary image. The colour of the entity which is usually white is considered as the first colour. The rest (normally black) is referred as the base colour. However, depending on the image to be thresholded, this polarity may be reversed, in which case the object appears with 0, and the background has a value non zero.

Figure 25.4 shows the images on the MATLAB that appeared after pressing the ‘Run’ button. Clearly, the greyscale image on the left is one in which the only shades of grey are the paints. The reason for distinguishing those images from some other kind of colour image is that fewer data has to be generated for each pixel. In fact, a grey colour is one in which all the red, green and blue components have equal RGB space intensity; thus, it is only appropriate to specify a single intensity value for each pixel, as opposed to the three intensities required to specify a full colour image for each pixel. The binary image, whose pixels only have two possible intensity values, is on the right. They are generally depicted as white and black. Numerically, for black, the two values are always 0, and for white, either 1 or 255.

25.4 Conclusion

The research shows that the development of monitoring fish population using MATLAB image processing is successfully achieved. This system can effectively count the number of fishes. There are three primary objectives that drive this project's growth. The first aim is to build the image processing system. The second goal is to count the number of fishes in a given area, and the last goal is to minimise time consumption to count the number of fishes. Overall, this project accomplished the desired goals. However, there is a constraint with the counting process using the IR module sensor, as it also detects the number of foreign items. This can be done by replacing the colour sensor with the IR module sensor. The colour sensor has greater functionality than the IR sensor. Therefore, in future, all issues related to identifying a foreign object can be solved using a colour sensor.

Acknowledgements The author would like to thank University Kuala Lumpur British Malaysian Institute and R4R Research Cluster for the provision of laboratory facilities and financial support.

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