Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction

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In Partial Fulfilment of the Requirements for the Degree

Bachelor of Science in Computer Science

by

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CERTIFICATION OF ORIGINALITY

This is to certify that the research work presented in this thesis/ dissertation, Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction, for the degree Bachelor of Science in Computer Science (BSCS) at the Polytechnic University of the Philippines embodies the result of original and scholarly work carried out by the undersigned. This dissertation does not contain words or ideas taken from published sources or written works that have been accepted as a basis for the award of a degree from any other higher education institution, except where proper referencing and acknowledgment were made.

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ABSTRACT

Title : Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction

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Living in an archipelago, Filipino people have always had fish as a part of their staple diet taking up 11.9% of their total food intake (BFAR, 2019). With people always aiming for the freshest fish possible, a good way of determining if a fish is fresh is by looking at the color of its gills (WHO & FAO, 2020). However, not everyone is confident that they can determine the freshness of a fish through the color of its gills, such as members of the population who are colorblind. N. J. David and J. P. Reyes (2017) addressed this problem by making software that evaluates the freshness of a tilapia fish by utilizing thresholding and morphological close operation for gill segmentation and the usage of the red channel average value for feature extraction. In this study, the researchers have developed a tilapia fish freshness evaluation system that uses GrabCut and Yolov3 Algorithm for image segmentation and try to use all the three color channels of the RGB color space for feature extraction to create a system that can produce a higher accuracy than the System of David and Reyes (2017) in evaluating the freshness of a tilapia fish. The researchers have replicated the System of David and Reyes (2017) to achieve a proper comparison. The proposed system has produced an accuracy of 74.7%, and the previous system produced 71.08%. The proposed system produced higher accuracy than the previous system by 4.97%.

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Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

Fish has always been a staple in the diet of an average Filipino. According to the Bureau of Fisheries and Aquatic Resources (2019), fish and fish products took up 11.9% of the total food intake in the Philippines back in 2015, 4.6% higher than the intake of meat and meat products which is 7.3% of the total food intake. This is no surprise considering how big fish production is in the Philippines, producing 4.42 metric tons of fish products totaling 281.63 billion pesos in terms of value in 2019 alone (BFAR, 2019). Knowing that fish is a big part not only of the Filipino diet but also of the Philippine economy, it is not wrong to think that Filipinos always try to look for the freshest fish in the market. But the question is, how would the consumers know if the fish is fresh or not?

Sensory evaluation is one of the best ways of evaluating the freshness of a fish, according to the Food and Agriculture Organization of the United States and the World Health Organization (2020). One of these sensory evaluations is performed by looking at the color of the gills. According to the Codex Alimentarius of the FAO and WHO (2020), a fish is considered old and unacceptable if the gill is colored grey-brown or bleached. The gills of a fresh fish should have a dark red or bright red color FAO (2001). This is a great way for consumers to know whether the fish they're buying is fresh, but there is one problem: what if consumers are color blind?

According to Turbert (2021) of the American Academy of Ophthalmology, color blindness, also known as color vision deficiency, happens when someone cannot distinguish between certain colors. This usually happens between greens and reds, and occasionally blues. The article was written by E. Lockett and medically reviewed by A. M. Griff (2020), states that global estimates show that 1 in 12 males and 1 in 200 females are colorblind. That means that in the

Philippines, approximately 4.26 million males and 0.25 million females are colorblind (according to the data from the May 2021 National Quick Stat provided by the Philippine Statistics). This shows that approximately 4.51 million colorblind people will have difficulty determining the freshness of the fish in the Philippines alone. There are many ways to solve this problem through computer science, and one of them is the usage of Computer Vision to check the color of the fish's gills to determine its freshness.

Studies about using Computer Vision to evaluate the freshness of the fish have been made in the past. The study of David and Reyes (2017) addressed this problem by making software that evaluates the freshness of the tilapia fish by utilizing thresholding and morphological close operation for gill segmentation and the usage of the red channel average value for feature extraction. The system takes in an input image of a fish with its gill exposed to provide an output corresponding to one of their three freshness levels: Very Fresh, Fresh, and Not Fresh. It is a very interesting software that consumers can easily use. However, their system only produced an 80% accuracy. To put it into perspective, when using the David and Reyes system, 1 in every 5 times that their system will make an incorrect evaluation. Those chances are very high, considering fish is a staple food in an average Filipino's diet.

There are two possible reasons for the system's accuracy result. The first is because they used thresholding and morphological close operation in their image segmentation technique inspired by Karagoz (2013). Still, David and Reyes (2017) did not include object detection before performing thresholding. The second reason is that they only used the red color channel of RGB color space mainly because the main color of a fish's gill is red. They forgot that brown, which is the color of the gills of an old fish, also contains green and blue values. Knowing this, the researchers used different image segmentation techniques such as using GrabCut and Yolov3 Algorithm and trying to use all the three color channels of the RGB color space for feature extraction.

GrabCut algorithm is a semi-automatic image segmentation method based on graph cuts. This is a great algorithm to produce a segmentation of the tilapia's gill from the input image since it uses the color distribution of the target object, which will help make it easier to determine the color value of the gill. The only problem is that it is semi-automatic in that the users must manually draw the object's bounding box, which is where the YOLOv3 algorithm comes in.

The YOLO algorithm, also known as the "You Only Look Once Algorithm," is an object detection algorithm that uses bounding boxes to capture and classify an object in an image or frame. YOLO makes less than half the background errors compared to Fast R-CNN (Redmon et al., 2016). YOLOv3 is the updated version of YOLO developed by the same people who made the original YOLO algorithm after the development of YOLOv2. This version is more accurate than the first two versions of the YOLO algorithm. As mentioned earlier, the YOLO algorithm captures an object within a bounding box. YOLO can be integrated into the proposed system to automate the GrabCut algorithm.

Given this information, the researchers propose the development of a Windows software that evaluates the freshness of a tilapia fish using the color of its gill by taking in an input image that has a picture of a tilapia fish with its gill exposed and process that image to produce an output that says whether the fresh, not fresh, or old. This software is developed to help the colorblind and unconfident fish buyers pick the freshest fish in the market.

Statement of the Problem

This study aims to find out if the proposed system that uses the YOLOv3 and GrabCut method for image segmentation as the utilization of all three of the RGB channels for feature extraction can perform more accurately than the previous system that utilizes thresholding and morphological close operation for image segmentation as the utilization of the red color channel in evaluating the freshness of a tilapia fish.

1. What is the accuracy of the two systems in determining the freshness of a tilapia fish compared to the freshness evaluation of experts?

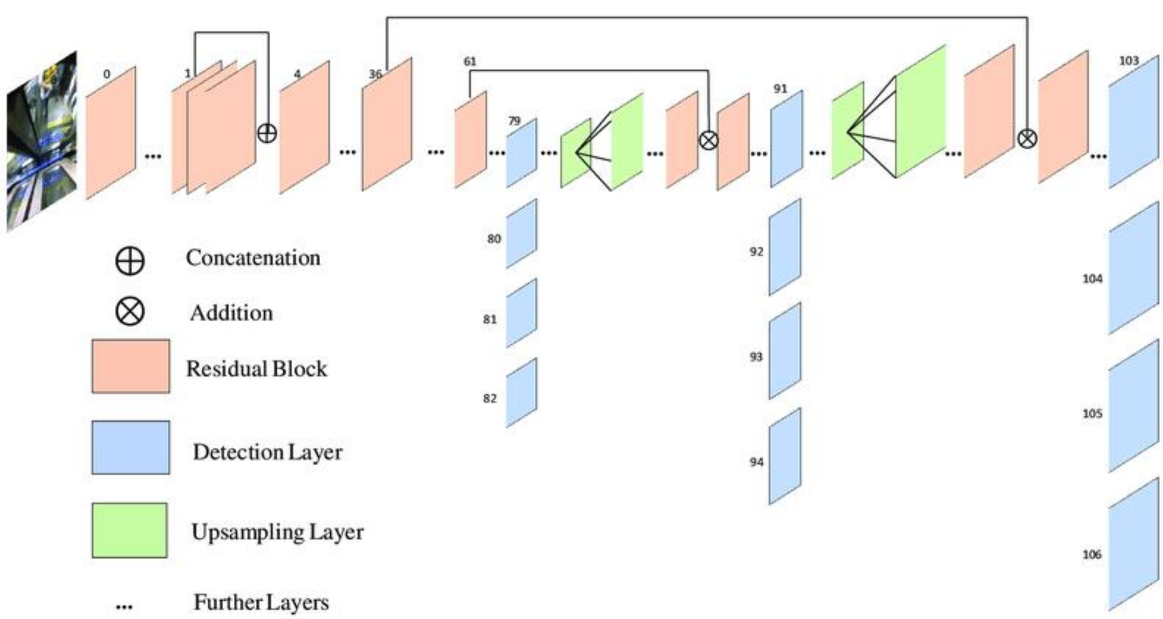
2. Is there a significant difference between the accuracy of the proposed system and the previous system in determining the freshness of a tilapia fish?

Hypothesis

There is no significant difference between the accuracy of the proposed system and previous system in determining the freshness of a tilapia fish.

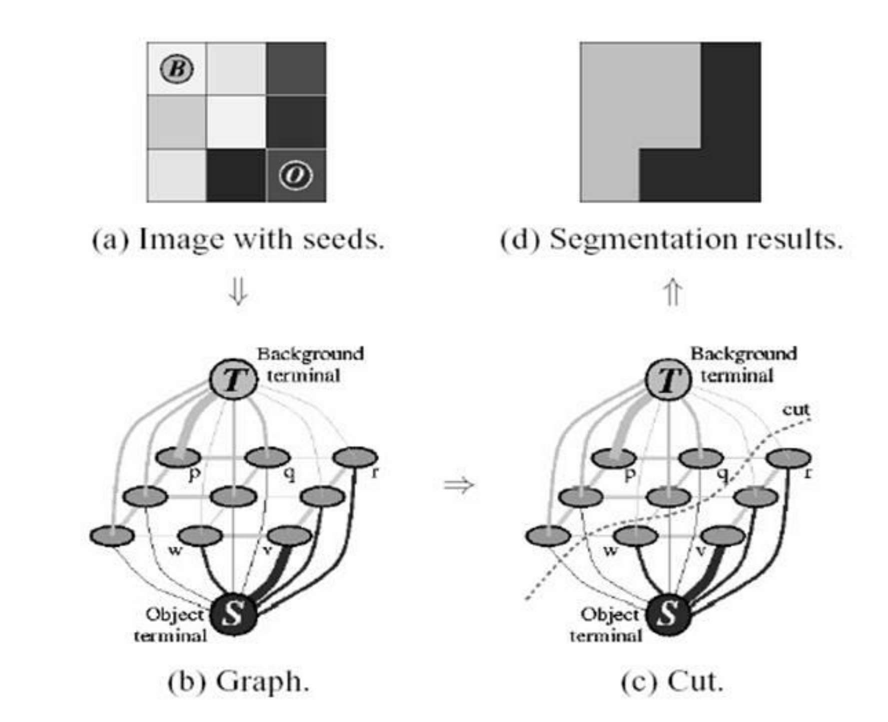
Theoretical Framework

Figure 1 - YOLOv3 Architecture



The figure above, acquired from the study of Dai et al. (2020), was used as the basis for the YOLOv3 Architecture. The figure shows how the input image will go through the residual blocks to extract a possible object's features. The detection layer detects the object in its particular image grid scale. Lastly, the upsampling layer increases the scale of the image grid.

Figure 2 - GrabCut Architecture



The researchers also used the figure above for the architecture of the GrabCut algorithm owing to the work of Matthew Marsh. The figure shows how GrabCut performs segmentation by building a graph where each node represents a pixel. The algorithm uses edge and region information to create an energy function that produces the best segmentation when minimized. The energy function is incorporated into the graph as weights between pixel nodes and between pixel and Source or Sink nodes. Weights between pixel nodes are determined by edge information in the image.

Figure 3 - Usage of YOLOv3 and GrabCut for skin lesion segmentation

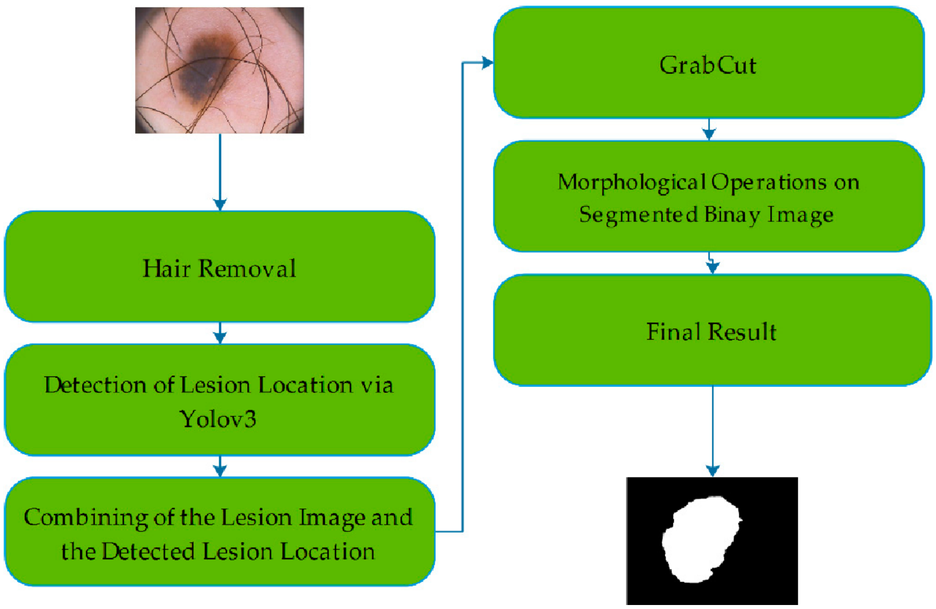


Figure 4 shows how Ünver and Ayan (2019) used the same YOLO and GrabCut algorithm for skin lesion segmentation. The figure shows how the YOLOv3 was used for skin lesion detection and created an input for GrabCut, the main segmentation algorithm. This technique was adapted for this study.

Figure 4 - System Architecture of the Previous System

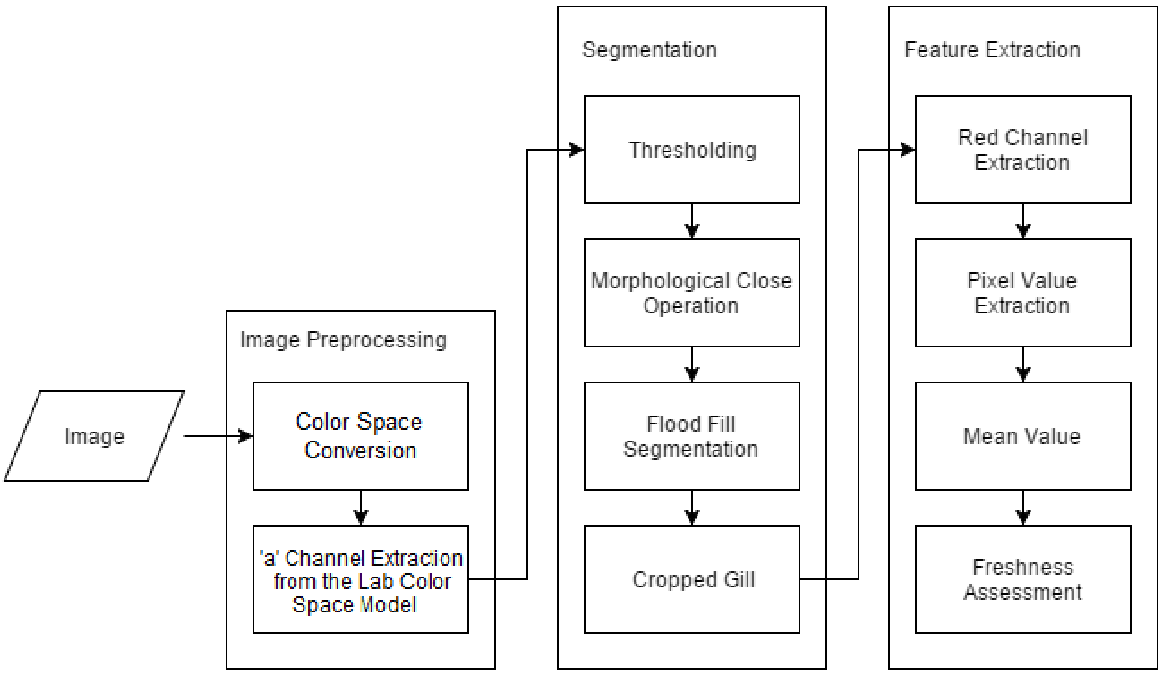


Figure 5 shows the system architecture David and Reyes (2017) used in their study. It accepts an image input and undergoes three phases of image processing. First is the pre-processing phase, where the image is converted into a Lab color space model. Next is a segmentation phase, where isolating the gill is done through techniques like Morphological Close Operation and Flood Fill Segmentation, among others. Lastly, feature extraction is executed by getting the red channel pixel value average and processing it through their freshness framework to get the freshness assessment.

Conceptual Framework

Figure 5 - Conceptual Framework

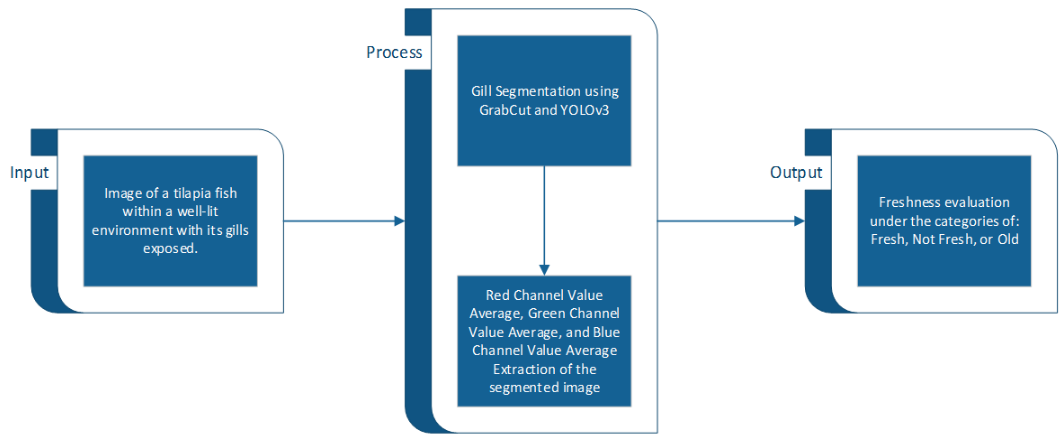


Figure 3, shown above, presents the conceptual framework of the system. As the input, the system takes in an image of a tilapia fish in a well-lit environment with its gill exposed. A well-lit environment means that the picture is taken in an environment where the tilapia and its gills are not covered by any degree of shade and shadow. After the input is taken, the system will use YOLOv3 for object detection to detect the gill and contain the gill in a bounding box, which is then processed by the GrabCut algorithm to segment within the bounding box to isolate to gill from the rest of the image. The average value of each RGB channel will be computed and used to determine the fish's freshness level: Fresh (dark red or bright red), Not Fresh (red or pink), or Old (brown/grey and bleached).

Scope and Limitations of the Study

This study uses the color of the tilapia fish's gill to determine its freshness. The reason for using it is the tilapia fish because it is the same fish that David and Reyes (2017) used in their research to determine the freshness of a fish using its gill color. The goal of this research is to determine whether using YOLOv3 and GrabCut as utilization of all three of the RGB channels for feature extraction can produce a higher accuracy than the image processing techniques used by David and Reyes (2017), so the researchers used the same type of fish that Dave and Reyes (2017) used in their research so that a more accurate comparison is produced.

The proposed software only runs on a Windows PC. It analyzes an input image that contains an image of a single tilapia fish in a well-lit environment with its gills exposed. The software detects the gill and analyzes its color. After that, the software categorizes and outputs the determined freshness of the fish according to the gill's color. There are only three freshness levels for each fish: Fresh, Not Fresh, and Old.

Since the study was conducted during the covid-19 pandemic, the researchers have experienced limitations on some resources that have impacted the execution of the experiment or the study itself. Quarantines and lockdowns as supply chain issues may contribute to the lack of face-to-face interactions and fish procurement for the study, among others.

Significance of the Study

The findings of this study will benefit the following:

Color blind people – This study is beneficial for color blind people who cannot use the color of the fish's gills to determine their freshness.

Consumers – Since not all consumers are confident that they can determine the freshness of a fish by looks alone, this study can help the consumers be more assured when picking and buying the freshest fish.

Fish Vendors – This study will help the fish vendors to help them determine if they should or could still sell their fish, depending on how old they are.

Future Researcher – Future researchers in related fields can use this study for their research or expand on the same knowledge area.

Definition of Terms

Bounding box – A square/rectangle-shaped boundary used by the YOLO algorithm to show the detected object's location.

Gills – Organs that allow fish to breathe underwater. It can be used to determine the freshness of the fish after its death.

GrabCut – A semiautomated image segmentation method based on graph cuts.

Segmentation – The process of isolating a foreground object from the rest of the image.

Tilapia – A type of fish used in the freshness evaluation. It is one of the most commonly found fishes in the Philippine market.

Well-lit environment – An environment where the focused object of an image is not covered by any degree of shade or shadow.

YOLOv3 – Also known as the "You Only Look Once" algorithm. It is a real-time object detection algorithm that is highly regarded for being faster than r-cnn, fast r-cnn, and faster r-cnn. Created by the developers of the original YOLO algorithm. This version is said to be more accurate than its predecessors.

Proposed system - the system developed in this study uses YoloV3 and GrabCut for image segmentation and RGB Channels for feature extraction.

Previous System - David and Reyes (2017) developed a system that uses Thresholding and Morphological Close operation for image segmentation and the red channel for feature extraction.

Fish experts - someone who has a comprehensive experience within the field of the fishery. Preferably someone with at least four or more years of experience working in the field or industry.

Chapter 2

REVIEW OF RELATED LITERATURE

Fish Production and Consumption in the Philippines

Fish culture has been a very important part of the Philippines since before Spanish colonization. It can easily be seen as an important part of an average Filipino's diet. According to the Philippine Fisheries Profile 2019 by the Bureau of Fisheries and Aquatic Resources, fish and fish products took up 11.9% of the total food intake in the Philippines back in 2015, 4.6% higher than the intake of meat and meat products which is 7.3% of the total food intake.

Not only in terms of food intake, but fish culture is also a significant sector in the Philippine's economy, considering how big fish production is in the Philippines, being able to produce 4.42 metric tons of fish products that total 281.63 billion pesos in terms of value in 2019 alone (BFAR, 2019). Knowing that fish is a big part not only of the Filipino diet but also of the Philippine economy, it is not wrong to think that Filipinos always try to look for the freshest fish in the market.

Evaluating Fish Freshness Using Gill Color

	E	**A**	**B**
Gills	dark red or bright red; mucus translucent	red or pink; mucus slightly opaque	brown/grey and bleached; mucus opaque and thick

Table 1. Descriptive Guide to Grades of Freshness of White Fish With Gills

According to the Food and Agriculture Organization of the United Nations (2001), using the color of the gills of a fish to evaluate its freshness is part of a sensory assessment process. It is said to be one of the best ways to assess the freshness of a fish without the help of tools, according to the FAO and WHO (2020) in their publication called the Codex Alimentarius. The table above, taken from the publication of the FAO (2001) titled "Sensory Assessment of Fish Quality," shows how the color of the gills of the fish is given a freshness grade. The researchers can use this as a basis for the freshness evaluation framework.

Color Blindness

The world has seen a rise in the cases of visual impairment in the past years; one of those impairments is color blindness. Color blindness affects a considerable portion of the human population. For reference, an article written by E. Lockett and medically reviewed by A. M. Griff (2020) states that global estimates show that 1 in 12 males and 1 in 200 females are colorblind. Keeping that in mind, approximately 4.26 million males and 0.25 million females are colorblind in the Philippines (according to the data from the May 2021 National Quick Stat provided by the Philippine Statistics Authority). Protanopia and deuteranopia, the two most common forms of inherited color blindness, are red-green color vision defects caused by the absence of red or green retinal photoreceptors, respectively (Wong, 2011). Color blindness is widely spread among the whole population. It is not limited by age. Darge's study about the prevalence of visual impairment and color blindness in school-age children of two primary schools reported that 4.2% of children have color blindness or weakness.

In contrast, the study of color blindness and the use of computers in distance education by Miguel Alcalde-Alvites discovered a relationship between color blindness and age, although not highly significant. But it is important to note here that correlation does not equate to a causal relationship, and a low percentage does not mean it is unimportant. In the same field of data results, Dargahi et al. discovered a significant correlation between color blindness and age among students and employees of TUMS Medical Laboratory when examining the medical employees and students. Although having near-perfect eyesight is critical to jobs in the medical and police fields, it also has importance in everyday lives, such as picking fresh edibles in the market. Certain tools have been developed to fight visual impairment, but color blindness is still a constant problem today. However, according to Wong, there are several tools for computers and mobile devices that may be helpful for colorblind individuals viewing existing images with colors that are hard to discriminate.

Computer Vision

According to IBM, Computer Vision is "a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos, and other visual inputs — and take actions or make recommendations based on that information." The core factor of having computers see and interpret the real world as humans do is interpreting usable information for machine decision-making from a two-dimensional representation of an object. As stated by (Ballard, 1982), it is constructing meaningful, explicit descriptions of physical objects from images. These representations can sometimes exhibit irrelevant or misleading variation, and analysis in computer vision pertains to achieving invariance and cohesion. This is in line with (Klette, 2014), where images represent high-dimensional data from the real world. Acquiring, processing, analyzing, and understanding these images produce numerical or symbolic information for the system to make informed decisions.

The field of computer vision is where research in image analysis and digital processing falls. The study of Karagoz (2013) is a prime example with the use of MATLAB to process the images obtained and create meaningful inferences on the status of the object being represented, in their case, the freshness of the fish in the captured photo. This literature is the prime inspiration for the System of David and Reyes (2017), where they have implemented the same techniques for their image segmentation. However, Karagoz's (2013) image segmentation used edge detection to separate objects before thresholding. This information has been overlooked by David and Reyes (2017). They have also used a different feature extraction technique, using a red channel to quantify the fish's color. It is unknown why they used the red channel alone instead of all three color channels. However, the researchers have determined that a possible reason is that David and Reyes (2017) had a misconception that the red channel is enough. After all, the color of a fish's gills is also red. They did not consider that brown, which is the color of the gills of an old fish, has blue and green channel values.

Digital Image Processing

Image processing is one of the most rapidly growing fields today. Digital images extract different features using computers to perform some processes on images, which can be automated. Recognizing and categorizing various types of defects is one of the most important and required operations on digital images (Chavan, 2016). They process digital images through certain algorithms to recognize the fault from a given image.

Two types of methods are used for image processing: analog and digital. Digital image processing techniques help manipulate digital images by using computers. The three general phases that all types of data have to undergo while using digital techniques are pre-processing, enhancement, display, and information extraction. Digital image processing has two principal aims: enhancement of images for humans; and processing of image data for autonomous machine perception, storage, transmission, and representation (Karagöz, 2002).

Although different researchers in image processing have conducted much research, there is scope to apply image processing techniques for quality control of various industrial products. The image processing techniques are a very powerful tool for automatic, fast, and easier defect detection and quality control of various products.

Usage of Image processing in Evaluation of Fish Freshness

As much as the consumers want to buy and eat freshly caught fish, it is common for local markets to display and sell two-week-old fish before the day they were collected from the seas. To guarantee the safety of fish consumers, one must practically check for quality indicators to determine whether the fish they are going to eat is fresh or not (Navotas et al., 2018).

Many studies have used different methods to evaluate the freshness of the fish. An electronic nose was used in a study by Najib et al. (2006) to distinguish between fresh and preserved fish. The odor profile of the fish samples was collected and normalized. Case-Based Reasoning was used to extract their characteristics. Another study was developed on an android application that automatically identifies the three most consumed fish in the Philippines: milkfish, round scad, and tilapia. According to Navotas et al. (2018), the application classifies the staleness or freshness of the fish from level 1 to level 5, with level 5 being the freshest fish, by using the RGB values of the eyes and gills to determine its remaining shelf life.

The quality of fresh fish will decrease immediately after death. One of the indicators of fish quality is the changes in the color of the gills. The study by N. J. David and J. P. Reyes (2017) titled "Tilapia Fish Freshness Assessment using Image Processing Techniques," contains the development of software that evaluates the freshness of the tilapia fish by utilizing thresholding and morphological close operation for gill segmentation and the usage of the red channel average value for feature extraction. The system takes in an input image of a fish with its gill exposed to provide an output corresponding to one of their three freshness levels: Very Fresh, Fresh, and Not Fresh. It is a very interesting software that consumers can easily use.

Their system produced an accuracy of 80% when they compared the freshness evaluation outputs of the software to the freshness evaluation of experts using the same image inputs used by the software. To put it into perspective, when using the David and Reyes system, 1 in every 5 times that their system will make an incorrect evaluation. Those chances are very high, considering fish is a staple food in an average Filipino's diet.

The researchers have come up with two possible reasons that the system produced such accuracy. The first possible reason is that the image segmentation of the system is not accurate enough and is affecting their mean pixel value. Image segmentation with a complex background is a tedious task. According to Karasulu (2018), image segmentation has a preliminary role in content-based image analysis. It subdivides a given image into its constituent parts to obtain objects of interest. Thus valuable information can be extracted from this image. Analyzing the image segmentation process of David and Reyes (2017), the researchers have noticed that their system is not properly isolating the gill from the rest of the image. The researchers have determined that this is caused by using the thresholding method without any prior object detection. Although thresholding is an accurate tool for color-based image segmentation, it is not an ideal technique for segmenting specific objects alone. An example is given in Figure 1 below, where the thresholding method is used in an image of a snowy landscape.

Figure 6 - Thresholding Sample

It can be seen that the thresholding method produced an accurate segmentation of the dark-colored parts of the image. Still, the same method cannot be used to segment a specific object from that image like the tree or the railings (and in the case of the study by David and Reyes, the gill of a tilapia fish). Given this information, it is a question why David and Reyes (2017) still used thresholding despite the given flaw.

A possible reason lies in their literature review, where they included the study of A. Karagoz (2013). This study used thresholding to evaluate the freshness of fish. A most likely inspiration for their decision to use thresholding. However, Karagoz's (2013) image segmentation used edge detection to separate objects before thresholding. This information has been overlooked by David and Reyes (2017).

The second possible reason for their accuracy is that the system only utilized the image's red channel for feature extraction and not all three channels (red, blue, and green). David and Reyes (2017) did not elaborate on their reason for using the red channel alone, but the researchers have determined that a possible reason is that they thought the red channel was enough. After all, the color of the gills of a fish is primarily red. They did not consider that brown, which is the color of the gills of an old fish, has huge blue and green channel values that affect the freshness framework of the system. Knowing this, the researchers used different image segmentation techniques such as the GrabCut and Yolov3 Algorithm to try to use all the three color channels of the RGB color space for feature extraction.

YOLO and YOLOv3

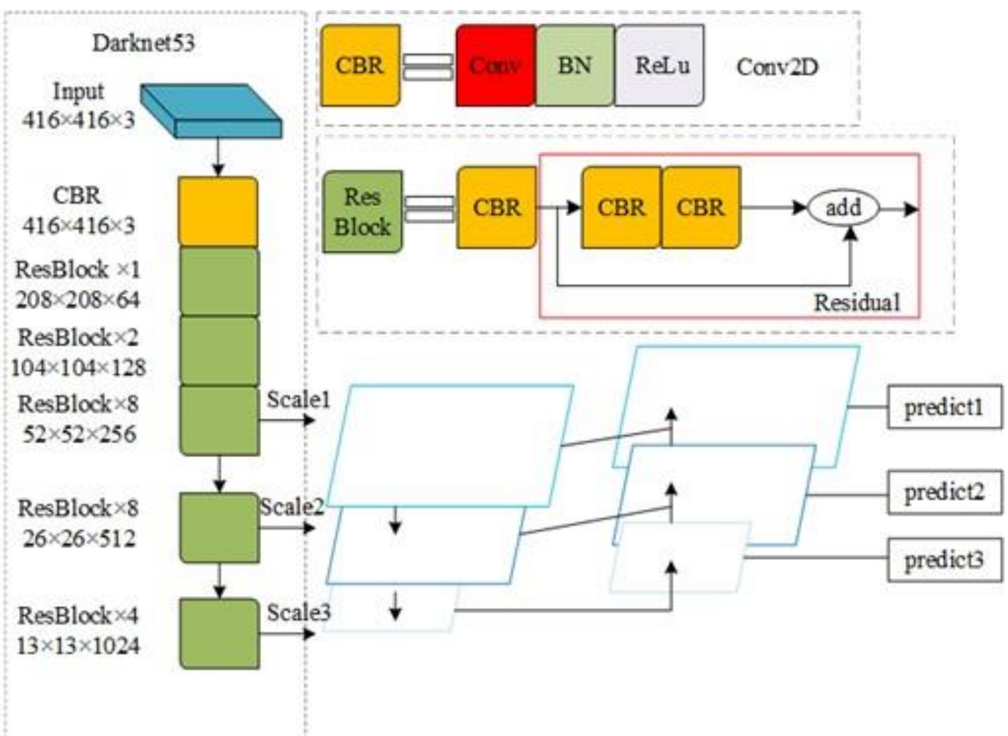
Object detection plays a vital role in computer vision, and lots of research have used different algorithms such as CNN or Convolutional Neural Network and its modified versions. In line with this, Redmon et al. (2016) introduced a new approach to object detection was introduced by Redmon et al. (2016). YOLO or You Only Look Once is a modified algorithm using a CNN single network. They described YOLO as the fastest general-purpose object detector, pushing the state-of-the-art in real-time object detection. Additionally, Lee and Kim (2020) compared CNN and YOLO algorithms in object detection regarding the accuracy, speed, and cost. They used YOLO to solve the problem of the CNN bounding box and discovered that the YOLO algorithm achieved a better performance in terms of speed and accuracy.

According to

Wang et al., 2021, YOLO is included with the family of techniques utilizing Case-Based Reasoning, which is implemented by the Darknet framework for YOLOv3. Image segmentation based on CBR has seen promising results in many aspects, such as choosing the appropriate image segmentation parameters/methods and providing feedback to the system during training to improve performance (Frucci et al., 2008). YOLO algorithm is one of the most advanced techniques in object detection. However, its accuracy is highly dependent on training, especially custom object detection. According to a study about mobile robot navigation using object recognition software and the YOLO algorithm, YOLO performs poorly with on-board processing. On the other hand, when they used a dedicated graphics card and CPU, they obtained a processing time of less than 0.5s per image (GPU-based) and 9.45s per image (CPU-based). This just proves that this type of technology requires good processing power as being equipped with graphic processing (Dos Reis et al., 2019).

Over the years, YOLO has been the go-to algorithm for object detection because of its speed. However, it was not considered the best in terms of accuracy. In response to this, Redmon and Farhadi (2018), who initially introduced the YOLO algorithm, made some changes and called it YOLOv3. A key advancement of this is that the Darknet, the framework used by YOLOv3, deepens the convolutional network capacity by adopting multi-scale features in a pyramid structure (Wang et al.). These improvements constitute multi-scale predictions, which, as shown in the figure below, are structured uniquely in Darknet53 in the Cased Based Reasoning. This CBR portion makes sense, as stated by Frucci et al. (2008), that systems using image segmentation benefit from CBR as it can apply to all aspects of image segmentation.

Figure 7 - YOLOv3 Prediction Network Structure



An additional advancement, YOLOv3 is bigger than the initial one but is also more accurate while retaining its speed. Some researchers tried applying YOLOv3 in face recognition and revealed that a detection method based on YOLOv3 obtained great performance on speed and accuracy (Li et al., 2019). Benjdira et al. (2019) compared the performance of Faster R-CNN and YOLOv3 in the context of car detection from aerial images. Results show that YOLOv3 outperforms Faster R-CNN in sensitivity and processing time. However, in terms of precision metrics, both state-of-the-art algorithms are comparable. Finally, YOLOv3 also produced great results in detecting colors, having recorded a 90.8% recall rate (fruit detection rate) when it was used in a machine vision system for detecting apples in orchards (Kuznetsova et al., 2020).

GrabCut

As reported by (C., V., A., 2004), GrabCut is the approach of using graph cuts to optimize image segmentation. The classical approaches before this are contextual background removal via texture (or color) information such as Magic Wand and edge (or contrast) information such as Intelligent Scissors. Under the field of computer vision, (OpenCV,2021) details the GrabCut algorithm's use in extracting foreground images by using a 'foreground rectangle' and strokes that signify which regions should be in the foreground rather than the background. This foreground extraction obtains foreground alpha mattes of good quality for moderately difficult images with a rather modest degree of user effort. The system combines hard segmentation by iterative graph-cut optimization with border matting to deal with blur and mixed pixels on object boundaries.

Following (C., V., A., 2004), the advanced analysis of GrabCut by (Talbot & Xu, 2006) recommends the usage of GrabCut for its very user-friendly tool base and robust results. They have noted the use of better approaches such as components number based on color complexity for future work. Another example would be the implementation made by Karasulu (2018), albeit using a Boltzmann Machine, which falls under RNN instead of CNN. The system testifies to be both preferable and usable due to GrabCut than standalone GF2T methods for image segmentation. This echo is in line with the statements of (Vela et al., 2012), in which the use of

GrabCut for human segmentation in video sequences is tested. They have concluded that the general and full-automatic human segmentation, pose recovery, and tracking methodology of GrabCut showed higher performance than classical approaches in public image sequences and a novel Human Limb dataset from uncontrolled environments, which makes it useful for general human face and gesture analysis applications.

Usage of YOLO and GrabCut for Image Segmentation

Using the YOLO and GrabCut algorithm for image segmentation is not a new technique. Ünver has developed it and Ayan (2019) in their article titled "Skin Lesion Segmentation in Dermoscopic Images with Combination of YOLO and GrabCut Algorithm." As the title suggests, the article shows how the usage of GrabCut for feature segmentation in an image has proven to be useful for developing computer-aided diagnostics (CAD) used by doctors to assist them in diagnosing diseases with visual symptoms; in their study's case, melanoma. According to Ünver and Ayan (2019), "The use of human vision alone for the detection of melanoma in dermoscopic images may be inaccurate, subjective, or irreproducible because it depends on the dermatologist's experience. Diagnostic accuracy of melanoma from the dermoscopic images by an inexperienced specialist is between 75% to 84%," which means developing the skin lesion segmentation system would prove to be significantly helpful.

There is only one problem with GrabCut. It is semi-automatic. GrabCut needs a user to input a bounding box that contains the object that is needed to be segmented, which is, in their case, skin lesions. Ünver and Ayan (2019) solved this problem using the YOLO algorithm for skin lesion detection. The combined usage of the YOLO and GrabCut algorithm helped their system achieve a performance of 93.39% in terms of accuracy.

Color Distance using RGB Data and Euclidean Distance

An article from CompuPhase (2019) titled "Colour Metric" showed that the Euclidean distance formula could be used to map and calculate the distance between two colors.

Equation 1 - Color Metric

$$||C_1 - C_2|| = \sqrt{(C_{1,R} - C_{2,R})^2 + (C_{1,G} - C_{2,G})^2 + (C_{1,B} - C_{2,B})^2}$$

The formula above shows how the distance can be calculated where C1 is the first color, C2 is the second color, R is the red channel, B is the blue channel, and G is the green channel. The researchers utilize this formula in developing the freshness framework by calculating the distance between the color of the gill of the freshest tilapia sample and the color of the gill of a tilapia sample and using that distance as a basis of how fresh the tilapia sample is since as a fish gets less fresh by time, the more its gills lose its color. This idea was inspired by the paper of Negi et al. (2019) titled "An Effective Technique for Determining Fish Freshness using Image Processing. *International Journal of Innovative Technology and Exploring Engineering,*" where they used the variance of a common carp and a curled gill gold fish's gill color uniformity over nine days.

Synthesis of Related Literature

The related literature gathered and read by the researchers shows the relevance of this study for fish and fish product consumers, particularly colorblind consumers. As illustrated by (Karagoz, 2002), using digital image processing techniques is relevant for tackling problems related to analyzing images, such as fish freshness. Development of programs in the field of computer vision that deals with these image processing techniques are also indispensable, as stated by (Navotas et al., 2018), and conventional methods of determination can lead to inaccuracy and false assessments. Various tools in the field of computer vision fit this bill, including GrabCut and YOLOv3. The literature gathered also helped the researchers identify an important flaw in David and Reyes' (2017) study; they only extracted and used the red color channel on their feature extraction, which affected the accuracy of their system. This discovery will help the researchers in developing their system. In line with this, the research of Ünver and Ayan (2019) has given this study a solid foundation with their usage of YOLO and GrabCut for image segmentation. This study would significantly help expand the knowledge of this segmentation method.

Chapter 3

METHODOLOGY

Research Design

For this study, the researchers decided to use the Experimental Research Design. The reason for choosing the Experimental Design is to determine the accuracy of using the YOLOv3 and GrabCut algorithm in determining the freshness of a tilapia fish by the color of its gill and determine the difference in the results to the System of David and Reyes (2017) and possibly other systems in the future.

Sources of Data

Several tilapia fishes were bought from local vendors to find data for testing accuracy. These fishes had their picture taken with their gills exposed in a well-lit environment. The pictures were shown to fish experts, and the researchers listed the expert's freshness evaluation of each fish according to the same freshness levels; this is the basis for finding the accuracy to answer the research question.

The pictures of the tilapia fish that were used in training and data gathering for experimentation were taken with an iPhone 7 Plus phone with a dual 12-megapixel camera with the following settings:

a. Exposure time: 1/15 sec
b. ISO speed: 80
c. Focal length: 3.99 mm
d. F-stop: f/1.8

The environment where the pictures were taken is lit under a white LED bar light with a distance of 60 cm between the light source and the fishes. The distance between the camera and the fish when the pictures were taken was ~20 cm.

Research Instrument

This research used an experiment paper to gather relevant data to answer the research questions. The data written in the experiment paper was used to answer the research question, which asks to find the system's accuracy compared to the freshness evaluation of experts.

Software Development Tools

The following were used for the development of the system:

Python. The researchers mainly used Python as their programming language to develop the system using OpenCV.

OpenCV. OpenCV is a huge open-source library for computer vision, machine learning, and image processing.

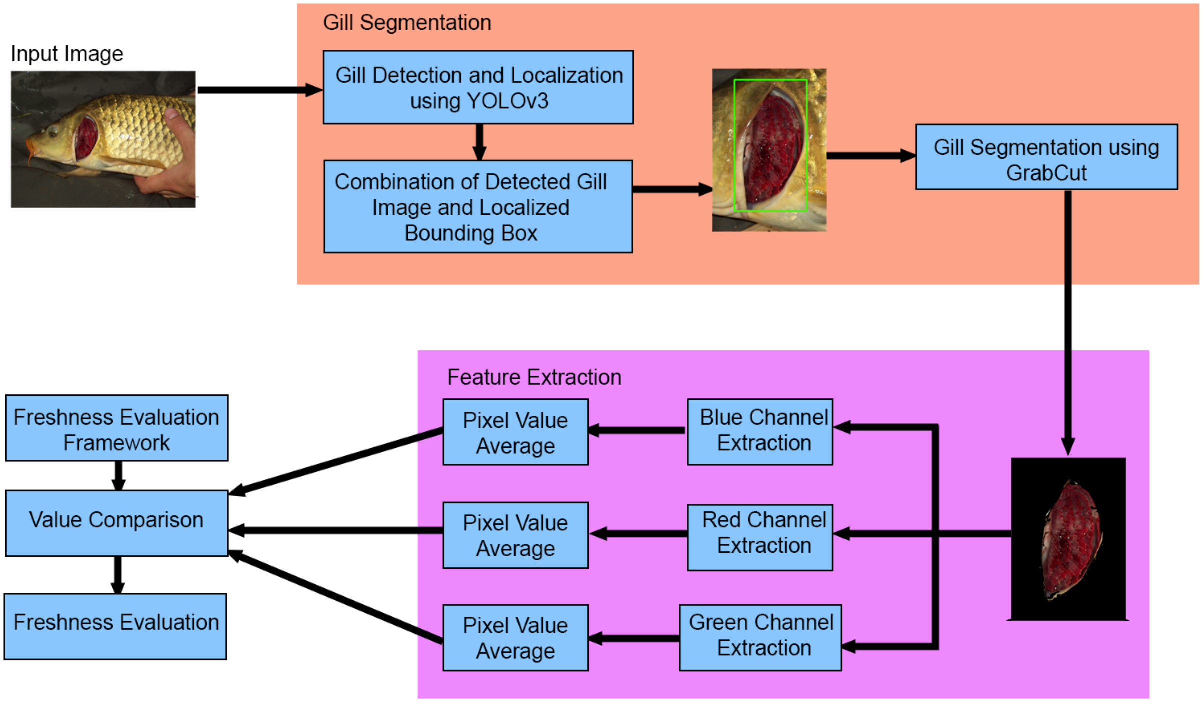
Darknet. Darknet is an open-source neural network framework written in C and CUDA. This is considered essential in using the YOLO algorithm.

Camera. This was used for data collection. The camera specification is an iPhone 7 plus, with Dual 12MP wide-angle and telephoto cameras

Google Colab. Google Colab is Google's free cloud service for AI developers and is used to develop and train deep learning models on GPUs for free.

System Architecture

Figure 8 - System Architecture



Shown in Figure 8 is the system architecture for this study. For the system to evaluate the freshness of a tilapia fish. An image of the fish with its gill exposed in a well-lit environment will be used as an input to the system. Using YOLOv3, the system will then try to detect the location of the fish's gill in the image and use a bounding box to show its detected location. A combination of the image and the bounding box will then be used as an input for the GrabCut algorithm, which will segment the gill from the rest of the image. This image segmentation technique has been adapted from the study of Ünver and Ayan (2019). After segmentation, the average value of the image's RGB channels will be compared to the values in the freshness evaluation framework so that the system can determine the fish's freshness which will then be outputted as the system's freshness evaluation.

Data Generation/Gathering Procedure

For training the system, the researchers generated their own data set. To achieve this, three live tilapia fishes were gathered and observed. Upon the death of the tilapia, their gills were exposed and taken a picture in a well-lit environment and then stored back in a fridge. This was repeated daily to all the tilapia fish until the fish's gills turned brown/grey and bleached in color, indicating that the fish was now old and unfit for consumption. The pictures taken were used to build a freshness evaluation framework used by the system to evaluate the freshness level of the fish.

For finding the sample size, the researchers used the formula of the infinite population as stated in the article (BYJUS, 2021). The formula is as follows:

Equation 2 - Formula for Infinite Population

$$SS = \frac{[Z^2 \ p\ (1 - p)]}{C^2}$$

Where *SS* stands for sample size, *Z* is the given Z value, *C* is the Confidence level, and *p* is for the percentage of the population. The researchers have chosen a 90% confidence interval and 9 percentage points for the level of precision provided to the confidence level. These values yielded a sample size larger than the previous research while still retaining a conservative amount that can be handled during the study's time. This resulted in 83.01 or 83 pictures of tilapia fishes as a sample size.

Equation 3 - Sample Size Equation

$$SS = \frac{[1.64^2 \ * 0.5\ (1 - 0.5)]}{0.09^2} = 83.01$$

For experimenting, 83 tilapia fish images were gathered. Each of these was categorized into one of the three freshness levels: Fresh, Not Fresh, or Old. Each fish has its gills exposed and taken a picture in a well-lit environment. The picture was inputted in the proposed system, as the previous System of David and Reyes (2017) developed using their system architecture so both systems can output a freshness level evaluation.

The evaluation of the system was compared to the freshness level assessment of experts to find the system's accuracy. Please refer to Appendix 1 to show how the data collected from the system's evaluation was used and the comparisons mentioned.

Statistical Data Analysis

To answer the first question in the problem statement, the following formula was used to determine the system's accuracy compared to the freshness evaluation of experts.

Equation 4 - Freshness Evaluation Accuracy

$$Accuracy = \frac{number\ of\ correct\ freshness\ evaluation}{number\ of\ evaluated\ fish}\ x\ 100$$

After the system's accuracy had been computed, the result was compared to the accuracy of the previous system using the table below. This tells us which of the two systems has higher accuracy.

Systems	Accuracy
Proposed System	
Previous System	

Table 2. Table Showing the Comparison of the two Systems in Terms of Accuracy

Paired t-test was used to answer the second research problem and test the hypothesis of the research. In calculating for the P-value, the value of the significance level used is 0.05.

Chapter 4

RESULTS AND DISCUSSION

This chapter will discuss the results of the experiment performed by the researchers and how these results will answer the research questions presented in Chapter 1.

To answer the research question, "What is the accuracy of the systems in determining the freshness of the tilapia fish compared to the freshness evaluation of experts? Which of the two systems is more accurate in evaluating the freshness of the tilapia fish?" the two tables below present the data gathered from the experiment.

Proposed System	Fresh	Not Fresh	Old
Total Number of Test Cases	30	34	19
Total Number of Test Cases Correctly Determined by the System	23	24	15
Accuracy Rate per Freshness Category	76.67%	70.59%	78.95%
Total Matches / Accuracy	62 Correct Matches / 74.7%		

Table 3 – Findings from the Experiment Paper of the Proposed System

After experimenting using the proposed system, the researchers found that out of 83 test cases, the proposed system had made 62 matching evaluations with the expert. This means that the accuracy of the proposed system is 74.7%. The formula for the accuracy is shown below:

Equation 5 – Proposed System Accuracy Computation

$$74.7\% = \frac{62}{83}\ x\ 100$$

Previous System	Fresh	Not Fresh	Old
Total Number of Test Cases	30	34	19
Total Number of Test Cases Correctly Determined by the System	21	23	15
Accuracy Rate per Freshness Category	70%	67.65%	78.95%
Total Matches / Accuracy	59 Correct Matches / 71.08%		

Table 4 - Findings from the Experiment Paper of the Previous System

After experimenting using the previous system, the researchers found out that out of the same 83 test cases used for the experiment on the proposed system, the previous system had made 59 matching evaluations with the expert. This means that the accuracy of the previous system is 71.08%. The formula for the accuracy is shown below:

Equation 6 – Previous System Accuracy Computation

$$71.08\% = \frac{59}{83}\ x\ 100$$

The data can be further explored by showing how accurately both systems performed in each freshness category and what they mean. The matrix below shows the breakdown of the performance of both systems in each freshness category.

Proposed System	System Evaluation per Freshness Category		
Expert Evaluation per Freshness category	Fresh	Not Fresh	Old
Fresh - 30	23	6	1
Not Fresh - 34	10	24	0
Old - 19	0	4	15

Table 5 - Proposed System Data Breakdown Matrix

In table 5, the system evaluation per freshness category is shown on the x-axis of the table, with the actual freshness evaluation done by the expert shown on the y-axis. The cells marked in green are the correct evaluation per the freshness category of the system shown. The same has been done for table 6, illustrated below.

Previous System	System Evaluation per Freshness Category		
Expert Evaluation per Freshness category	Fresh	Not Fresh	Old
Fresh - 30	21	7	2
Not Fresh - 34	11	23	0
Old - 19	2	2	15

Table 6 - Previous System Data Breakdown Matrix

Exploring the data shown by the tables above, the correct evaluations per category of fresh, not fresh, and old can be seen in green. The proposed system has shown a higher accuracy for the fresh category, with the proposed system having 76.67% accuracy than the previous system with 70%. The same can be said for the not fresh freshness category. The proposed system achieved 70.59%, against the previous system with 67.65%. Both systems have the same accuracy for the old category of 78.95%.

In examining the proposed system's evaluation in table 5, most of the system evaluation, both correct and incorrect, is skewed toward the not fresh category with 34 evaluations. As shown in Table 5, out of all 34 of the majority evaluations of the proposed system, 70.59% are correct. As for the previous system in table 6, most evaluations are skewed toward the fresh category. Out of all 34 of the majority evaluations of the previous system, 61.76% are correct.

In an analysis of both systems' incorrect evaluations, the proposed system had 7 evaluations as its highest incorrect count. Both are designating fresh and not fresh to an old evaluation of expert, as shown in table 5. This is lower than the previous system, with 13 incorrect not a fresh evaluations for the old evaluation of the expert and 8 incorrect not fresh evaluations for the fresh evaluation of the expert.

Systems	Accuracy
Proposed System	74.7%
Previous System	71.08%

Table 7 - Table of Comparison of the Results of the Two Systems in Terms of Accuracy

Using the findings from the first research question, the paired t-test was used to calculate for the p-value. The results of the test is shown below:

Table 8 – Paired T-test Results

	Previous System	*Proposed System*
Mean	20.66666667	19.66666667
Variance	24.33333333	17.33333333
df	2	
t Stat	1.732050808	
P(T<=t) two-tail	0.225403331	
t Critical two-tail	4.30265273	

As shown from the table above, the P-value is 0.255. Since the P-value is higher than the significance value, which is 0.05, the null hypothesis will be accepted. This means that there is no significant value between the accuracy of the proposed and previous system.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Findings

As stated in Chapter 1, the study seeks to answer this research question regarding the accuracy of the two systems:

1. What is the accuracy of the systems in determining the freshness of the tilapia fish compared to the freshness evaluation of the fish expert? Which of the two systems is more accurate in evaluating the freshness of the tilapia fish?
   a. The proposed system using the YOLOv3 and GrabCut algorithm for segmentation and all three RGB color channels for feature extraction produced an accuracy of 69.88%. The system produced 76.67% accuracy in the Fresh category, 70.59% in the Not Fresh category, and 78.95% in the Old category.
   b. The previous system using the thresholding and morphological close operation for segmentation and the red color channel for feature extraction produced an accuracy of 71.08%. The system produced 70% accuracy in the Fresh category, 67.65% in the Not Fresh category, and 78.95% in the Old category.
2. Is there a significant difference between the accuracy of the proposed system and the previous system in determining the freshness of a tilapia fish?

   With the calculated P-value of 0.255 being higher than the significance level of 0.05 using Paired t-test, the researchers have determined that there is no significant difference between the accuracy of the two systems.

Conclusions

After analyzing the data gathered from the experiment and further analysis of both systems' concepts and architecture, the researchers have the following conclusions:

The proposed system has proven to be more accurate than the previous system. Despite the accuracy of the proposed system being higher than the previous system, the paired t-test have determined that there is no significant difference between the accuracy of the two systems. This means that the two systems may be tested in other areas such as system speed, reliability in producing consistent outputs using the same input, etc., to find out which of the two systems is better.

While examining both systems post-experimentation, the researchers have determined a common fault in the feature extraction technique of both systems. That faut uses the RGB color space on both systems for their feature extraction because the RGB color space does not separate the luminosity or lightness of an image from its actual perceived color. The RGB color space does not have a separate channel for determining the lightness of a color. This means that even a small difference in a few images' lighting environment can cause a huge variation between their average RGB values, which can then affect the framework's accuracy.

Recommendations

The researchers have listed the following recommendations for future research:

1. Consider testing both systems in other areas besides accuracy to find out which of the two systems performs better. The following areas can be used:

    a. Specificity (Unver & Ayan, 2019) - testing if either system's image segmentation techniques can segment the tilapia fish's gill better than the other.

    b. Reliability (David & Reyes, 2017) – testing whether either system can produce a more consistent output than the other by using the same input multiple times.

    c. speed - testing if either system can produce output faster than the other.

2. Use a different color space for the feature extraction method that separates the lightness or luminosity of color in a different channel, a feature that the RGB color space does not have. The following color spaces can be used:

a. The HSV color space has the Hue, Saturation, and Value channels. This color space separates the lightness of color using the V (Value) channel (Karagoz, 2013).

b. The Lab color space has the L (Luminosity), a (red-green), and b (blue-yellow) channels. This color space separates the lightness of color using the L (Luminosity) channel (Ly et al., 2020).

3. Consider testing both systems on different fish species aside from tilapia and see if the findings would differ. In the study of Negi et al. (2019), they used a Common Carp and a Curled Gill Goldfish in their experiment where they tried to quantify the freshness of both fish and how the quantified freshness of the fishes changes as each day passes. They found that different fish species have a different rate of increased fish freshness value as each day passes. This finding can be a foundation for a study on how much the accuracy of the Fish Freshness Evaluation System varies on different fish species.
4. Consider using a different part of the fish to determine the freshness of a fish in conjunction with the fish gills. Using multiple parts of a fish that can indicate its freshness together can increase the system's accuracy in determining a fish's freshness. According to the World Health Organization and Food and Agriculture Organization (2020), the other parts of the fish that can be used to determine the freshness of a fish aside from the gills are the eyes, skin, and odor of the fish. Not including the odor in the choice is advisable if the system only uses image processing.

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Appendices

Appendix 1. Instrumentation

1. Experiment Paper for System Accuracy as Compared to Experts' Freshness Evaluation

Test Case	System's Freshness Evaluation	Expert's Freshness Evaluation	Evaluation Match
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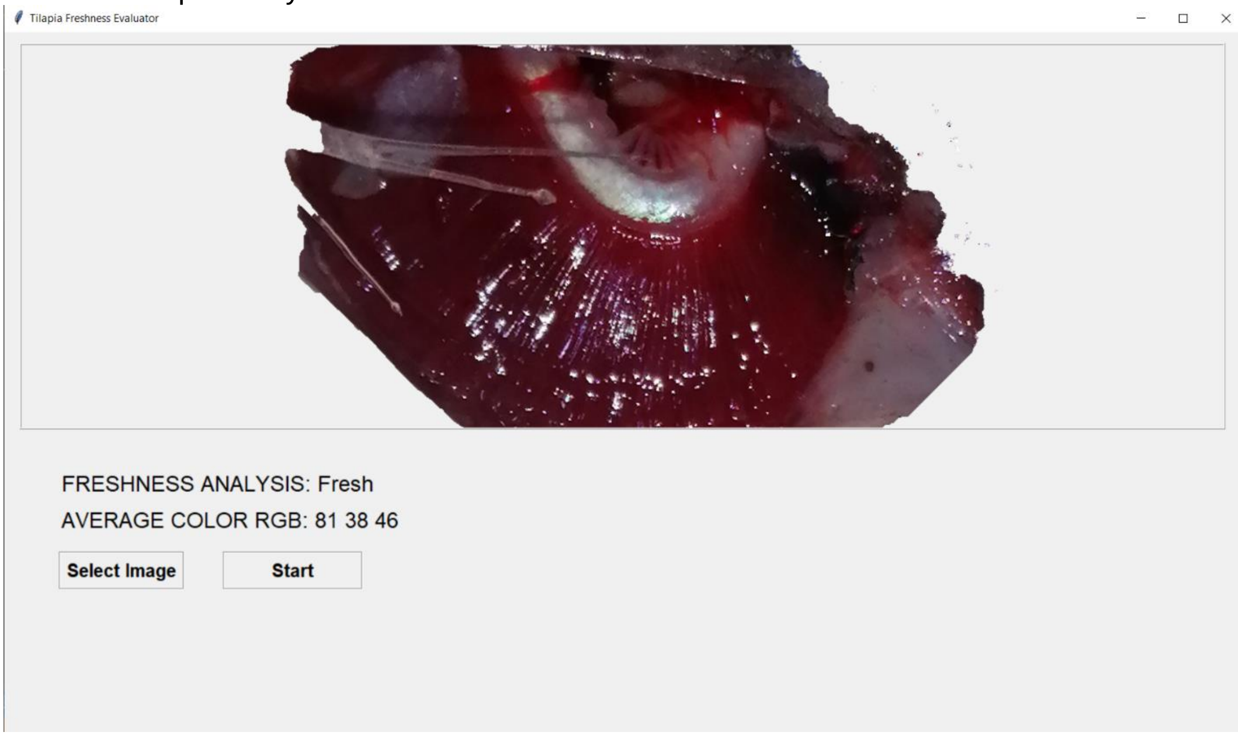
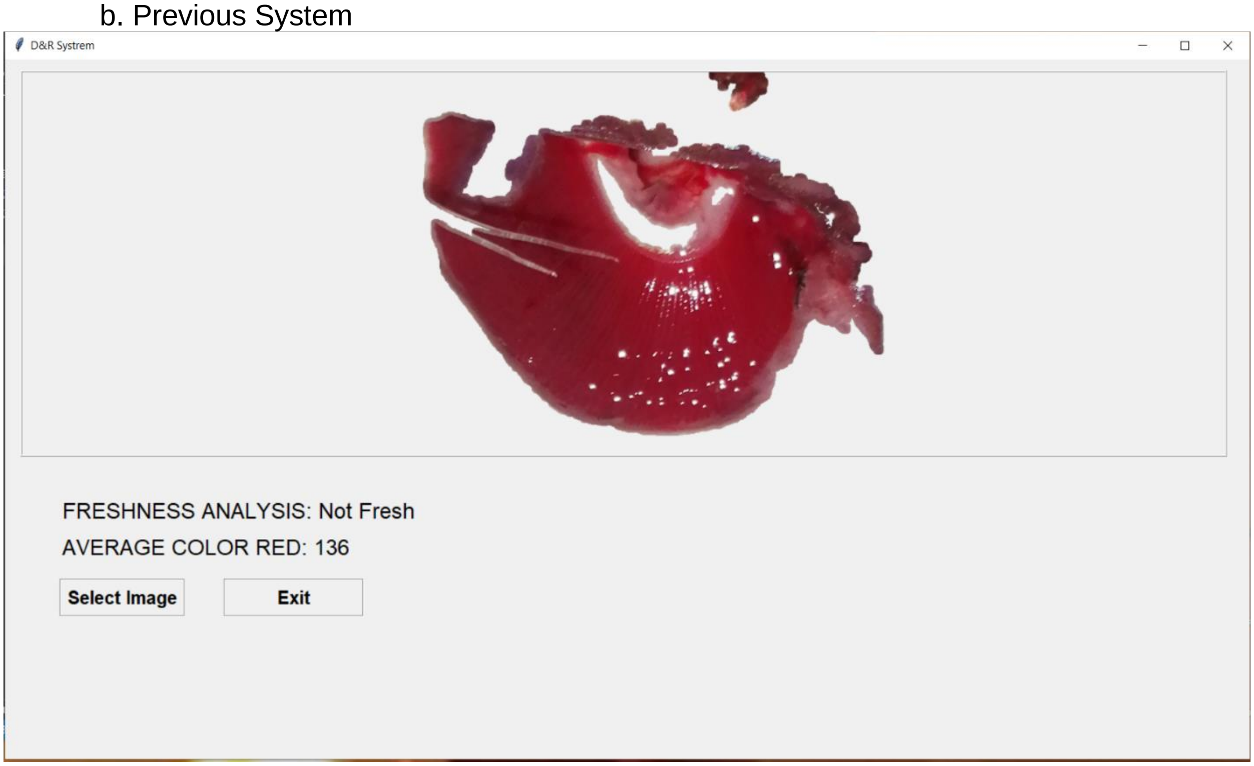
83			
		Total:	

2. Tool Snapshot

a. Proposed System



b. Previous System



Appendix 2. Dataset Validation

I, Teresita Alvaran, have examined thoroughly and/or have given changes to the Freshness Framework Dataset that is to be used by the Group 6 of BSCS 4-1. Let this paper be the proof that I have validated the dataset and have given the approval for this dataset to be used for developing the Freshness Framework for the system on the 13th day of December 2021.

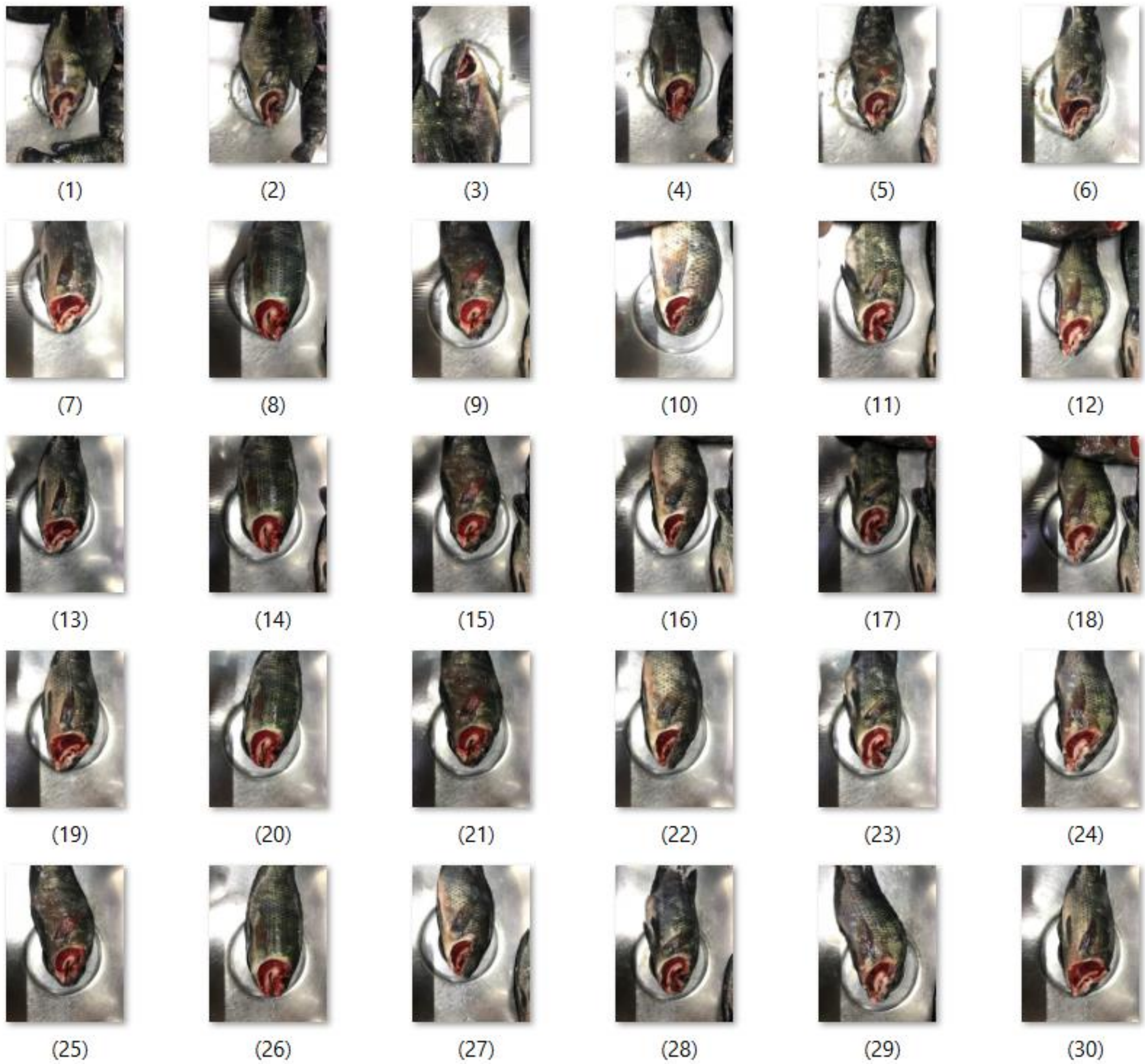
Alvaran

Teresita Alvaran,

Fish Expert of the study

Appendix 3. Experiment Dataset

FRESH



NOT FRESH


(31)

(32)

(33)

(34)

(35)

(36)

(37)

(38)

(39)

(40)

(41)

(42)

(43)

(44)

(45)

(46)

(47)

(48)

(49)

(50)

(51)

(52)

(53)

(54)

(55)

(56)

(57)

(58)

(59)

(60)

(61)

(62)

(63)

(64)

OLD


(65)


(66)


(67)


(68)


(69)


(70)


(71)


(72)


(73)


(74)


(75)


(76)


(77)


(78)


(79)


(80)

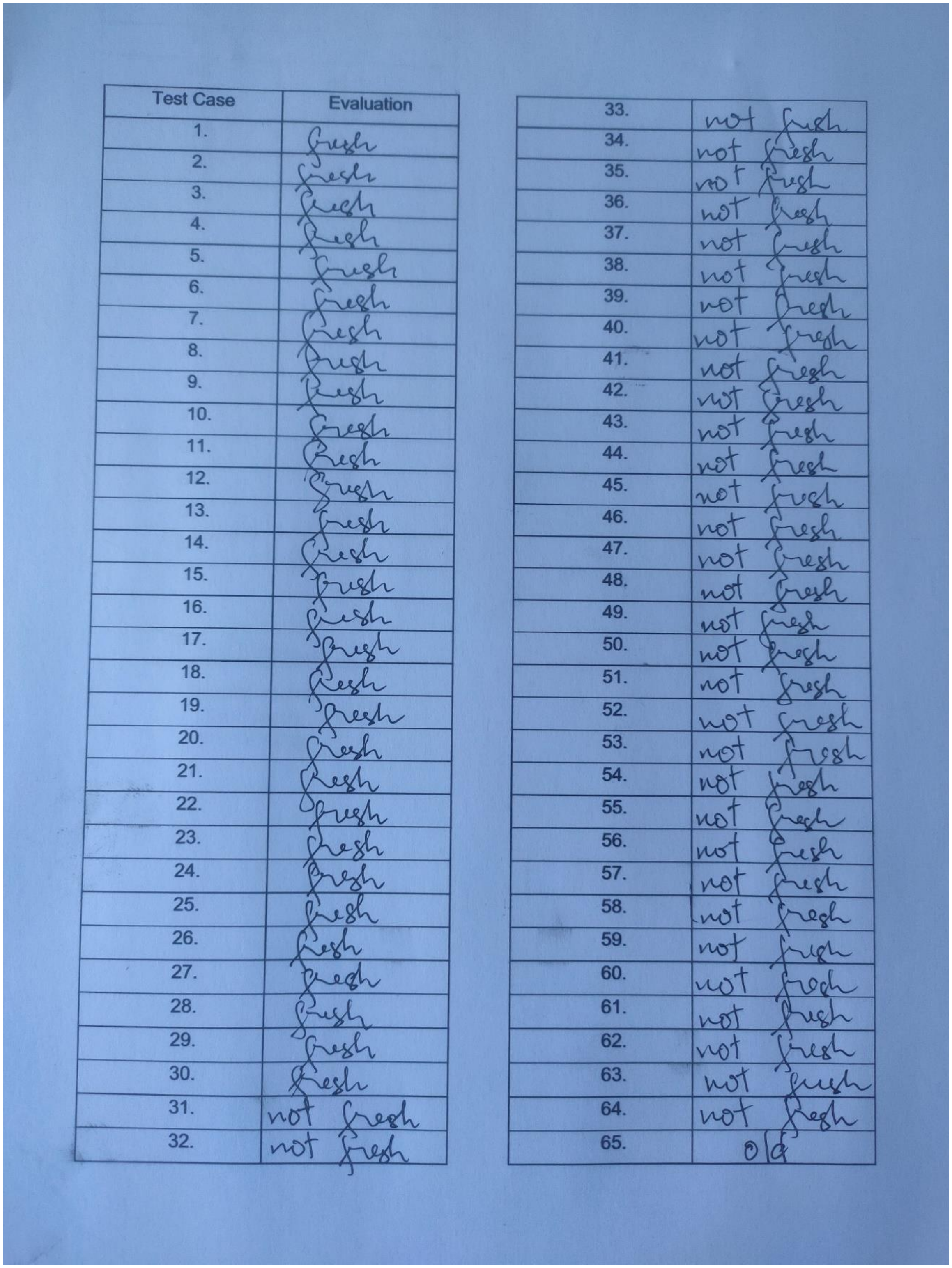

(81)


(82)


(83)

Appendix 4. Raw data

1. Fish Expert Evaluation Paper



Test Case	Evaluation
1.	fresh
2.	fresh
3.	fresh
4.	fresh
5.	fresh
6.	fresh
7.	fresh
8.	fresh
9.	fresh
10.	fresh
11.	fresh
12.	fresh
13.	fresh
14.	fresh
15.	fresh
16.	fresh
17.	fresh
18.	fresh
19.	fresh
20.	fresh
21.	fresh
22.	fresh
23.	fresh
24.	fresh
25.	fresh
26.	fresh
27.	fresh
28.	fresh
29.	fresh
30.	fresh
31.	not fresh
32.	not fresh
33.	not fresh
34.	not fresh
35.	not fresh
36.	not fresh
37.	not fresh
38.	not fresh
39.	not fresh
40.	not fresh
41.	not fresh
42.	not fresh
43.	not fresh
44.	not fresh
45.	not fresh
46.	not fresh
47.	not fresh
48.	not fresh
49.	not fresh
50.	not fresh
51.	not fresh
52.	not fresh
53.	not fresh
54.	not fresh
55.	not fresh
56.	not fresh
57.	not fresh
58.	not fresh
59.	not fresh
60.	not fresh
61.	not fresh
62.	not fresh
63.	not fresh
64.	not fresh
65.	old

66.	old
67.	old
68.	old
69.	old
70.	old
71.	old
72.	old
73.	old
74.	old
75.	old
76.	old
77.	old
78.	old
79.	old
80.	old
81.	old
82.	old
83.	old

Alvaran

Teresita Alvaran,
Fish Expert
for the study

2. Proposed System's Experiment Paper

Test Case	Proposed System's Freshness Evaluation	Expert's Freshness Evaluation	Evaluation Match
1	Fresh	Fresh	CORRECT
2	Fresh	Fresh	CORRECT
3	Fresh	Fresh	CORRECT
4	Fresh	Fresh	CORRECT
5	Not Fresh	Fresh	INCORRECT
6	Fresh	Fresh	CORRECT
7	Fresh	Fresh	CORRECT
8	Fresh	Fresh	CORRECT
9	Not Fresh	Fresh	INCORRECT
10	Fresh	Fresh	CORRECT
11	Not Fresh	Fresh	INCORRECT
12	Fresh	Fresh	CORRECT
13	Fresh	Fresh	CORRECT
14	Fresh	Fresh	CORRECT
15	Fresh	Fresh	CORRECT
16	Not Fresh	Fresh	INCORRECT
17	Fresh	Fresh	CORRECT
18	Not Fresh	Fresh	INCORRECT
19	Fresh	Fresh	CORRECT
20	Fresh	Fresh	CORRECT
21	Fresh	Fresh	CORRECT
22	Fresh	Fresh	CORRECT
23	Fresh	Fresh	CORRECT
24	Old	Fresh	INCORRECT
25	Fresh	Fresh	CORRECT
26	Fresh	Fresh	CORRECT
27	Fresh	Fresh	CORRECT
28	Fresh	Fresh	CORRECT
29	Not Fresh	Fresh	INCORRECT
30	Fresh	Fresh	CORRECT
31	Fresh	Not Fresh	INCORRECT
32	Fresh	Not Fresh	INCORRECT
33	Not Fresh	Not Fresh	CORRECT
34	Not Fresh	Not Fresh	CORRECT
35	Fresh	Not Fresh	INCORRECT
36	Not Fresh	Not Fresh	CORRECT
37	Fresh	Not Fresh	INCORRECT
38	Not Fresh	Not Fresh	CORRECT
39	Not Fresh	Not Fresh	CORRECT
40	Fresh	Not Fresh	INCORRECT
41	Fresh	Not Fresh	INCORRECT
42	Not Fresh	Not Fresh	CORRECT

43	Not Fresh	Not Fresh	CORRECT
44	Fresh	Not Fresh	INCORRECT
45	Not Fresh	Not Fresh	CORRECT
46	Not Fresh	Not Fresh	CORRECT
47	Not Fresh	Not Fresh	CORRECT
48	Not Fresh	Not Fresh	CORRECT
49	Fresh	Not Fresh	INCORRECT
50	Not Fresh	Not Fresh	CORRECT
51	Not Fresh	Not Fresh	CORRECT
52	Not Fresh	Not Fresh	CORRECT
53	Not Fresh	Not Fresh	CORRECT
54	Not Fresh	Not Fresh	CORRECT
55	Not Fresh	Not Fresh	CORRECT
56	Not Fresh	Not Fresh	CORRECT
57	Fresh	Not Fresh	INCORRECT
58	Not Fresh	Not Fresh	CORRECT
59	Not Fresh	Not Fresh	CORRECT
60	Not Fresh	Not Fresh	CORRECT
61	Not Fresh	Not Fresh	CORRECT
62	Not Fresh	Not Fresh	CORRECT
63	Fresh	Not Fresh	INCORRECT
64	Not Fresh	Not Fresh	CORRECT
65	Old	Old	CORRECT
66	Not Fresh	Old	INCORRECT
67	Old	Old	CORRECT
68	Old	Old	CORRECT
69	Old	Old	CORRECT
70	Old	Old	CORRECT
71	Old	Old	CORRECT
72	Old	Old	CORRECT
73	Old	Old	CORRECT
74	Old	Old	CORRECT
75	Old	Old	CORRECT
76	Not Fresh	Old	INCORRECT
77	Old	Old	CORRECT
78	Old	Old	CORRECT
79	Old	Old	CORRECT
80	Not Fresh	Old	INCORRECT
81	Old	Old	CORRECT
82	Old	Old	CORRECT
83	Not Fresh	Old	INCORRECT
		Total:	62

3. Previous System's Experiment Paper

Test Case	Previous System's Freshness Evaluation	Expert's Freshness Evaluation	Evaluation Match
1	Not Fresh	Fresh	INCORRECT
2	Fresh	Fresh	CORRECT
3	Fresh	Fresh	CORRECT
4	Fresh	Fresh	CORRECT
5	Fresh	Fresh	CORRECT
6	Not Fresh	Fresh	INCORRECT
7	Fresh	Fresh	CORRECT
8	Fresh	Fresh	CORRECT
9	Old	Fresh	INCORRECT
10	Fresh	Fresh	CORRECT
11	Not Fresh	Fresh	INCORRECT
12	Old	Fresh	INCORRECT
13	Not Fresh	Fresh	INCORRECT
14	Fresh	Fresh	CORRECT
15	Fresh	Fresh	CORRECT
16	Fresh	Fresh	CORRECT
17	Fresh	Fresh	CORRECT
18	Fresh	Fresh	CORRECT
19	Fresh	Fresh	CORRECT
20	Fresh	Fresh	CORRECT
21	Fresh	Fresh	CORRECT
22	Fresh	Fresh	CORRECT
23	Fresh	Fresh	CORRECT
24	Not Fresh	Fresh	INCORRECT
25	Fresh	Fresh	CORRECT
26	Fresh	Fresh	CORRECT
27	Fresh	Fresh	CORRECT
28	Fresh	Fresh	CORRECT
29	Not Fresh	Fresh	INCORRECT
30	Not Fresh	Fresh	INCORRECT
31	Fresh	Not Fresh	INCORRECT
32	Not Fresh	Not Fresh	CORRECT
33	Fresh	Not Fresh	INCORRECT
34	Not Fresh	Not Fresh	CORRECT
35	Fresh	Not Fresh	INCORRECT
36	Fresh	Not Fresh	INCORRECT
37	Fresh	Not Fresh	INCORRECT
38	Not Fresh	Not Fresh	CORRECT
39	Not Fresh	Not Fresh	CORRECT
40	Not Fresh	Not Fresh	CORRECT
41	Fresh	Not Fresh	INCORRECT
42	Fresh	Not Fresh	INCORRECT

43	Not Fresh	Not Fresh	CORRECT
44	Not Fresh	Not Fresh	CORRECT
45	Not Fresh	Not Fresh	CORRECT
46	Not Fresh	Not Fresh	CORRECT
47	Fresh	Not Fresh	INCORRECT
48	Not Fresh	Not Fresh	CORRECT
49	Not Fresh	Not Fresh	CORRECT
50	Not Fresh	Not Fresh	CORRECT
51	Not Fresh	Not Fresh	CORRECT
52	Fresh	Not Fresh	INCORRECT
53	Fresh	Not Fresh	INCORRECT
54	Not Fresh	Not Fresh	CORRECT
55	Not Fresh	Not Fresh	CORRECT
56	Not Fresh	Not Fresh	CORRECT
57	Not Fresh	Not Fresh	CORRECT
58	Fresh	Not Fresh	INCORRECT
59	Not Fresh	Not Fresh	CORRECT
60	Not Fresh	Not Fresh	CORRECT
61	Not Fresh	Not Fresh	CORRECT
62	Not Fresh	Not Fresh	CORRECT
63	Not Fresh	Not Fresh	CORRECT
64	Not Fresh	Not Fresh	CORRECT
65	Not Fresh	Old	INCORRECT
66	Old	Old	CORRECT
67	Old	Old	CORRECT
68	Fresh	Old	INCORRECT
69	Old	Old	CORRECT
70	Old	Old	CORRECT
71	Old	Old	CORRECT
72	Fresh	Old	INCORRECT
73	Old	Old	CORRECT
74	Old	Old	CORRECT
75	Not Fresh	Old	INCORRECT
76	Old	Old	CORRECT
77	Old	Old	CORRECT
78	Old	Old	CORRECT
79	Old	Old	CORRECT
80	Old	Old	CORRECT
81	Old	Old	CORRECT
82	Old	Old	CORRECT
83	Old	Old	CORRECT
		Total:	59

Appendix 5: Certificate of Editing

EDITORIAL CERTIFICATE

This document certifies that the thesis paper listed below was edited for English language, grammar, punctuation, spelling, and overall style by MARVIN DOMINIC B. BUENA, Learning Experience Designer, Southeast Asian Minister of Education Organizations Regional Center for Innovation and Technology (SEAMEO-INNOTECH), Diliman, Quezon City

Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction

AUTHOR:

Cortez, John Elway P.

Obispo, Dustin Uriel V.

Sanchez, King Red M.

Viola, Briel Aldous M.

DATE ISSUED:

July 12, 2022

With the issuance of this certification, the editor waives any right to publish or reproduce this thesis paper without the author's consent.

MARVIN DOMINIC B. BUENA, Ph.D.(cand.),MA,LPT

Editor

Appendix 6. Biographical Statement

John Elway P. Cortez is a fourth-year graduating student at Polytechnic University of the Philippines with a Bachelor of Science in Computer Science (BSCS). He is well-versed in programming languages such as Java, PHP, and JavaScript, as frameworks such as Laravel and Vue. He knows object-oriented programming, data structures, and algorithm concepts. He is eager to broaden his knowledge and experience through communication and collaboration.

Dustin Uriel V. Obispo, born on October 31, is a fourth-year Bachelor of Science in Computer Science student in Polytechnic University of the Philippines. He lives in Antipolo City and is an athlete for the College of Computer and Information Sciences. He is knowledgeable in programming and scripting languages such as C++, JAVA, PHP, and MySQL. His interests include Database management and server-side development.

King Red M. Sanchez is a fourth-year graduating student from Polytechnic University of the Philippines at the time of writing the study, under the Bachelor of Science in Computer Science program. He has a fascination of problem solving and an interest with software development. He is knowledgeable with various tools such Microsoft Office 365, and programming languages such as C, Java, Python, PHP, MySQL, among others. He is pursuing his interests in puzzle solving and producing creative solutions using software development.

Briel Aldous M. Viola is a fourth-year graduating student of Bachelor of Science in Computer Science from the Polytechnic University of the Philippines. He knowledgeable in programming languages such as C and Java, basic knowledge in front-end and back-end web development using PHP and JavaScript. He is also honing his skills in non-photorealistic 3D modeling using Blender.

Appendix 7. Implementation Report

Introduction

The study of Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction contains the development of a Windows-based application that helps the user identify the quality of a tilapia fish in three different categories: Fresh, Not Fresh, and Old using the gill of a tilapia fish. The user will input an image of a tilapia fish with its gill exposed and the system will output the freshness evaluation of the fish.

Problem Statement

This study aims to determine if the proposed system can perform more accurately than the previous System of David and Reyes (2017) in evaluating the freshness of a tilapia fish.

1. What is the accuracy of the two systems in determining the freshness of a tilapia fish compared to the freshness evaluation of experts?

2. What is the difference in the accuracy between the two systems in determining the freshness of a tilapia fish?

Respondents/Subjects

The researchers calculated that they would need 83 tilapia image samples to execute the experiment. The samples were gathered, and the fish expert evaluated each fish into the three categories: Fresh, Not Fresh and Old. The samples were then used as inputs for the proposed System and previous System so that they can output their evaluation of each sample.

Implementation Procedures

The researchers followed these steps during the implementation of the experiment:

- The researchers gathered 83 tilapia fish sample images that they acquired from fish vendors

- Each of the samples are shown to the fish expert and their evaluation on each image are recorded

- Same samples are then used as inputs and then fed to the proposed System and the previous System

- The output of both system on each sample are then compared to the evaluation of the fish expert

- If the System's output on a particular sample matched with the evaluation of the fish expert, then that evaluation of that system is labelled as CORRECT. Otherwise, the evaluation is labelled as INCORRECT

- The previous step is repeated on all the samples

- After the evaluation matching step, each System's CORRECT evaluation is counted and then used to calculate the accuracy of both systems.

- The difference on the accuracy of both system is then calculated.

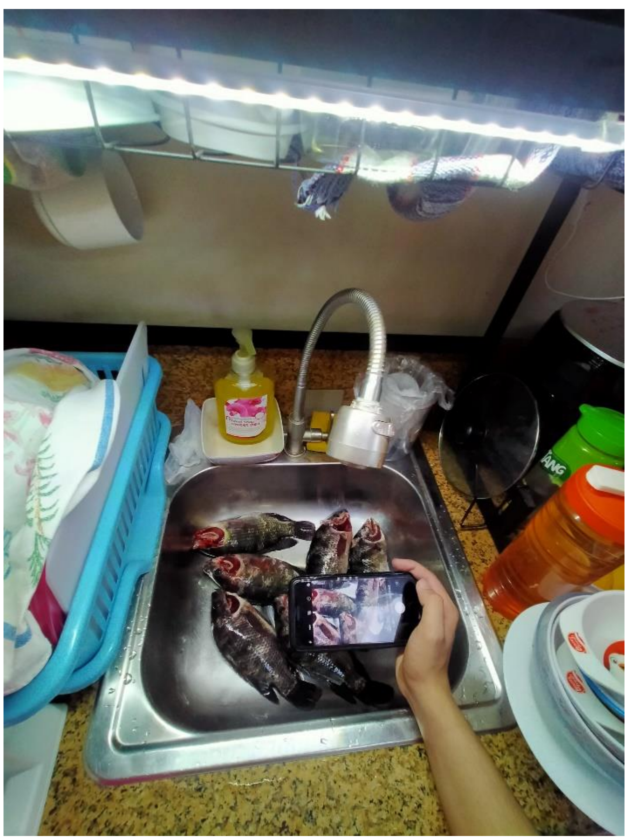
Time Frame

Activities	1st Week	2nd Week	3rd Week	4th
Thesis Tool Final Defense				
Finalization of Experimentation Procedure				
Implementation				
Computation of Gathered Data				

Activities	5th Week	6th Week	7th Week	8th Week
Draft of Chapter 4 and Chapter 5				
Paper Revisions				
Tool Debugging				
Paper Revisions				

Activities	9th Week	10th Week	10th Week	11th week
Mock Defense				
Final Defense				

Proof of Implementation

Issues and Concern

The main issue encountered during the implementation phase was the pixel value averaging algorithm used by the researchers does not produce the average color channel values of the segmented image correctly. This is because the first averaging algorithm includes transparent pixels in the calculation. This was immediately resolved by recoding the algorithm so that the system will only use the pixels of the segmented image to calculate the average pixel value.

Some inevitable issues have been encountered with regards to the timeframe the study was conducted. The necessary resources, both monetary and time, have been in great fluctioations the duration of the study. the creation of the software supposedly on the summer has to be limited with the researchers varying schedules due to mandatory OJT. The prices of fresh tilapia fish, as its scarcity brought by the holidays also slowed data gathering. more importantly, the COVID-19 pandemic has hampered everything from movement of fish goods to markets, the ability to explore other vendors, and time coordinating with the freshness expert without access to proper devices. Various steps were taken to face these obstacles, such as squeezing time spent with the holidays, using publicly available resources such as Google Colab and continuous development cycle throughout academic health breaks. These technical bottlenecks as personal interruptions (becoming ill) has required some changes to the timeline for the project development.

Appendix 8. Revision Matrices

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Sta. Mesa, Manila

THESIS PROPOSAL REVISION MATRIX

PROPOSAL TITLE:								SECTION:	GROUP NO.:
Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction								BSCS 4-1	6
Document Part	COMMENTS/SUGGESTIONS/RECOMMENDATIONS by the Panel	ACTION TAKEN by the Proponent/s	Page No.	REMARKS (Panelist Approval by indicating the date)					
				Panel 1	Panel 2	Panel 3	Panel 4		
Title									
Preliminaries									
Chapter 1	• SOP 2 it is not be processed by the use of subtraction only it need to be statistical. No detailed process of the system that is used to answer the SOP 2. "What is the accuracy in determining the freshness of the fish", change it to this, remove the overall in the SOP.	• Removed the term "overall" from Q1 of the SOP to eliminate confusion on the statistical analysis of Q1. • Changed Q2 of the SOP from "What is the difference of the overall accuracy of the system compared to the system of David and Reyes (2017)?" to "Which of	• Page 6						

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		the two systems is more effective in evaluating the freshness of the tilapia fish in terms of accuracy?".					
Chapter 2	• Algorithms of YOLO and GrabCut procedures for proposal software make a breakdown in the chapter 3. Make a sub architecture of the 3 algorithms	• Added theoretical frameworks that show how YOLOv3 and GrabCut works. • Added more information/ related literature in Chapter 2 on how the RGB data can/will be used.	• Page 7-8 • Page 23				
Chapter 3							
References							
General Observations	• You should take the following factors such as camera resolution and camera distance for the accuracy of the camera. • Measure the accuracy per process to overall the SOP. Remove the overall word in the SOP 1 and 2. Methodology on how to compare percentage accuracy in a professional manner.	• Added the specifications of the camera that will be used for the study. • Changed the statistical analysis for Q2 since it was changed to better suit the study.	• Page 25 & 26 • Page 28-29				

(Please use additional Sheet if Necessary)

Legend:

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Sta. Mesa, Manila

fa
Name of Panel 1: Carlo G. Inovero

Name of Panel 2: Iluminada Vivien Domingo (approved June 21, 2022)

Name of Panel 3: Mary Jane Tan

Name of Panel 4: Montaigne Molejon

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THESIS TOOL REVISION MATRIX

TITLE:							SECTION:	GROUP NO.:
Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction							BSCS 4-1	6
Document Part	COMMENTS/SUGGESTIONS/RECOMMENDATIONS by the Panel	ACTION TAKEN by the Proponent/s	Page No.	REMARKS (Panelist Approval by indicating the date)				
				Panel 1	Panel 2	Panel 3	Panel 4	
Title								
Preliminaries								
Chapter 1	• Rephrase the Statement of the Problem number two (2) to 'significant difference' of the proposed system to the existing system in terms of accuracy. • Do not include the name of David and Reyes in the Statement of the Problem number two. Include and explain what you're comparing in the synthesis in Chapter 3. •	• Changed the SOP #2 to "What is the difference in the accuracy between the two systems in determining the freshness of a tilapia fish?" • Changed "System of David and Reyes" into "previous system" as well as added the term "current	• Page 5 • Applied to the whole paper.					

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		system" to refer to the system being developed by the researchers.						
Chapter 2								
Chapter 3	• Include in the study a detailed explanation about the fish freshness preservation.	• Added further elaboration on how the fish was stored during the experimentaion	• Page 29					
References								
General Observations	• As of now, the prototype should at least have an initial data, result or percentage of accuracy. • Present and/or submit the datasets • No interface. Filenames should not be typed, it is a matter of uploading the pictures or images. • Images must be clustered or tagged as fresh or not fresh. • YOLOv3 is underutilized • Using the YOLOv3 for object detection, the system should first accurately determine whether the object is tilapia or not tilapia before the detection or extraction of gills. •	• N/A • Datasets added to the Appendices • Added UI to the software • Added freshness classification by fish expert in the datasets. • N/A as it will change the whole framework of the study • N/A as it is not within the scope of the study, but will be added to recommendations.	• N/A • Page 48 • N/A • Page 48 • N/A • N/A • Page 38					

(Please use additional Sheet if Necessary)

Legend:

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Sta. Mesa, Manila

Name of Panel 1: Carlo G. Inovero

Name of Panel 2: Iluminada Vivien Domingo

Name of Panel 3: Mary Jane Tan

Name of Panel 4: Aleta Fabregas

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THESIS FINAL REVISION MATRIX

TITLE:								SECTION:	GROUP NO.:
Tilapia Fish Freshness Evaluation by Gill Color Using YOLOv3 and GrabCut Algorithm for Image Segmentation and Utilization of RGB Channels for Feature Extraction								BSCS 4-1	6

Document Part	COMMENTS/SUGGESTIONS/RECOMMENDATIONS by the Panel	ACTION TAKEN by the Proponent/s	Page No.	REMARKS (Panelist Approval by indicating the date)			
				Panel 1	Panel 2	Panel 3	Panel 4
Title							
Preliminaries							
Chapter 1							
Chapter 2							
Chapter 3	• In determining the freshness of gills, we have to make a difference in terms of the distance, the type of the cellphone used in terms of camera and the megapixel, the type of unit.	• Added all of the necessary specifications of the camera and the environment in the "sources of data" of the paper.	• Page 26-27				

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Chapter 4	• Should have a tabulated data: "Dapat may tabulated data kayo, na ito yung unit na ginamit, tas ito yung unit na ginamit. Tapos in terms of light kung sabi nyo ay equal kase kinocompare na natin ngayon yung accuracy." (follow-up question/clarification from King Sanchez)	• Since the experiment have been performed once again using a single phone camera, this revision can no longer be applied to our paper.	• N/A				
Chapter 5	• Regarding Conclusion 1, make it clear. Rephrase the Conclusion 1.	• Rewritten Conclusion 1 and 2 to make it more comprehensible and make the ide easier to understand.	• Pages 36-37				
References							
General Observations	• Follow-up questions and comments concerning the implementation process/ controlled environment: -"From the 83, ilan yung iphone, ilan yung android, anong version nitong phone na 'to? Anong time of the day na kinunan yung tilapia?" (Answered by King Sanchez and Briel Viola) -"Kase dapat kapag ka nagtesting kayo equal lahat. When I say equal isang cellphone lang ang ginamit for all 83 samples, kase magkakaroon ng variation sa megapixel ng camera. Again, factor si time of the day." -"Dapat nung tinest nyo, nagkuha kayo ng picture ng 83 samples, isang cellphone unit lang para masabi nyo ito ang	• In response to this, the group have performed the experiment once again by using a single phone camera, unlike last time where four different phones cameras used. The group also made sure to perform the experiment in a controlled environment.	• Specifications of the phone camera and the environment are listed in the "Sources of Data" in pages 26-27. • Results of the new experiment is shown in				

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	output nya. Ngayon kung ginamitan nyo ng iba-iba, ano yung unit ang ginamit nyo for how many samples? At the time of the day, at the distance assuming na pare-parehas yung distance like 10 inches difference. Gaano kalapit or gaano kalayo could be a factor pagkuha ng picture." - "Kaya nga yung accuracy, hindi mo pwedeng ma-generalize yung picture kase magkakaiba yung phone na ginamit, factor one. So, dapat inadentify nyo, ang accuracy ng same phone unit ay ito, ang accuracy ng same phone unit ay ito." - "Hindi nyo pwedeng i-generalize na 69% accurate because you are using different types of cell phone camera." - Be consistent with the image file, preferably .png for reliability.		Chapter 4 at page 32.					

(Please use additional Sheet if Necessary)

Legend:

Name of Panel 1: Carlo G. Inovero

Name of Panel 2: Iluminada Vivien Domingo

Name of Panel 3: Mary Jane Tan

Name of Panel 4: Aleta Fabregas