Automatic Shrimp Size Measurement for Pacific White Shrimp Farming Industry Using Artificial Intelligence

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Abstract.

The objective of this project is to build an automatic shrimp size measurement machine. The method that farmers currently use to measure the size is to use a fishing net to catch shrimps. This method will cause injuries and accidents to the shrimp. To solve this problem, we design an automatic shrimp size measurement machine to help measure the shrimp safely. The machine will have a plate to catch and raise shrimp above the water surface. The machine's camera will then capture a shrimp image on the plate and send it to a deep learning algorithm to analyze and evaluate shrimp size.

Keywords. Pacific White Shrimp, Deep Learning, Object Detection.

1. INTRODUCTION

At present, the Thai vannamei shrimp farming industry generates a lot of income for the country. In 2019, Thailand produced more than 260,610.08 tons of white vannamei shrimp in the farm system, and exported more than 134,737.85 tons, worth 39,815.52 million baht [1]. In terms of production and exports, lifting the shrimp up to measure the size is one of the reasons for a large reduction in output because shrimp is fragile and must be in the water at all times. Lifting it up will expose the shrimp to air exposure and other stimuli, but the raising of white vannamei shrimp is necessary to provide the right amount of food for each stage of the shrimp age. In addition, human labor is scarce, expensive, and labor's skills cannot be controlled either by looking at the size with the naked eye and on cleanliness.

Therefore, if there is research and development of automatic white shrimp size measurement, Vannamei can make Farmers can greatly reduce their labor usage. In addition, production costs can be directly reduced, and the exact size of white vannamei shrimp can be realized without direct contact with the shrimp. Make feeding possible most appropriate for each age group resulting in higher efficiency and productivity in production.

2. THEORY AND RELATED RESEARCH

2.1. Characteristics and rearing of white vannamei shrimp

Vannamei white shrimp [2] is a Pacific marine shrimp species. Scientifically known as Litopenaeus vannamei or Penaeus vannamei, it is widely cultivated in many countries due to its vigorous nature. In Thailand nowadays, Thai farmers tend to raise this type of shrimp. Because it is a fast growing shrimp species and takes a short time to raise. General characteristics of white vannamei shrimp The body is white with 8 segments and one segment of the head. The greek is triangular. reddish brown Shrimp intestines can be clearly seen. And when adults are 9 inches long, they are fast moving shrimps. Able to adapt to salinity in a wide range from 3-35 parts per thousand, can eat many types of food. Therefore, it grows and adapts to dense development culture in deteriorated pond conditions better than black tiger shrimp. White Vannamei Shrimp can be raised in both natural systems and semi-dense system This type of shrimp can be familiar with and adjust the habits under various aquaculture systems well. It has a habit of being sensitive to changes in water conditions in the pond. and easily startled Farmers need to have a good farm management system in order to produce good yields in large quantities. The proper form of shrimp farming depends on the location of the farm and on management issues and disease outbreaks that may arise during raising. The development of white shrimp farming in Thailand prefers to use coastal areas or areas with access to sea water. The pond used for raising at present is a rectangular pond. The width and length are not much different. Currently, there are 2 types of popular styles, which are clay ponds and polyethylene fabric ponds.

2.2. The size according to the age of the shrimp is important to the amount of feeding

Food is an important factor in successful shrimp farming. Therefore, it is necessary to manage the nutrients and the amount of food that the shrimp will receive appropriately (Table I). divided by the weight or size of the shrimp itself Developed shrimp farming It is commonly used as a readymade pellet food. The deterioration of the shrimp pond was caused by poor feeding management leading to accumulation of food waste from the chin and excreta. There were continual problems concerning raising management and preparation of the pond to have a suitable environment. In addition, shrimp production costs come from feed, approximately 50-60%. Mismanagement of feed that leads to too high a meat exchange rate increases feed costs. Therefore, good shrimp feeding management is necessary to The most efficient shrimp production. The criteria used must ensure that the shrimp are fed the right amount of food at the right time. Every meal during the party The rate of feeding depends on the amount of food you eat. growth rate and shrimp mortality feeding too little causing the shrimp to grow slowly and causing cannibalism especially high-density shrimp farming overfeeding causing the quality of water and soil to deteriorate This made the stressed shrimp weak and the chance of infection with shrimp disease increased. and the growing bacteria use insufficient oxygen in the water for shrimp growth. Daily amount of food Calculated from shrimp quantity and feed rate [2] are: Feed amount (kg/day) = total shrimp quantity × percentage feeding / 100, Total shrimp volume (kg) = total shrimp in pond × average weight, Total number of shrimp in the tank = number of shrimp released × percent survival / 100

Table 1 Feeding rates according to shrimp weight

Average weight of shrimp (g.)	Feeding rate (% of weight / day)	Average weight of shrimp (g.)	Feeding rate (% of weight / day)	Average weight of shrimp (g.)	Feeding rate (% of weight / day)
< 1	35-25	5.0-5.9	5.5-5.0	13.0-13.9	3.0-2.75
0.1-0.24	25-20	6.0-6.9	5.0-4.5	14.0-14.9	2.75-2.5
0.25-0.49	20-15	7.0-7.9	4.5-4.25	15.0-15.9	2.5-2.3
0.5-0.9	15-11	8.0-8.9	4.25-4.0	16.0-16.9	2.3-2.1
1.0-1.9	11-8	9.0-9.9	4.0-3.75	17.0-17.9	2.1-2.0
2.0-2.9	8-7	10.0-10.9	3.75-3.5	18.0-18.9	20.-1.9
3.0-3.9	7-6	11.0-11.9	3.5-3.25	19.0-19.9	1.9-1.8
4.0-4.9	6-5.5	12.0-12.9	3.25-3.0	20.0-20.9	1.8-1.7

2.3. RetinaNet

RetinaNet [3] is a simple one-stage model unlike Faster R- CNN or Yolo, it uses Feature Pyramid Network (FPN) [4] (Fig. 1). It detects objects based on multiple scaled image data to improve detection accuracy but takes more time and memory than other detection models to create images of different sizes. RetinaNet performs two functions: 1) identifying what is inside the frame of detection and 2) analyzing the built frame of detection against the ground truth.

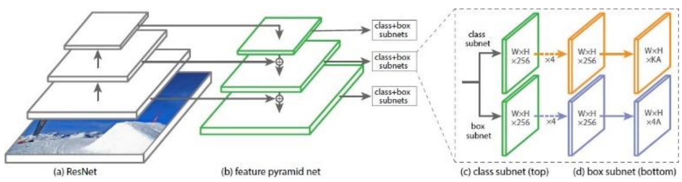


Figure 1 Architecture of RetinaNet [3]

2.4. *Shrimp size measurement method*

To measure the shrimp size, we have to detect the shrimp inside the picture that we captured. We use RetinaNet to detect the shrimp. After that, we can use similar triangle properties to calculate the shrimp size.

3. THEORY AND RELATED RESEARCH

3.1. *Main structure of the machine*

We use PVC pipe as the main structure of the machine which is lightweight, durable and does not erode in saltwater conditions. In addition, the PVC pipe is cheap and easy to buy compared to stainless steel and aluminum (Fig. 2).

For buoyancy, we use floating foam attached to the frame on all sides to help keep the machine balanced. And we use a square shape to maintain balance when the waves hit the machine

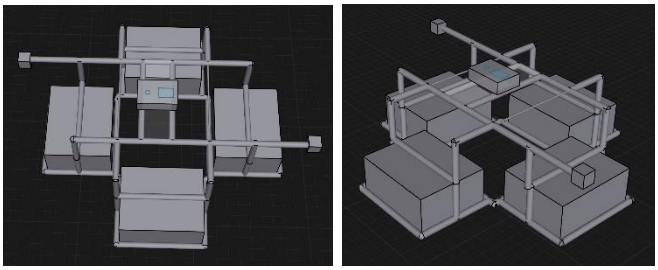


Figure 2 3D model of the machine.

3.2. *The shrimp net and motor system*

We use an acrylic sheet (Fig. 3) for the shrimp net because it has a smooth surface, making the shrimp size calculation process easier. But the acrylic sheet will not drain water, so we drill holes on the sheet, allowing the water to drain and reducing the water pressure when lifting. For the motor system, we use 2 motors to control the shrimp net on the left and right sides. When the system sends a command to lift

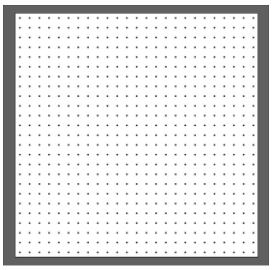


Figure 3 Acrylic sheet design for the shrimp net

the net, both motors will be activated. And when we want to release the shrimp, the motor will tilt the net to one side for the shrimp to be released.

3.3. Processing system and control unit

The automatic shrimp scale processing system is based on the Raspberry Pi. Raspberry Pi is the most popular single- board computer that is widely available and small. It can also be connected to the camera of the Raspberry Pi, allowing to take pictures of the shrimp and the shrimp size can be measured locally after imaging. The camera system and the Raspberry Pi are packaged in a water and dust resistant case, which can prevent salt vapor from the shrimp pond. The bottom box is transparent so that the camera can take pictures. Which will use a glass coating that is resistant to salt vapor.

3.4. The detecting and measuring shrimp size

In this paper, we have developed a system to detect and measure the size of shrimp. The image obtained from the shrimp imaging was used to detect the shrimp inside the image using RetinaNet, an object detection model. The captured shrimp was analyzed to measure the size of the shrimp by image processing technique.

Developing a RetinaNet model requires the preparation of images before using images to teach the model using the fastNlMeansDenoisingColored [5] technique. It is a technique for reducing noise by adjusting the colors around each point of the colored pixel, which is better than image segmentation with KMean clustering. The image is scaled to fit the model, with the result of the RetinaNet model being the coordinates of the shrimp in Fig. 4

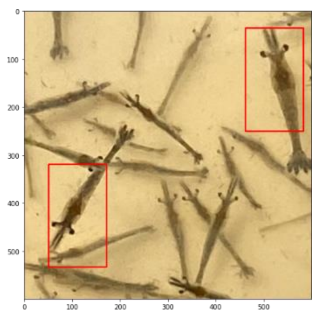


Figure 4 Detect shrimp in images with RetinaNet

Shrimp size measurement uses image processing to analyze the image data to obtain the length of shrimp within the image captured by using RetinaNet. The initial analysis step is the preprocess data.

Preparing the image before being analyzed to measure the size of the shrimp inside the image will convert the RGB image to a grayscale image. It is easy and convenient to analyze by reducing the data size from RGB 3 channel color image to 1 channel grayscale image, reducing processing time and power of computing. The grayscale image is then blurted to reduce the details of the image to make it easier to see the shrimp inside the image and to reduce noise, making it easier for further analysis (Fig. 5).

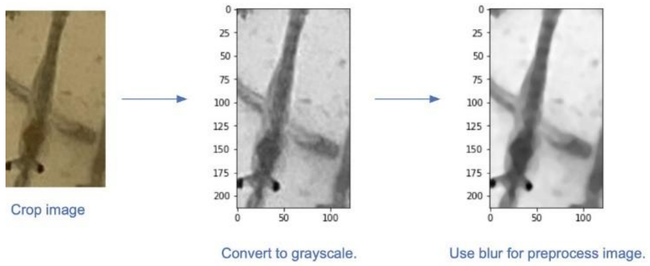


Figure 5 Convert RGB image to Grayscale image and use blur with shrimp image

Once the image preparation is complete, we will separate the shrimp image from the background of the image. It uses an Adaptive threshold [6] algorithm for filtering image data between objects and backgrounds. This allows us to get a black and white image that clearly distinguishes the subject and the background of the image. After obtaining an image that distinguishes the object and its background, two methods were used to measure the size of the shrimp.

1) Shrimp size was measured by using a shrimp image that was separated from the object and the background and then finding the points on the shape of the shrimp using the findContours [7] algorithm.
2) Shrimp size was measured by using a shrimp image isolated from object and background and then used to find the bones of the image by thinning technique [8], [9]. It finds the object's axes within the image before using the findContour algorithm to find points on the shape of the shrimp.

We will use those points to find the points that are farthest apart when forming a straight line to get the shrimp's longest straight line. The shrimp's longest straight line assumes that line is the one that passes through the shrimp's rostrum and telson, which is the size of that shrimp (Fig. 6).

4. EXPERIMENTAL RESULT

Development of an automatic shrimp size measurement as mentioned in the Methodology section. It consists of photo-graphic equipment and a system for measuring the size of shrimp. The results are as follows.

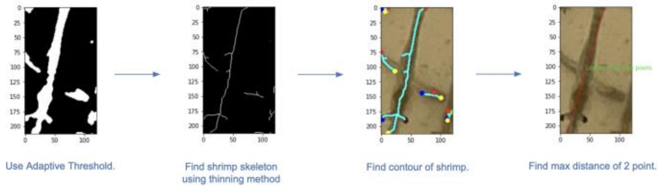


Figure 6 Flow of find shrimp's length

4.1. Automatic shrimp size measurement machine

We've built the machine as designed on the 3D model but we've reduced the size of the machine to better suit real-world usage (Fig. 7).

Figure 7 The shrimp size measurement machine

4.2. Result from the detecting and measuring shrimp size

Performance testing of the shrimp detection system within the image with RetinaNet. It was found that the RetinaNet model was able to detect shrimp inside the image (Fig. 8a), but was less effective when the image was noisy and underexposed (Fig. 8b). We trained the model with 300 shrimp pictures and validate it with 100 shrimp pictures, then we took the trained model to test with a test set that contains 100 pictures. The precision, recall, and F1 score value from IoU of the model is 57.28%, 31.98%, and 41.04% respectively, which we're focusing on the precision value because detecting only some of the shrimp is sufficient enough to measure the overall shrimp size.

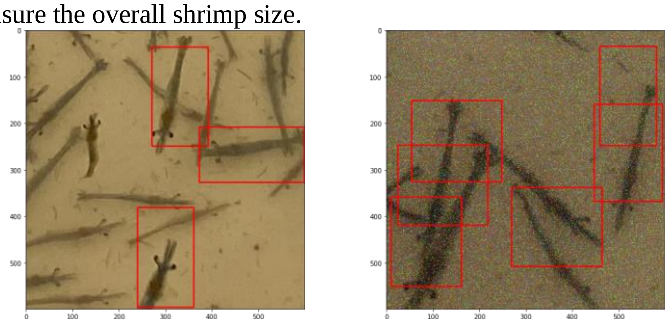
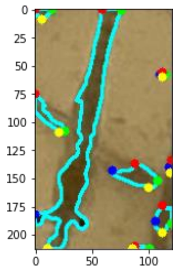
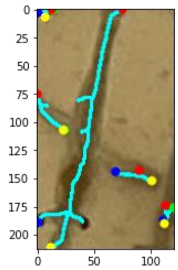
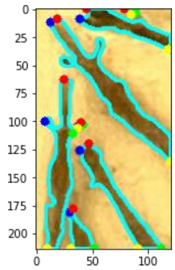
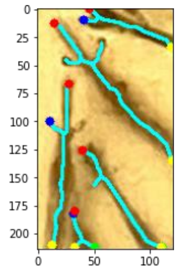


Figure 8 Shrimp Detection Test Pictures

From testing the efficiency of shrimp size measurements using various techniques, the results were as follows in Table II

Table 2 Table comparing the efficiency of shrimp length determination using different techniques

Contour technique	Contour technique with Thinning
	
	

According to the results, the contour technique together with thinning [8], the shape of the shrimp can be seen effectively. Using thinning will help to find the shape of the shrimp better.

5. Conclusion

The automatic shrimp size measurement machine is capable of measuring shrimp size efficiently by taking shrimp pictures. The machine relies on object detection technology to detect shrimp, and the machine uses the information to analyze shrimp size. The machine collects pictures at a specified time every day, then calculates an average shrimp size using the pictures. This will let users know the proper amount of shrimp food, and as this process is fully automatic, it can reduce human workers. This automatic shrimp size measurement ma- chine consists of two components: The shrimp net controller component: It uses two motors to lift the shrimp and release it by tilting the net to one side. The detecting and measuring shrimp size component: The process starts from taking a shrimp picture and pre-processing it. After that, the picture will get into the object detection process using RetinaNet. When completed, we will crop it to measure shrimp size by using thinning to find the skeleton and then take the information to compute contour to calculate the shrimp size. The precision value from the RetinaNet model, which was trained by 300 shrimp pictures and tested with 100 pictures, is 57.28%. We believe that the performance can be improved further by increasing training set pictures and tuning parameters.

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