Faculty of Engineering

BASS FISH MEASUREMENT SYSTEM (BASS)

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Grade: ____________

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Final Year Project Report ☑

Masters ☐

PhD ☐

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BASS FISH MEASUREMENT SYSTEM (BASS)

Bass Fish Measurement System (Bass)

NADZIRAH IRFANI BINTI FATHI

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering
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ABSTRACT

The measurement of fish length is an essential factor in aquaculture sector since it is used for a variety of purposes, including monitoring, and determining fish development, gender, age, and reproduction. Till now, businesses that specialise in fish farming utilise measuring boards made of wood or acrylic plastic. However, this conventional technique puts the fish through a great deal of strain when measuring their length while they are still alive. In addition, utilising a measuring board to manually measure the length of each fish, one at a time, is a time-consuming process. This process will acquire high cost, manual labour and expert knowledge for the measurement process. Hence, this project presents an intrusive method for measuring the length and weight of Asian sea bass (*Lates Calcarifer*) using image processing and statistical analysis for measurement data study. This Bass Fish Measurement System was developed to measure the fish length and weight while estimating its age accurately. The BASS was designed by using an image processing tool which consists of data acquisition, image pre-processing, and measurement in Python with OpenCV library. The dataset image used in BASS was collected from Stesen Perikanan Darat Samariang Batu. The image acquisition and image pre-processing consist of pre-treatment, segmentation, and feature extraction stages. Further analysis was carried out to compare the estimated measurement with the exact measurement. The lateral view was chosen as it more accurate in term of total percentage error, Mean Absolute Error and Root Mean Square Deviation for length, weight, and age respectively in the three cases. Therefore, this BASS project will have an efficient and accurate data result for future analysis or research on fish measurements.

ABSTRAK

Pengukuran panjang ikan adalah faktor penting dalam sektor akuakultur kerana ia digunakan untuk pelbagai tujuan, termasuk pemantauan, dan menentukan perkembangan ikan, jantina, umur dan pembiakan. Sehingga kini, perniagaan yang pakar dalam penternakan ikan menggunakan papan pengukur yang diperbuat daripada kayu atau plastik akrilik. Walau bagaimanapun, teknik konvensional ini meletakkan ikan melalui banyak ketegangan apabila mengukur panjang mereka semasa ia masih hidup. Di samping itu, menggunakan papan pengukur untuk mengukur panjang setiap ikan secara manual, satu demi satu, adalah proses yang memakan masa. Proses ini akan memperoleh kos tinggi, buruh manual dan pengetahuan pakar untuk proses pengukuran. Oleh itu, projek ini membentangkan kaedah intrusif untuk mengukur panjang dan berat siakap Asia (*Lates Calcarifer*) menggunakan pemprosesan imej dan analisis statistik untuk kajian data pengukuran. Sistem Pengukuran Ikan Bass ini dibangunkan untuk mengukur panjang dan berat ikan sambil menganggar umurnya dengan tepat. BASS direka bentuk dengan menggunakan alat pemprosesan imej yang terdiri daripada pemerolehan data, pra-pemprosesan imej dan pengukuran dalam Python dengan perpustakaan OpenCV. Imej dataset yang digunakan dalam BASS dikumpul dari Stesen Perikanan Darat Samariang Batu. Pemerolehan imej dan pra-pemprosesan imej terdiri daripada peringkat pra-rawatan, pembahagian dan pengekstrakan ciri. Analisis lanjut telah dijalankan untuk membandingkan ukuran anggaran dengan ukuran yang tepat. Pandangan sisi dipilih kerana ia lebih tepat dari segi jumlah peratusan ralat, Min Ralat Mutlak dan Akar Min Sisihan Kuasa Dua untuk panjang, berat dan umur masing-masing dalam tiga kes. Oleh itu, projek BASS ini akan mempunyai hasil data yang cekap dan tepat untuk analisis atau penyelidikan masa hadapan tentang ukuran ikan.

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LIST OF ABBREVIATIONS

BASS	-	Bass Fish Measurement System
CNN	-	Convolutional Neural Network
IoT	-	Internet of Things
Km	-	Kilometres
RM	-	Ringgit Malaysia
FAO	-	Food and Agriculture
B40	-	Bottom 40%
BCE	-	Before the Christian Era
UAV	-	Unmanned Aerial Vehicles
Ph	-	Potential hydrogen
AIP	-	Analogue Image Processing
DIP	-	Digital Image Processing
NN	-	Neural Network
BR445	-	Barra-Ruler-445
Kg	-	Kilogram
TL	-	Total Length
cm	-	centimetre
mm	-	milimetres
RMSE	-	Root Mean Square
MAE	-	Mean Absolute Error
MARE	-	Mean Absolute Relative Error
MXAE	-	Maximum Absolute Error
OpenCV	-	Open-Source Computer Vision Library

XML	-	Extensible Markup Language
CSV	-	Comma-Separated Values
YOLO	-	You Only Look Once
SSD	-	Single-shot Detector
R-CNN	-	Regions with Convolutional Neural Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter contains an overview of the project titled Bass Fish Measurement System (BASS). It also includes the motivation of project, problem statement, project objectives, project scope, project motivation, and project outlines in sections 1.2 through 1.7, in order.

1.2 Background

Aquaculture refers to the cultivation of fish, crustaceans, molluscs, and other aquatic organisms in either freshwater, brackish water, or saltwater. Aquaculture may manifest in many ways, including ornamental fish cultivation and fish farming. Fish farming consists of the raising and growing of aquatic creatures in captivity with the primary goal of consuming them as food, clearing out vegetation and animals that aren't wanted, replacing them with species that are, improving those species through breeding and selective breeding, and increasing the amount of food that's readily available [8]. It is also called fish culture. The two main categories of fish farming methods are conventional and unconventional [9]. Agricultural fish farming may occur in one of four different environments, including open ponds, raceways, tanks, or cages. This method has been used by fish farmers over the past years.

Malaysia's fishing business may be classified into three major subsectors which are aquaculture, freshwater fishing, and offshore fishing [1]. Diverse advantages accrue to humans because of fisheries, which may be itemized in various ways [2]. A significant proportion of Malaysia's gross domestic product is contributed by the fishing industry, which is one of the country's expanding industries. Over the last three decades, the fishing industry has expanded swiftly and vigorously [3]. In 2013, the fisheries industry and aquaculture each contributed 0.4% to the global production share of 1.1% [4]. In terms of revenue, foreign exchange, and occupation, this demonstrates that the fishing industry in Malaysia plays a vital part in the domestic economy [5]. The agriculture industry employs a total of 444,531 people, has had a yearly growth of 2.6% over the last five years, and is responsible for paying salaries and compensation of RM7,904.3 million [10]. The average monthly salary in this industry rose by 7.3% to RM1,504 in 2015, making it the sector with the greatest year-over-year rise in compensation [10].

As one of the leading economic contributors to Malaysia, fish farming responsibilities and tasks may sometimes become more difficult. As the quantity of fish samples increases, the system will confront a variety of difficulties and obstacles, particularly if the fish were treated conventionally. The data on fish biomass is crucial for future analysis since it provides information about the reef's trophic structure and total reproductive output. Accurate growth assessment of a farm's specimens is necessary for the proper feeding and harvesting of the farm's produce [11]. Problems with conventional fish handling in aquaculture might vary in terms of procedure, expense, labour, and time. Process and efficiency are crucial for managing large regions of fish farming since they impact the fish and the farm's condition. Manual processes in fish farming require human labour to do the job and task. This will increase the fish farming cost as an expert person is needed for a certain task such as measurement.

In recent years, control engineering principles are applied to fish production in what's known as "precision aquaculture," which aims to improve farmers' monitoring and management of fish farms using smart technologies such as sensors like probes and optical systems for water and fish monitoring along with statistical analyses [6]. For instance, FishDeTec uses an image processing method to identify the varieties of freshwater fish in Malaysia using a deep CNN model, such as VGG16, which is used for massive-scale picture categorization [7]. In modern agriculture, IoT and machine learning are synonymous and have been extensively used to facilitate processes and operations.

The Internet of Things or commonly known as IoT is a well-known concept that outlines a dynamic ecosystem of interconnected computer devices with various components enabling smooth communication and data transmission [16]. It is a relatively innovative paradigm that is fast gaining traction in the scenario of contemporary wireless telecommunications, with a projected increase of 25 to 50 billion linked devices by the year 2020 [17]. Image Processing is the mathematical processing of pictures using any kind of signal processing for which the input is an image, a sequence of images, or a video, such as a photograph or a video frame, and the output is either an image or a collection of characteristics or parameters connected to the image [20]. Analog image processing and digital image processing are two image processing techniques [21].

IoT and image processing in the healthcare sector has the capability to monitor the physical activity of users and make assessments of their health [18]. Meanwhile, in factories with image processing and IoT integration, planned job activities performed by industrial equipment can be monitored effectively, which improves troubleshooting while ensuring automated controls to prevent work task failures. Moreover, image processing and IoT are also prevalent in the aquaculture industry, where IoT-integrated linked devices with image processing capability provide for effective monitoring of device-to-device interactions. Consequently, the needed processing of the planned activities in aquaculture may be executed with precision due to accurate management.

Sensors, image processing, cloud computing, and data analytics are applicable for IoT deployment as the IoT allows dynamic connection of devices to the network, while cloud computing offers virtualization of data storage and processing [19]. With the development of IoT applications and image processing techniques, it is now feasible to implement this project using BASS, where IoT and image processing are used to facilitate the growth of bass fish. Using efficient aquaculture principles, the development of the fish farming process may reduce the time and energy required to complete repetitive operations and increase fish production.

The implementation of image processing and IoT in smart aquaculture is mainly used for specific tasks with certain requirements, especially in terms of the operating environment. Smart aquaculture is not only capable of real-time monitoring, prediction, warning, and risk control of the physical and chemical factors of the aquaculture environment, but also real-time monitoring of the characteristics and behaviours of the fish, which infers the changes in the aquaculture ecological environment [22]. Recent aquaculture operations rely mostly on automated integrated systems that are widely accessible on the market. The majority of current automated integrated systems are primarily focused on process monitoring and feeding. The fundamental aquaculture tasks such as the growth measurement process are still demanding human resources and labour. The measurement process is a significant task that needs to be considered and carried out with precision as it is the key to the fish's health and diet.

Hence, the BASS project is developed to simplify the process of measuring in order to provide precise, low-cost, less labour and time-saving data recording with image processing. Additionally, because no manual labour is involved to deal with the fish, this method will not lead to any contamination in the surrounding environment of the pond. Fish products may be contaminated not only by human diseases already present in a processing facility, but also by pathogens transported from contaminated raw materials to finished fish products, processing equipment, and workers. In combination with this, diseases and stresses that are common in fish may be prevented, as well as any subsequent infections. For example, *Aeromonas hydrophila*, which is widespread in aquatic habitats, is not only capable of causing infections in humans and animals, but also increases histamine levels, offering a chemical threat to human health. This proves that hygiene issue is not only important for fish but also for the consumer.

1.3 Problem Statement

Whether in saltwater or freshwater, fish farming is the practice of raising fish commercially for human consumption by selective breeding. Located in the northern part of the Federation of Malaysia, the state of Sarawak is a major fishing destination because of its extensive coastline. According to the Malaysian Department of Fisheries, tiny pelagics provide a particularly promising opportunity for Sarawak to pursue deep-water fisheries. Besides adding to Sarawak's gross domestic product, the fishing industry also provides jobs and revenue to the local population. Threats to Sarawak's fisheries come mostly from illicit fishermen, weak fisher associations, and, more recently, the effects of the Covid-19 pandemic. As a result, an illegal fishing organisation was formed to manage fisheries operations such as the Department of Marine Fisheries Sarawak, Stesen Perikanan Darat Semenggok, Stesen Perikanan Darat Semariang Batu, and Tanjung Manis Aquaculture. In the industry of captive freshwater bass, the growth process must be tracked at regular intervals, mostly by hand from measurement to data recording. The manual approaches for measuring and managing the database for the development of freshwater bass are time-consuming, laborious, expensive, and involve the use of human eyes. The bass will experience stress because of these issues (handling), and the data will become less precise and more prone to inaccuracy. Fish growth is essential to monitor their health, plan their daily feeding and medication, control the stock, and determine the ideal harvesting time. In large-scale fish farming, the measuring procedure is more challenging due to the enormous number of fish samples, necessitating specialised knowledge. Costs will rise in line with the increased demand for labour. In addition, improper sample handling will result in fish disease and contamination. Inadequately, no strategy exists for integrating data on fish. This creates a problem for data predictions and will limit data forecasting. Consequently, this project suggests the development of a freshwater bass measurement system based on image processing techniques to assess the bass's growth efficiently and precisely. This project is anticipated to aid both small- and large-scale fish farmers in the fish growing process, as well as provide future reference data for researchers.

1.4 Objectives

Based on the problem statement, there are three main research or project objectives that have been identified as follows:

1. To design a non-intrusive fish growth monitoring system, specifically for measuring the development of Asian bass fish.
2. To integrate image processing into an effective freshwater bass growth measuring system.
3. To assess the effectiveness of the proposed effective freshwater bass growth measuring system to measure and estimate the size, length, and age for data collection.

1.5 Project scope

The following are descriptions of the project scopes:

1. The project mainly focuses on freshwater bass growth.
2. The project focuses on *Lates calcarifer* species ranging in length from 7 cm to 82 cm and weighing an average of 1 kg.
3. The project uses an image processing method to analyse and estimate the taken freshwater bass image.
4. The study *Lates Calcarifer* species is raised in a bass cage with sizes varying from 10-50 cm in depth and 50-500 meters in area.
5. The *Lates Calcarifer* sample was taken from the Stesen Perikanan Darat Samariang Batu.

1.6 Project motivation

The whole length of Malaysia's coastline is 4,809 km, and its total area is 329,750 square kilometres. Out of this total, 2,031 km of coastline can be found in Peninsular Malaysia, while 2,778 km can be found in Sabah and Sarawak (East Malaysia) [12]. The Malaysian state of Sarawak is located on the island of Borneo and spans along the northwest coast of the island, where it has several beaches on the South China Sea. It runs about 800 km along the northwest coast of Borneo and has a total size of 124,449.51 square kilometres [13]. Sarawak is composed of three distinct areas which are the coastal lowlands, which have peat swamps and narrow deltaic and alluvial plains, a wide region with hills that rise to around 300 metres the mountain highlands that go all the way to the border with Kalimantan [13]. Sarawak is the home of Borneo's seventh-longest river and Malaysia's longest river. As shown by Sarawak's mostly wetland-based natural characteristics and structures, it is evident that the country benefits financially and materially from fishing operations. In the northwestern aquatic regions of Borneo (Sarawak), a total of 564 species of fish belonging to 123 families and 32 orders have been reported [14]. Approximately 50% of them (271 species) were freshwater residents, followed by marine (207 species), marine euryhaline (73 species), and brackish water (14 species) [14]. Depending on the fish species, fish farming was conducted in fish tanks or artificial enclosures such as fishponds to conserve the fish ecology and sustain fish output.

Fish farming operations have had a favourable effect on Sarawak's economy, labour force, and food supply. In 2019, Sarawak contributed RM 190,768.71 to the wholesale value of aquaculture output of the culture system in Malaysia, accounting for around 5.7% of the total [15]. In terms of marine fish landings and values, Sarawak produces 171,487 tonnes of resources worth 927.97 RM Million in 2019 [15]. Sarawak's fish industry is mostly concentrated on freshwater fish of inland fisheries, with landings totalling 1,646.01 in 2019 and ranking second highest in Malaysia [15]. This resource will ensure the continuation of the food supply in order to provide the people of Sarawak with food and nutrition. Besides that, the fisheries industry has provided employment and career prospects for all ages to the Sarawak people. In 2019, 12,063 fishermen and 5443 licensed fishing vessels from Sarawak were reported by the Department of Fisheries Malaysia [15]. This shows that the fisheries industry can help people to gain income to sustain their households.

In order to retain the stainability of the fisheries industry, it is necessary to use effective fish farming methods and techniques. Currently, aquaculture industry employs a variety of cutting-edge technologies, with the IoT, cloud computing, machine learning, and artificial intelligence serving as the primary emphasis. From handling to growth and reproduction, technological advancements are used throughout the whole fish-rearing process. For example, in [16], an aquarium fish smart farming was established with an IoT and Android-based mobile application solutions for controlling the aquarium water system. In addition, research [17] discusses Smart Monitoring Systems for Pond Management and Automation in Aquaculture. This system work with sensors that provides water temperature, humidity, and pH to the cloud. This is done using a cloud-based app. If the measured numbers are out of range, the app notifies the user so they may act. These two studies prove that the implementation of technology in aquaculture is beneficial to humans in terms of efficiency, time, money, and labour.

Therefore, the BASS system is intended to provide the fish business and its employees with an improved approach to handling fish as opposed to the traditional method. This strategy may also assist promote knowledge and awareness about the use of digital technology in aquaculture among the people of Sarawak. Exposure to the most recent technology in aquaculture may result in digital technology competence and improved aquaculture technologies in the future which will benefit the people of Sarawak. In addition, this initiative may improve fish and marine life productivity. A correct and superior approach for fish handling and farming improves the fish's health and prevents stress. A healthier ecology will be provided for the fish. Lastly, the data that has been recorded in the system can be kept and used for future reference or studies.

1.7 Project outline

This project covers six chapters, which includes:

- Chapter 1 – Introduction
- Chapter 2 – Literature Review
- Chapter 3 – Methodology
- Chapter 4 – Results and Discussion
- Chapter 5 – Conclusions

Chapter 1 covers the project overview, which introduces the research on aquaculture and fish farming in Malaysia, the Internet of Things (IoT), and image processing. This chapter also includes a problem statement, project objective, project scope and project motivation.

Then, Chapter 2 presents the background of Malaysia aquaculture, smart aquaculture, the current technology in fish farming, approach, and research gap.

Research Methodology is provided in Chapter 3. It consists of the planning and research, and project process in image processing and data analysis. The third chapter is methodologies of implementing the proposed project. Tools and techniques to be used are described and discussed.

Chapter 4 focuses on the results and discussion of the three different scenarios. All the data such as the measurement, error analysis and data analysis throughout this study are presented and discussed in this section.

The concluding chapter, Chapter 5, provides a summary of the project's key findings. In addition, the recommendations to improve the proposed system further is provided.

1.8 Summary

Based on the previous study, the requirement in the measurement process to be automated is significant in order to ensure the measurement process can be done well and in a proper way, which saves time, money and manual labour. Therefore, the BASS is introduced in order to facilitate in the measurement process, which then helps to measure in efficient and accurate way.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature to confirm the viability of this study and identify the research need. This chapter begins with a discussion of the history of fish farming, the background of the Asian bass fish, and intelligent aquaculture. In addition, this chapter highlights research on the application of IoT and image processing that is used in aquaculture.

2.2 Background

The history of aquaculture recounts the evolution of fish farming from its ancient origins to its contemporary highly sophisticated technologies [24]. Aquaculture has about 4,000 years of history. It may have originated in China owing to an emperor's need for a steady supply of fish. It is hypothesised that the methods for preserving fish in ponds started in China with fishermen who temporarily kept their extra catch alive in baskets immersed in rivers or tiny bodies of water made by damming one riverbed. Another idea is that aquaculture evolved from ancient fish-trapping traditions, with operations gradually advancing from fish-holding to fish-holding-growing to total husbandry.

A range of aquaculture techniques is used in freshwater, brackish water, and marine environments for a vast array of cultured species. Aquaculture in freshwater is conducted in fishponds, fish pens, fish cages, and, to a lesser extent, rice paddies. Primarily, brackish water aquaculture is conducted in coastal fishponds. Either fish cages or substrates for molluscs and seaweeds, such as stakes, ropes, and rafts, are used in marine culture. Figure 2.1 shows the data on the aquaculture production system and practices by region from the Food and Agriculture Organisation of the United Nations. At least 75 species of freshwater and marine fish are produced in traditional extensive to intensive culture