Overview of Machine Vision on Digital Imaging Approach for Automatic Tuna Length Measurement

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Overview of Machine Vision on Digital Imaging Approach for Automatic Tuna Length Measurement

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Abstract. The demand of fish and marine product have increased significantly throughout the year. Therefore, overfishing had become major concern for various parties around the world especially the United Nation(UN). Collecting numerical data is a first step toward preservation and conservation of tuna and other fish population. This paper reviews automatic tuna length measurement by using machine vision techniques. This is one of the steps in collecting necessary data on size of fishes caught by fishermen. Previous research had been done on measuring the length of fish, but the accuracy rate of the length measurement is not satisfactory enough. Many factors affecting the accuracy of the length measurement processes such as lighting inequalities, blood on the platform and others. Machine vision techniques have a great potential to be used in automating the measurement of the fish length with high accuracy. Machine vision techniques could improve the accuracy and efficiency of the measurement of the fish length that would substitute the tedious manual work.

1. Introduction

The fisheries sector is one of the most important food sources throughout the world. Due to growth of human population, tones of fish have been catch throughout human history. Currently, overfishing has been a great concern due to the rapidly shrinking population of fish especially tuna. This issue is taken seriously by various parties including the United Nation Organization (UN). By 2020, the Sustainable Development Goals, a target from UN want to effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics [1].

According to statistical data reported by Department of Fisheries, Ministry of Agriculture Malaysia, fish production in Malaysia increased from 2005 to 2017 with latest marine fish catches proportion are 1.46 million tons of fish in 2017. To avoid fish extinction, Malaysia government enforce Malaysian tuna fishermen to measure and record each catch's length and weight they caught. This enforcement is one of the government effort to preserve and sustain wild tuna stock in the ocean. Usually, tuna fishermen will measure their catch by using a measuring tape and weighing scale. This current method took the longest time and effort. To tackle this problem, several machine vision techniques had been proposed by researchers. Machine vision is the technology and techniques used to provide imaging-based automatic inspection and analysis.

In this paper, the author will review techniques of machine vision technology and the different method of measuring the length of the tuna on flat surface from 2D image. The machine vision technology can help fishermen to obtain the length information of that would overcome the limitation of the traditional methods as well as reducing the labor cost [2,3]. Criteria of this review is the accuracy of length measurement. Fish point identification will be discussed in section 2.1. then we discuss the length measurement method in section 2.2.

2. Fish Length Measurement

Fish length is one of the parameters of measurement needed to record the tuna's data. This section discusses automatic tuna length measurement from a 2D image. There are two steps of automatic tuna length measurement process which are; fish's snout and tail point identification (FSATPI), and length measurement method. Fish used in this review are tuna and the tuna will be treated as a linear measurement because the body of the fish is regarded as a straight line and not curve. Several types of fish length have been identified but the common length measurement used for tuna is fork length as in figure 1.

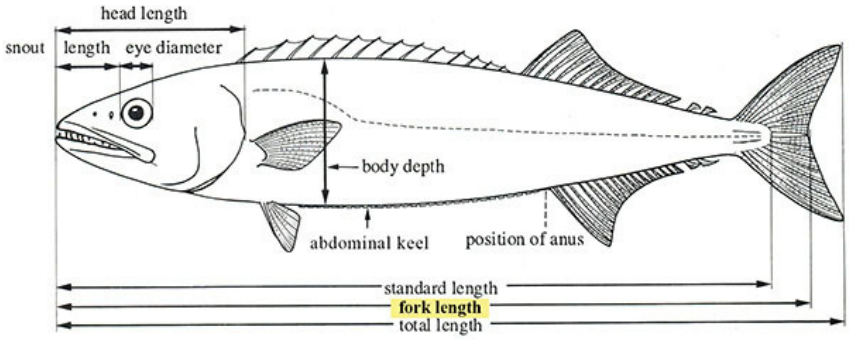

Figure 1. Different types of fish's length measurement.

2.1. Fish Points Identification

Past studies report on the method used to FSATPI. FSATPI play a major role on automatic length measurement. Without points identification, the length measurement cannot be done. Several methods are used for point identification such as; estimation by human eyes[3], Hsiu method[6], and Truss Morphometric Network (TMN) [8]. Estimation by human eyes were compared in several studies. From Table 1, human eyes are used to point the fish snout and tail before the points are used by the machine to automatically measure the fish length [3]. However, human eyes cannot be reliable on a long time task due to fatigue. There are result show approximately 10% of error [5]. While, Hsiu method[6] used in point identification has error rate less than 2.19%.

Simultaneously, TMN can also identify the fish snout and tail point. TMN constructed with the help of landmark points are one of the tools for fish body identification. Truss length measured between these landmark points should either lie on curved surfaces or be on straight lines lying on a flat plane[8]. Figure 2 show TMN constructed on a bluefin tuna body.

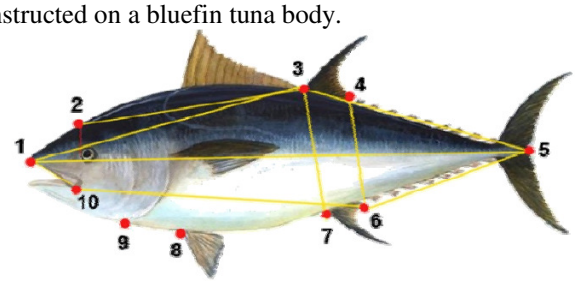

Figure 2. Truss Morphometric Network (TMN) of a Bluefin tuna.

Table 1. Detailed information on method of fish snout and tail point identification.

Method	Mode of measurement	Error rate	Strengths and weaknesses
Estimation by human eyes [5]	Manual	10%	- not very accurate - accuracy depend on the people
Hsiu method [6]	Automatic	<2.19%	+ Highly accurate - Accuracy depending on lighting qualities
TMN [10]	Automatic	-	- no result of accuracy rate show from previous research

2.2. Length Measurement Method

When the point of fish snout and tail have been identified, the length of the fish can be measured. The fish length can be calculated by using the relation of fish body pixel length and the image reference scale. The reference scale can be obtained through a square on the color plate. Currently, the widely used method used by fishermen are estimating by human eyes and measuring tape. However, estimation by human eyes is a hard labor job and concentration for a long time is needed. Less than 10% of error was shown by estimation by human eyes. From Table 2, Hough transform used by Hsieh [3] shown the error of measuring the length of tuna was less than 5%. But, the accuracy of the Hough transform method can be increased by using projective transform to reposition the reference plate before length measurement was calculated.

While, image thinning used by Jun showed a measurement error of less than 3% [9] as shown in Table 2. Man show that the Hsiu method used for measuring fish length where resulted less than 3% of measurement error [6]. Unfortunately, there were no past researches yet have been done to a bigger fish such as tuna because of the distance of targeted object and camera, and the angle of the targeted object and camera needed to be recorded for this method to calculated the length measurement of tuna [6]. The tuna caught by fishermen will be put into the freezer as fast as possible to retain the freshness of the fish and this will be a hindrance for researcher to record every single angle pf the fish during the photo taken by the camera.

Best fitting rectangle used by Hao for measuring fish length where resulted less than 0.5% of measurement error [2] as shown in Table 2. Unfortunately, same with Hsiu method, this method not yet been research on tuna fish which is much bigger than fish use in the research and tuna fin structure cause a significant factor of error for this method as best fitting rectangle always measure the total length of fish rather than fork length which are intended for measuring the length of a tuna. Though, the length measurement result may vary due to the different size of the subject [2].

Grade-3 polynomial regression method was used by Torres for measuring tuna where resulted less than 4% of measurement error [7] as shown in Table 2. Regression used in many research as it one of the simplest method used to measure the length of the object. Nevertheless, no research had been done yet to a bigger fish by using this method.

Table 2. Methods of fish length measurement.

Method	Object	Measurement error rate	Strength and Weakness
Hough transform [3]	Tuna	<5%	+ have relatively high accuracy of measuring tuna length + accuracy rate can be increase by using projective transform
Image thinning [9]	Tuna	<3%	+ have high accuracy on measuring tuna length
Hsiu Method [6]	Fish	<2.19%	+ have high accuracy on measuring smaller fish length - No past research have been done to measure tuna using this method
Best fitting rectangle [2]	Fish	<0.5%	+ have high accuracy on measuring smaller fish length - No past research have been done to measure tuna using this method
Grade-3 polynomial regression [7]	Fish	<4%	- No past research have been done to measure tuna using this method

3. Discussions

Automation of the tuna length measurement process is important because it will make the length measurement more accurate and faster compare to manual measurement. Thus, it is important to make the measurement process automatic to increase the efficiency of the measurement process and increase the effectiveness of tuna catch regulation.

There are other features that need to take into consideration in measuring tuna length using machine vision such as the visual perspective of the object, the angle of the camera to the object, and the distance between the camera and the object. The angle of the camera is very important as it will greatly affect the visual perspective of the object [3]. There are study had been made by taking in the one of the features for fish length measurement method [6,11] but no research had been done yet by using all of the features for fish length measurement method by considering all of the measurement environment factor. Usage of lightbox have higher accuracy in measuring the length of other smaller fish [2] but the disadvantage of using lightbox is it cannot fit the tuna body as tuna body is too big to be fit into the lightbox. There were a number of researches had been done with smaller fish species, but they were not yet tested on tuna fish [8].

Although the length measurement result has a low error rate, it is still not satisfactory. More research needed to be done in order to increase the accuracy rate of fish length measurement. Based on [2], although the method can be used on both smaller and bigger fish, the result of the length measurement very different from each other.

4. Conclusions

Problems such as image noise, lighting inequalities and poor contrast are obstacles to implementing effective and accurate machine vision techniques. Besides, there are factors that can affect the machine vision process such as blood stain on the reference plate, blood stain on the fish body and position of the fish. The approach of single image camera imaging system in a controlled environment was expected to improve image capture conditions, as backlighting techniques. Furthermore, segmenting fish before measurement made is a must do process as it eliminates foreign image noise and uncontrolled setting.

As for fish measurement, the fish was assumed to be positioned along the x-axis of the environment setup. The result from previous research shows that a relatively simple method such as polynomial regression can be used for calculating the fish length with remarkable accuracy [7].

5. Acknowledgements

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