Computer Vision and Fuzzy Logic for Sustainable Indonesian Fisheries

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Abstract. Tuna fishing in Indonesia is excessive and if left unchecked, some types of tuna will become extinct within 3-10 years. There is an urgent need to help MMAF for producing more accurate fish catches data. This paper proposed a system that utilizes computer vision, fuzzy logic and Global Positioning System (GPS) for supporting a sustainable Indonesian fishery by recognizing and measuring fish length, determine fish age and where is the catch location. The system can help authority to manage sustainable fisheries management in Indonesia.

Keywords: Huhate, Machine Learning, Fuzzy Logic, Fish Management

1. Introduction

Indonesia is known as the number one supplier for tuna fish in the world in the past five years. In terms of frozen tuna fillets, Indonesia was ranked as the 5th largest exporter to America, European Union, Japan, Korea, and Hong Kong, with a value of USD 202 million for the year 2018 alone [1, 2]. Indian Ocean Tuna Commission (IOTC) assesses that tuna fishing in Indonesia is excessive. If left unchecked, some types of tuna will become extinct within 3-10 years [3, 4]. Eastern part of Indonesia is a place that has the biggest fishermen fleet for catching tuna fish. Skipjack (Katsuwonus pelamis) is a leading economic activity in the fisheries sector of the North Sulawesi, commonly captured by pole and line fishing gear or known as Huhate [5-7].

Every month fish catches data are collected from community level, district level management, and provincial level management into national level management. National or regional fishery and environmental agencies will need the monthly figures compiled into quarterly or six-monthly reports so that they can see if this impacts on other species, trade or commercial aspects [8]. The State Department of Fisheries in Kenya tried to conduct routine fisheries data collection based on total...
enumeration. However, due to the staff shortages, and the costs involved had has recognized that this routine is no longer viable. From the perspective of the statistical validity of routine catcher effort data, full enumeration offers relatively minor advantages over a sampling approach. Furthermore, full enumeration of busy fish landing sites is practically impossible to achieve, and therefore there are significant questions as to the accuracy of the data that are collected [9]. As it was not possible to measure or weigh all catch and by catch, some weights were estimated [10]. These problems also occur in Basis Landing of Fish or called Tempat Pendaratan Ikan (TPI) in Indonesia too [11]. Since the ship moratorium at the end of 2014 by Ministry of Maritime Affairs and Fisheries (MMAF), small-sized vessels under 10 GT control 89 percent of the total 600.000 national fishing vessels in all territorial waters of Indonesia [12]. There is an urgent need to help MMAF for producing more accurate fish catches data. Therefore, this paper proposed a system that utilizes computer vision, fuzzy logic and Global Positioning System (GPS) for supporting a sustainable Indonesian fishery by recognizing and measuring fish length, determine fish age and where is the catch location. This paper is about an early stage research or the first year from multiyear research supported by The Directorate General of Strengthening for Research and Development, Ministry of Research, Technology, and Higher Education, Republic of Indonesia.

2. Related Works
2.1. Fishing Area and Fish Production
As shown in Figure 1, Indonesia ocean is divided into eleven fishing areas according to Minister Regulation No. 18/ 2014 to achieve Ecosystem Approach to Fisheries Management (EAFM) [13]. According to the Indonesian Ministry of Maritime Affairs and Fisheries, large Pelagic fish resources in the Sulawesi Sea are in overfishing exploitation status, and several potential areas in Indonesia, the population of several species of fish, are critically threatened [14].

![Figure 1. Map of Fishing Areas in Indonesia [13]](image)

The process starts from collecting fishes catches data as one of the considerations in the management of fisheries resources using the help of computer vision and fuzzy logic. It can be assumed that if fishes are caught at a gonad size before they are mature, then it needs to be done selectively so that aquaculture management can be maintained. Computer vision and fuzzy logic to estimate the types of fish that are worth catching in helping the management of fisheries resources in Indonesia that is sustainable.

As shown in Figure 2, there is a relationship among several catches, maximum fishing percentage, and fish production status [15]. If the system is success to be implemented, fishermen can be informed
that where are the locations that should be avoided because from fish catches information that fishes at that location are not in production age yet. The system must be able to notify the potential for fishing and capture fisheries production, so that it can know the status of overfishing [14].

![Figure 2](image.png)

**Figure 2.** The relationship graph is the number of catches, maximum fishing percentage and fish production status [15]

### 2.2. FishNet

Deep learning has been recognized as a practical tool in the application of image processing, natural language processing, speech recognition, text classification, robotics and control, computer vision [16-17]. Through the Convolutional Neural Network (CNN) for a practical approach to machine learning using a collection of images, CNN can learn a rich representation of characteristics for a variety of images.

![Figure 3](image.png)

**Figure 3.** FishNet processing results

As shown in Figure 3, fish classification can use transfer learning and Matlab as the first step to solve the problem of hulate fishing. FishNet is a transfer learning from AlexNet to classify *Katsuwonus pelamis* (skipjack), *Euthynnus affinis* (Tuna) and *Coryphaena hippurus* (Mahi-mahi) captured by fishermen applying five steps to teach machine learning [11]:

- **Step 1:** Making fish image data from popular names such as *Katsuwonus pelamis* known as skipjack.
- **Step 2:** Image processing with CNN and augmentation process to create enough images as deep learning data. Augmentation can be in the form of scale, rotation, turning, tilting, cropping [18].
- **Step 3:** Prepare a data set of 15,120 fish images, 5,040 for each fish. Data is divided into 70:30 for training and validation sets. Training is doing by matching classifier parameters [19].
- **Step 4:** Modify AlexNet into FishNet with Matlab, which is used to predict fish classes.
- **Step 5:** Set hyperparameter from FishNet.
2.3. Fuzzy Logic
There is a relationship between fork length and weight of skipjack tuna as shown in Figure 4. The computer vision program try find out the fish length automatically using instance segmentation called Mask R-CNN [20]. From its length then using the relationship between fish length the program will compute its weight.

![Figure 4. Relationship between fork length and weight of skipjack tuna [21]](image)

Fuzzy logic is one branch of artificial intelligence to build intelligent systems. Fuzzy logic is often used in solving problems that explain the system not through numbers, but linguistically, or variables that contain uncertainty/uncertainty. One of the implementations of fuzzy logic that will be used is in deciding to determine the size of skipjack fish. The fuzzy logic uses FIS (Fuzzy Inference System), which is a system that can evaluate all the rules simultaneously to produce conclusions, and the order of the rules can be random. Juvenile = 0-1 year old, Mature = 1-4.5 year old, and Old = 4.5-12 year old, see Figure 5.

![Figure 5. FIS – Fuzzy logic tool](image)
3. Proposed Methods

![System Block Diagram](image)

**Figure 6.** The system block diagram

The system block diagram as seen in Figure 6, fishes captured by a web camera, then some image processing will enhance image. After that, FishNet will determine fish type. The Mask R-CNN will find fish’s contour to get the length of the fish and calculate its weight. GPS module will give fishermen boat location and recorded. From its length then the fuzzy logic will determine fish age. Assuming that the fish caught at size as a juvenile has not yet ripened or in other words has not had the opportunity to do mating, then the fish must be released to avoid a shortage of fish resources in future and reduce the tendency to become extinct. The fishing process data can be analysed to be appropriately managed according to the policy. Figure 7 shows the web cam installation.

![Web Camera Installation](image)

**Figure 7.** Web Camera Installation

As for the standard data, the average weight is estimated at 2.1 kg for small skipjack and 5.7 kg for large skipjack. Supporting data for these values were improved throughout 1970-2016 collected as a standard weighting [22].

**Conclusions**

Computer machine vision and fuzzy logic can be used to estimate skipjack tuna size measuring to know the productive ages efficiently at Sulawesi or Manado sea; this system can be installed on Huhate ship which is useful to manage sustainable and aquaculture security in Manado specially and Indonesia generally. Therefore, the implementation of computer machine vision and fuzzy logic urgently required to be implemented base on said the reason to maintain the sustainability of aquaculture in Indonesia properly.
Acknowledgments
Authors wishing to acknowledge the support from the Directorate General of Strengthening for Research and Development, Ministry of Research, Technology, and Higher Education, Republic of Indonesia as a part of PenelitianUnggulanPerguruan Tinggi Research Grant to Binus University entitled “Perancangan Algoritma Untuk Pengenalan Ikan Cakalang, Tongkol dan Lemadang Otomatis Hasil Tangkap Nelayan Huhate di Bitung, Manado” or “Design of Algorithm for Automatic Skipjack, Tongkol, and Lemadang Recognition of Fishermen using Huhate in Bitung, Manado” with contract number: 225/SP2H/LT/DRPM/2019, 12/AKM/PNT/2019, 039/VR.RTT/IV/2019 and contract date: 27 March 2019.

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