Tuna Meat Freshness Classification through Computer Vision

[1]Kenan Lugatiman, [1]Crisanto Fabiana, [1]Jairo Echavia, [2]Jetron J. Adtoon

[1,2]*Computer Engineering Program, College of Engineering Education*

[1,2]*University of Mindanao, Davao City, Philippines*

[2]jetron.adtoon22@gmail.com

***Abstract*— The Yellow Fin Tuna or Thunnus albacares is one of the most expensive in the family of tuna. Yellow Fin Tuna is the most common fish found and caught in tropical countries like the Philippines. This kind of tuna is caught by hand-lining or in the fishnet. The tuna is commonly exported or sold as cuts in the market, and there are times that tuna sold in the market are no longer fresh. Classifying the freshness of tuna meat cut is the main objective of this study. In this study, identifying the freshness of tuna meat cut was analyzed using RGB extraction. Photos of tuna meat cuts were captured using a Raspberry Pi and transmitted to a mobile phone for image processing. The cuts were classified using k-Nearest Neighbours (k-NN) algorithm and Waikato Environment for Knowledge Analysis (WEKA) in terms of the number of hours from slaughter. The result showed 86% overall accuracy in determining tuna meat freshness.**

Keywords*— k-NN, Yellow Fin Tuna, Mobile Application, WEKA, Image Processing

I. Introduction

Most of the catch of yellowfin tuna are taken by the industrial purse seiner, hand liner, and net in the Pacific Ocean, especially in the Philippines and Indonesia [1]. This yellowfin tuna is a species found in all oceans, and it supports all the fisheries in the Atlantic, Pacific, and the Indian Ocean. Among the three, the largest catch is from the Pacific Ocean [2]. In 2008 – 2009, the Philippines ranked third in terms of tuna meat per capita consumption. However, while increasing the demand for tuna in the market, it threatens the sustainability of supply gaps [3]. The declining of tuna stocks in the country is due to weak enforcement of regulations on fishing efforts that threaten the sustainability of the tuna fishery. Interventions to address this problem are instigated, which includes the change of fishing techniques, or fishers exit if their catch is declining. Four cities and municipalities in the Philippines, including General Santos City, Mati City, Lupon, and Governor Generoso Davao Oriental, are producers of tuna products. Only General Santos City, with ancillary industries and Lupon with lesser economic development, are more willing to change their fishing strategies to help the sustainability of the tuna stocks [4]. The problem today, people do not know if the tuna meat is fresh or not. However, the tuna meat stored in the storage at temperatures 10ºC, 5ºC, and 0ºC could be eaten up to 4 days. Change in the freshness of the yellow fin tuna meat is dependent on the storage temperature. The decline of freshness is relative to the increase in storage temperature [5]. At 7ºC temperature, the histamine starts to produce, but it is slower at 0ºC and 4ºC. Therefore, to prevent the formation of histamine, the temperature of storage must be set at less than 4ºC [6]. The fresh tuna meat color is bright red, but once frozen or thawed in 7 days in the iced cold storage, the color became yellowish, and the color is quickly changing [7].

New technology can now evaluate the quality of meat and identify the class of meat using computer vision by checking the color [8]. Machine vision is another way to make a suitable decision making. It can differentiate based on the color and can do quantifying color distribution in the sample of the uneven hue of the tuna meat [9]. The use of machine vision is helpful; it is a non-destructive method. This method gives higher accuracy and efficiency in visual quality detection in image processing and analyzing [10]. To make an automated system using digital image processing and machine vision for food quality evaluation requires instrumental devices to replace the manipulative effort of a human. Consistency and efficiency are useful for this method. [11] Image processing is the new trend of technology that can manipulate and handle the pixel of an image. It gives you value for red, green, and blue. The three primary colors are representing intermediate shades of gray. [12] With the help of the WEKA classifier, the classification of data is aided on prediction. Artificial intelligence used for data mining for the classification. Some data mining algorithms for classifying applied in a dataset like Naïve Bayes. [13] Using the Raspberry Pi camera that supports a 1080p image, taking image is now possible. The image is captured and broadcasted in the node of the raspberry pi camera. [14] With the advancement of technology in mobile phone computing capabilities, it can achieve real-time digital image processing techniques in thresholding, edge detection, and some complicated tasks. There are many techniques for image processing using Open Source Computer Vision Library (OpenCV) such as the setting of Region of Interest (ROI), Histogram equalization, and RGB to greyscale. [15]

The gap of this study focuses on the food safety particularly in the consumption of tuna meat products. An unbiased classification of tuna meat freshness allows the sellers and buyers to determine safety of their food.

978-1-7281-3044-6/19/$31.00 ©2019 IEEE

This study aimed to develop an android application that can set parameters for digital image processing to assess the freshness of tuna meat mainly through color. Also, to conduct a functionality test in storing and processing the image into a device, procuring and showing the parameter readings of the system, and determining the number of hours from the time the tuna is slaughtered. The researchers created a studio type box for the camera to capture the image of the tuna meat and to get a better result and stored on the mobile phone. Also, classifying the freshness in terms of hours from the day the tuna slaughtered using image processing techniques and display the results of the image in terms of hours (2, 4, and 8 hours), which are *Excellent*, *Good*, and *Acceptable*.

The safety and health of food consumption of tuna meat in our society is the importance of this study. The impact of new technology may help and assist the safety and health of the daily consumption of food. The success of the study gives the opportunity to determine the freshness of tuna meat.

The range of the study is focusing only on classifying the freshness of Yellow Fin Tuna based on the color of the meat and does not include another family of tuna. The size of the sample is of steak size. The camera used is from raspberry pi that is 1080p, which is programmable using python. This software design only for Android and does not support the iOS version of the device.

II. Materials and Methods

A. *Conceptual Framework*

Fig. 1 shows the framework that the system is following. The Raspberry Pi camera would capture the image of tuna meat and then stores the image in the gallery of the smartphone. RGB features of the image are fed for classification using the k-NN algorithm and WEKA classifier.

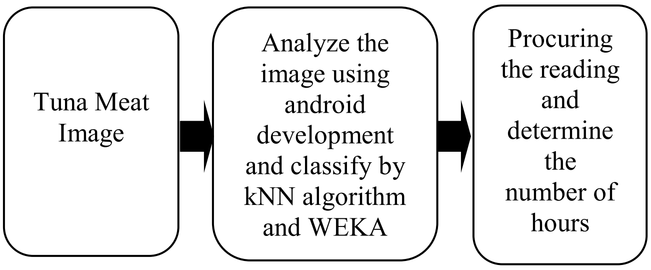

Fig. 1. Conceptual Framework

Fig. 2 shows the studio type box created for taking sample images. The box is an acrylic fiber sheet with a fluorescent lamp for the appropriate light distribution. A Raspberry Pi camera is mounted to the upper part of the box. The camera is being connected in wireless through the third party application that can connect through a mobile phone. For capturing images, the sample must be steak cut and put inside one at a time.

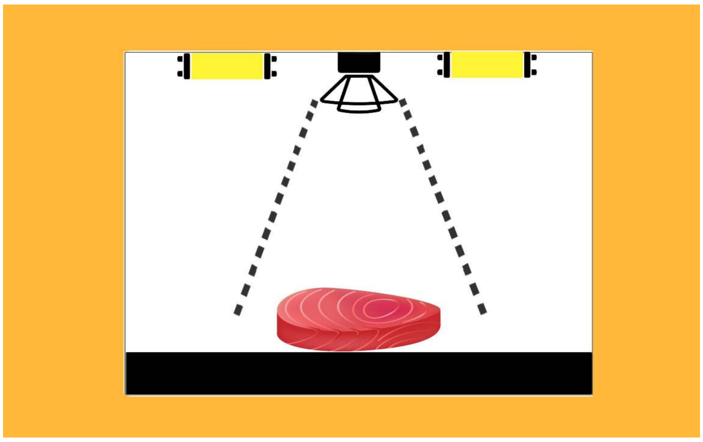

Fig. 2. Studio type box

B. *Block Diagram*

This block diagram in Fig. 3 shows the design for the hardware that communicates through the mobile application. It is consists of the studio type box, the tuna meat classifier application that is installed in mobile using the k-NN Algorithm, and the power supply. The studio type with the raspberry pi camera and lightings captures the image of tuna meat samples. Then the captured image is processed to the mobile application to be extracted with RGB features and goes directly to the k-NN algorithm and WEKA classifier for the classification. The reading and result showed after analyzing the image. Then the power supply only connected to the studio type box to provide electricity for the equipment installed.

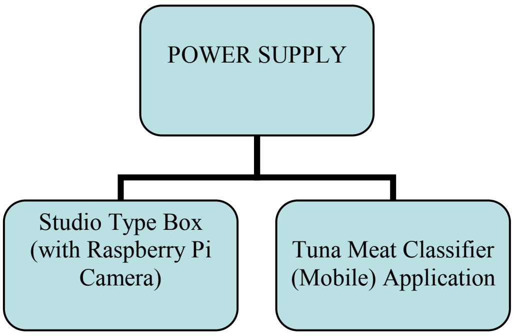

Fig. 3. Block Diagram

C. *Software Development*

The tuna meat classifier application uses Android Studio, which is based on the IntelliJ IDEA. To support application development within the Android operating system, Android Studio uses a Gradle-Based build system, emulator, code templates, and Github integration. Every project in modalities includes the Android app, Library, and Google App Engine modules. Android Studio uses the Instant Push feature to push code and resource changes to a running application. A code editor assists the developer with writing code and offering code completion, refraction, and analysis. The application built in Android Studio that compiled into the Android Package Kit (APK) format for submission to the Google Play Store. OpenCV used for the library for computer vision. It is an open-source computer vision and machine learning software library. Inside of it, more than 2500 libraries are the optimized algorithm. The algorithms used to detect, recognize, classify, and extract 3D models of objects. WEKA means Waikato Environment for Knowledge Analysis, which is a suite of machine learning software written in Java. WEKA classifier is under the algorithm of KNN that works in this development. Under the GNU General Public License, the software is free for all users. It contains a tool for visualization and algorithms for analyzing the data and predictive modeling with graphical user interfaces so that the user can easily access to these functions. WEKA is under by KNN that has a class called Instance-Based Learner (IBK). It uses for normalized distances for all attributes so that the different scales have the same impact on the distance function. It may return more k-Neighbor's may if there are ties in the distance. Therefore, it can identify the image correctly through the classifier for freshness.

D. Software Analysis and Design

Android Studio is the software development used by for the Graphic User Interface. Java and OpenCV library were also used to implement RGB features extraction and k-NN algorithm. In Fig. 4, the image analysis process shows that the sample image of the tuna meat is extracted for RGB color. The morphological gradient gets the value of RGB then converts to a binarized gradient. Then the image filled with a Binary gradient, applying water-shedding after that. Extraction of the RGB features generates the numeric value of the RGB, then the value saved as ".arff" file as the testing data. The training data is compared to the test data for classification. Classification is based on *"Excellent, Good, and Acceptable*."

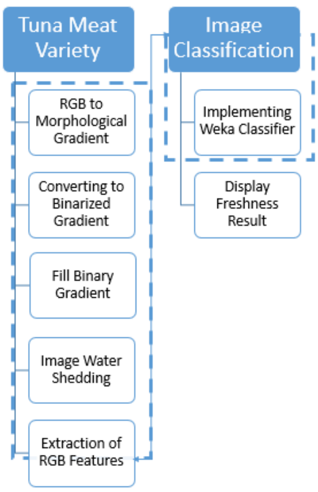

Fig. 4 Image analysis process flow

E. Data Analysis

A confusion matrix is implemented to analyze the gathered data and determine the system's accuracy. The accuracy computed as:

$$\text{AP} = \frac{a+c}{a+b+c+d} \quad (1)$$

where; AP is the total number of predictions, which are correct, then a is the number of correct of predictions which the result is negative, the b is the number of incorrect predictions which the result is negative, the c is the number of incorrect predictions which the result is negative and the d in the number of correct predictions which the result is positive.

III. RESULTS AND DISCUSSIONS

A. Graphic User Interface

Graphic User Interface (GUI), shown in Fig 5, was developed for the mobile application using the android studio. There are four icons available, which are the *Data Analysis, Gallery, Data Standards,* and *About*. The data analysis icon is where the analysis of the tuna meat processing to extract its freshness features and inside is an icon for the camera that is remotely connected to the Raspberry Pi camera. The gallery icon is for viewing a captured image. The data a standard is for showing the data set gathered from the training samples. Lastly, the about is for the developer's information and information about the application.

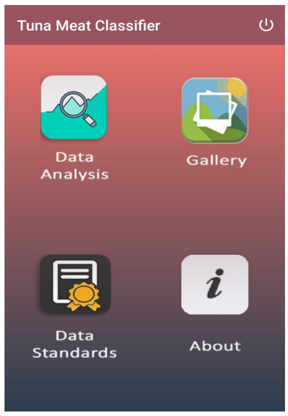

Fig. 5 Graphic User Interface

Fig. 6 shows the gallery where all the captured image from the RPi camera are stored and display. Data analysis directly goes through the camera viewing, and it has two buttons to press; add image and analyzing. Where the add image function as choose the image that to be analyzed. The analyzing functions calls all the functions that the system uses to analyze and classify the freshness of the tuna.

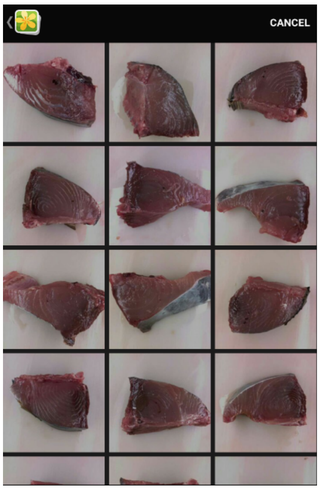

Fig. 6 Gallery

B. Pre Processing

Fig. 7 shows the image result of the pre-processing procedure of the study. The tuna meat is cut into steak size and put into the studio for original image capturing. The sample is aligned with the camera for a better result.

Fig. 7 Original Image of Tuna meat

The original image sample is then converted into a morphological gradient that is useful for the edge detection and image segmentation applications, as shown in Fig. 8.

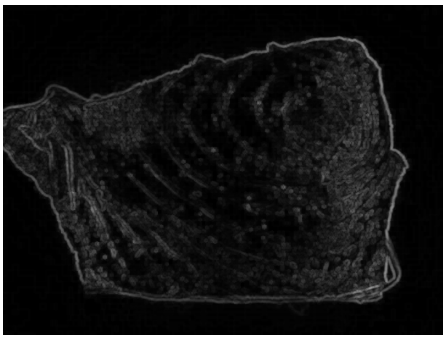

Fig. 8 Morphological Gradient

Fig. 9 shows the image of the binary gradient that is efficient for the estimation of an object from the morphological gradient.

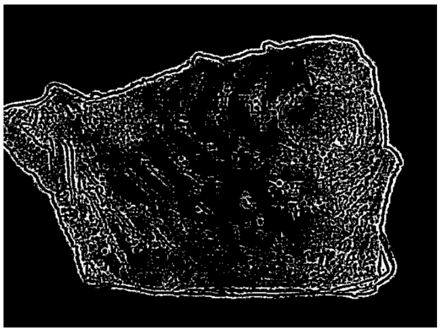

Fig. 9 Binary Gradient

Fig. 10, shows the image of the filled binary gradient of an object. The filled binary now fetches the result of the water-shedding.

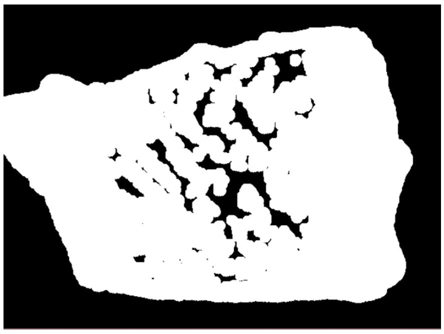

Fig. 10 Filled Binary Gradient

After filling every isolated area of an object, the water rises depending on the peaks or gradient nearby then different watercolors emerge. Resulting processes is shown in Fig. 11

Fig. 11 Water Shedding

Fig. 12 shows the sample result from the pre-processing that gives a Red, Green, and Blue result. The result displays an EXCELLENT classification which indicates the freshness into 1-2 hours from the fresh cut. The WEKA classifier classifies the result from the RGB.

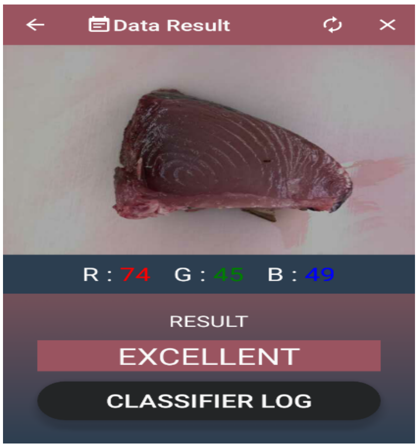

Fig. 12 Excellent Result (1-2 hours)

C. Data Sets

The researchers gathered the data for the classified samples for the data set. Sample image analyzes from the RGB. There are 60 samples distributed to 1-2 hours, 3-4 hours, and 5-8 hours. The images are extracted with RGB values plotted in Fig. 16.

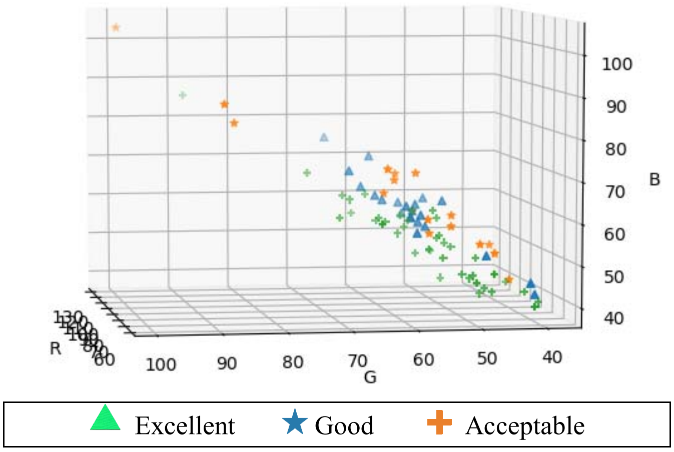

Fig. 16 Data Set

D. Data Analysis

The result shown in Table 1 is the tuna meat analysis conducted with 30 testing samples. Using the confusion matrix, the computation revealed that the result of 1-2 hours has 90% accuracy, which the system detects 9 out of 10 for 1-2 hours of tuna meat sample. While the 3-4 hours has 80% accuracy, which the system identifies 8 out of 10 3-4 hours tuna meat, and lastly, the 5-8 hours has 90%, which the system detects 9 out of 10 of 5-8 hours tuna meat samples. As a result, from the 30 testing samples being tested, 26 samples were correctly classified resulting in 86.67% accuracy.

TABLE 1. DATA ANALYSIS RESULTS

		PREDICTED DATA			Classification Overall	Producer Accuracy (Precision)
ACTUAL DATA		1-2 Hours	4Hours	8Hours		
	1-2 Hours	9	1	0	10	90%
	4Hours	2	8	0	10	80%
	8Hours	1	0	9	10	90%
TOTAL		12	9	9	30	
ACCURACY		75%	88.889%	100%		
OVERALL ACCURACY		86.667%				

IV. CONCLUSION AND FUTURE WORKS

This study was able to design and fabricate a system to detect tuna meat freshness in terms of 1-2, 3-4 and 5-8 hours, respectively. Testing of the designed system showed 26 out of 30 samples correct classifications thus giving an overall accuracy of 86.67%.

Further improvement of the study includes the use of another classifier or algorithm to allow an increase in the accuracy of detection. Also, discovery of additional features of tuna meat that may help in the increase of accuracy in classification.

REFERENCES

[1] John Hampton, David A. Fournier. ''A Spatially Disaggregated, Length Based, Age-Structured Population Model of Yellowfin Tuna (Thunnus Albacares) in the Western and Central Pacific Ocean''. *Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia,* 2001

[2] S.A Appleyard, P.M Grewe, B.H Innes, R.D Ward. ''Population Structure of Yellowfin Tuna (Thunnus Albacares) in the Western Pacific Ocean, Inferred From Microsatellite Loci'', 2001

[3] Jon Marx P. Sarmiento, Larry N. Digal, Miko Mariz C. Castro, Pedro A. Aviola IV.''Demand Estimation of Philippine Tuna and Other Fishery Products: Implications of Sustainability''. *University Of Philippines Mindanao,* 2013

[4] Edison D. Macusi, Robert E. Katikiro, Ricardo P. Barbaran. ''The influence of economic factors in the change of fishing strategies of anchored FAD fisheries in the face of declining catch, General Santos City, Philippines''. *Regional Integrated Coastal Resource Management Centre (RIC XI), Davao Oriental State College of Science and Technology, Mati City, Davao Oriental,* 2017

[5] Tri Winarni Agustini. ''Freshness changes of Yellow Fin Tuna (Thunnus albacares) During Storage at Low Temperatures'', *Department of Fisheries, Faculty of Fisheries and Marine Science Diponegoro University-Semarang,* 2002

[6] B.K.K.K Jinadasa, C.K. Galhena, N.P.P. Liyanage. ''Histamine formation and the freshness of yellowfin tuna(Thunnus Albacares) stored at different temperatures'', *Analytical Chemistry Laboratory, Institute of Post-Harvest Technology, National Aquatic Resources Research and Development Agency, Colombo 15, Sri Lanka,* 2015

[7] Xin Sun, Jennifer Young, Jeng Hung Liu, Quansheng Chen, David Newman. "Predicting Pork Color Scores Using Computer Vision Technology and Support Vector Machine Technology", *School Food and Biological Engineering, Jiangsu University, Zhenjiang, 212013, Chin,* 2018

[8] A. Mateo, F. Soto, J.A Villarejo, J. Roca-Dorda, F. Dela Gandara, A. Garcia. ''Quality Analysis of Tuna Meat Using an Automated

Color Inspection'', Universidad *Politecnica de Cartagena, Departamento Tecnologia Electronica, Doctor Flemming Campus Muralla del Mar, 30202-Cartagena, Murcia, Spain.*2005

[9] Murat O. Balaban, Hordur G. Kristinsson, W. Steven Otwell. ''Evaluation of Color Parameters in a Machine Vision Analysis of Carbon Monoxide-Treated Fish'', *Food Science and Human Nutrition Department, University of Florida, P.O Box 110370, Gainesville, FL, 32661, USA,* 2005

[10] Hanmei Hong, Xiaoling Yang, Zhaohong You, Fang Cheng.''Visual Quality Detection of Aquatic Products Using Machine Vision'', *College of Biosystems Engineering and Food Science, Zhejiang University, 866 Yuhangtang Road, Hangzhou 310058, People's Republic Of China,* 2014

[11] Cheng-Jin Du, Da-Wen Sun. ''Recent Developments in the Applications of Image Processing Techniques for Food Quality Evaluation'', *FRCFT Group, Department of Agricultural and Food Engineering, University College Dublin, National University Of Ireland, Earlsfort Terrace, Dublin 2, Ireland,* 2004

[12] Kavita Khobragade. ''A Comparative study of Converting Coloured Image to Gray-scale Image using Different Technologies'', *Department of Computer Science, Fergusson College, Pune India,* 2012

[13] Munaza Ramzan. ''Comparing and Evaluating the Performance of WEKA Classifier on Critical Diseases'', *Amity University Noida, Uttar Pradesh, India,* 2016

[14] Marko Viitanen, Ari Koivula, Jarno Vanne, Timo D. Hamalainen. ''Kvazaar HEVC Still Image Coding on Raspberry Pi 2 for Low-Cost Remote Surveillance'', *Department of Pervasive Computing, Tampere University of Technology, Finland.*2015

[15] Deepthi RS, S. Sankariah. ''Implementation of Mobile Platform Using QT and Open CV for Image Processing Applications'', *Manipal Centre for Information Science Manipal University, Manipal, Karnataka, India, and Faculty of Information Technology Multimedia University, Cyberjaya, Selangor, Malaysia.*2011