Identification of Fertilized Duck Egg using Image Processing

by

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Chapter 1

Introduction

"Balut" is traditionally seen as a post-sundown snack, with the joke being it's easier to avoid looking at the embryo in the dark. But there are a few other possible reasons why balut consumption increases at night. It's considered highly nutritious, a mini-meal that creates a lot of heat and energy in the body. Filipinos love balut, a hard-boiled duck egg. It sounds innocent enough, until you find out the egg is fertilized and allowed to develop from 16 to 20 days before it's cooked. By this point, the embryo will have become distinctly ducklike, sometimes complete with body parts like eyes, beaks, and feathers. You are essentially eating a duck fetus in utero(M., Paramita 2016). Since it has gained popularity around the globe, new ways of preparing and eating it were made but the traditional way of eating it is by removing its shell, sipping its broth, and then using salt or vinegar to further enhance its taste. Eaten usually as a snack, and not a formal food, fertilized duck eggs have been described to be as popular in Philippines like any other common street foods sold anywhere. Balut is a food made by incubating a duck egg for seventeen days. This process requires a lot of patience and manpower because every process is manually done. The process starts from the incubation where the eggs are being put in a warm temperature for ten days so that the embryo will grow. On the 11th day of incubation, the eggs are checked through a process known as "candling" to identify if the egg will become a fertile (balut) or infertile (penoy). Candling is the process of holding a strong light above or below the egg to observe the embryo. A candling lamp consists of a strong electric bulb covered by a plastic or aluminum container that has a handle and an aperture. The egg is placed against this aperture and illuminated by the light. Those that are identified as "possible balut" are to be incubated again for another seven days to ensure the development of the embryo. Moreover, both types are being boiled but those classified as “penoy” are being sold at a lower price.

The quality control in manufacturing food products is highly important to meet the user requirement set by the customer. By applying new technologies in the traditional ways of producing food, it improves not only the quality but also reduces the time to make it and food wastes produced (D., Gartenstein 2018). This shows the importance of technology in improving traditional processes as with the help of mechanical systems and of convolutional methods, the possibility of grading salted eggs has been found to be successful and feasible. The traditional way of making a balut involves processes that uses traditional equipment that are operated manually. Egg candling analysis is a process that consists in applying light to an egg in order to detect abnormalities inside it. The light makes the eggshell transparent; hence it is possible to analyze the components inside the eggs in a non-destructive procedure (Ramiro S., Lourdes C. and María C., 2018).

For the longest time, there has been no existing device used to identify fertilized duck egg, the only efficient way is through Candling process. Through years of using the same method, the only improvement made was the change of its primary tool – from candle to the usage of artificial light. Even so, the classification of the egg's type is still being determined by a worker who must have the experience in determining the identification of a duck egg.

The general objective of this study is to innovate the process of candling in identifying duck eggs based on its type, whether it is a “balut” or “penoy”. The specific objectives of this study are: (1) to create a device using NI MyRIO and Labview in identifying duck eggs; (2) to implement RGB color model and image segmentation method for checking the growth of the embryo while being candled; (3) to verify the accuracy between the traditional process and the system by confusion matrix, and (4) to use LED indicator that will determine if the duck egg is "balut", or "penoy".

This study will be significant for the balut manufacturers in ensuring the consistency of classified duck eggs for production also because they can use this research in aiding the creations of designs that may be helpful in making balut. This research will also provide aid for other researchers especially in the field of agriculture and animal study because it can be used for monitoring the growth of the embryo inside the egg. Moreover, this study will also be significant to future researchers as reference to the studies they will be conducting related to this field. Furthermore, the researchers could further widen their knowledge on the use of MyRIO and the image processing technique used in this research

This study intends to establish an classifier for duck eggs by thresholding method. The data gathered will be the total pixel value based on threshold and will be analyzed using a national instrument (NI), which is myRIO. The system will be calibrated in order to get more accurate results Moreover, this study will only be limited to the identification of one egg sample per round of tests and will not include the automation of the current candling method wherein it will still require the egg to be manually placed on the holder, and also the LED that will light up the egg must be less than 5 watts' because high power light bulb can affect the development of the embryo inside the egg which means the intensity of the bulb that is to be used is around 400+ to 450+ in lumens. Furthermore, on checking the egg samples, it is assumed that factors such as cracks may affect the accuracy of the results.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter contains articles and researches from different but related studies that will not only be used as a basis for completing the objectives but will also be used to further improve the proposed study. The literatures gathered are generally about balut, its characteristics, how to process it, different image processing techniques, and the application of image processing in the proposed study.

2.1 Balut (Anas Platyrhynchos Egg)

"Balut" is the Filipino term that probably originated from the malay term "balot" which means wrap. Balut is the developing duck egg that is boiled and eaten usually from its shell and can also be found in Cambodia, China, and Laos. use it is unusual in the perspective of other people especially those that are not of asian descent. Deutsch and Murakhver stated that balut eggs range from 14 to 21 days old and can come from different kinds of ducks and chicken, though the latter is less common, and the Mallard ducks are the most common breed for producing balut in the Philippines (2012). It is considered to be exotic because it is unusual in the perspective of other people especially those that are not of asian descent. Deutsch and Murakhver also stated that balut is not as exotic to eat when it comes the Philippines and other neighboring Asian countries (2012). In the Philippines and in some other neighboring Asian Countries, it is believed that eating this kind of delicacy has an aphrodisiac effect and is the most readily available source of energy for sexual activities because it can be found almost everywhere in the streets and can be sold at a very cheap price. According to Jeel Monde, a serving of balut contains 188 calories, 2 milligrams of iron, 116 milligrams of calcium, and 14 grams each of fat and protein (2017). Unfortunately, balut is also rich in cholesterol as it contains more than 250 milligrams of it. As stated by Carmen Chai in her article, "*Reality check: How much cholesterol should you really be eating?*", the daily recommended cholesterol intake of an individual should be no more than 300 milligrams (2015). Compared to the recommended daily intake of cholesterol, 250 milligrams of cholesterol is still a lot that is why balut should be avoided by people suffering from high-blood pressure.

2.2 Process of Making Balut

The traditional way of making balut takes a lot of patience as it takes days to produce balut. Sanceda, Ueda, Ibenez, Suzuki, Kasai, and Hatae of Japan study stated that the whole process of making balut usually takes place for 17 days wherein for 10 days, the eggs will be placed and heated under an incubator or sun [6]. The process starts with selecting the eggs that are fit for incubation. The eggs should be not more than five days old and should have thick shells without any cracks. The eggs are checked using the "pitik" method where the eggs are flicked or tapped which may produce hollow sound if it has cracks and a light brittle sound if it has a thin shell. The selected eggs will now undergo incubation at 40±2˚C in order to develop the embryo for about 18 to 22 days. While incubating, the egg's position should be turned at least two or three times a day to avoid death from sticking to the shells. The candling method will be done on the 11th, 14th, and 18th day of incubation where the inside of the egg is checked to know if the embryo is growing and developing. The eggs containing a normal embryo on the 18th day are then hard boiled and then sold as balut[6]. The eggs stay in the barrels to incubate for 18 days, and are "candled" using a lightbulb on the seventh, fourteenth and eighteenth days. A typical instrument for candling is the silawan, which is a box-like device in the shape of a triangle or a square. The Filipino balut-maker inserts the egg into a specially designed hole to hold it and by means of a light bulb inside the box, the contents of the egg can be seen. Something to watch out for while candling is a dark shape in the egg, which means an embryo has formed. If there are web-like veins, then the embryo is growing. If the light does not show anything but a whole yolk, then the egg is infertile. Sometimes, there is a crack on the egg or the embryo has died early. These are sold as penoy or made into salted eggs. In the U.S., the sale of eggs with dead embryos is prohibited [7].

2.3 Egg Candling

Egg candling is the process of applying a strong light against an egg in order to check any damages or abnormalities to the egg (Ragni, Cevoli, & Berardinelli, 2010). Long ago, this quality check was done by holding a candle behind an egg. Some hand-candling, using electric equipment, is still used for spot-checking or for training egg graders, but today most eggs pass on rollers over high-intensity lights, which make the interior of the egg visible. The eggs are rotated so all parts are visible. The candler checks the size of the air cell and the distinctness of the yolk outline. Imperfections such as blood spots show up in candling [10]. In applying the light against the egg, it is important to take the wattage of the light bulb to be used into consideration because it can kill or damage the embryo if the light is too strong. In the case of balut, it is used to check the growth of the embryo inside the egg so that it can be classified as penoy, abnoy, or balut. While candling the person should be able to see the air sac, pores in the eggshell, yolk, blood vessels and/or a red ring around the yolk and the embryo itself [11]. Candling of the eggs must be done after the 5th day of incubation and repeat again after the 10th day of incubation to see if there is a farther development of the embryo in the egg or if the embryo dies inside the shell.

After the candling of the egg on the 10th day of incubation, the eggs that are still possible of developing the embryo will have a dark portion inside the shell which means that the chick is being developed. The large end of the egg must have a space of the air pocket.

2.4 Image Processing

Image processing is the process of applying certain kinds of operations to in image in order to enhance it or to be able to obtain useful information from the image. It is just one of the many types of signal processing where the image to be used will become the input and the processed image is the output. The image processing represents the vision of an image technology but with the same perspective of a naked eye (Anbarjafari, G., 2018). There are two types of image processing; the analog image processing where the inputs or the images used are hard copies like printouts and photographs, and digital image processing where the digital images are used as input and are manipulated using computers. The main purpose of digital image processing is to allow human beings to obtain an image of high quality or descriptive characteristics of the original image. In addition, unlike the human visual system, which is capable of adapting itself to various circumstances, imaging machines or sensors are reluctant to automatically capture meaningful targets (Ye X. & McCluskey MD, 2016). Image processing techniques can restore information within the image that may have been lost in the image capturing technique but they cannot compensate for the ocular aberrations that degrade the image (Aachal Kotecha, Gloria Roberti, & Federick Fitzke, 2014).

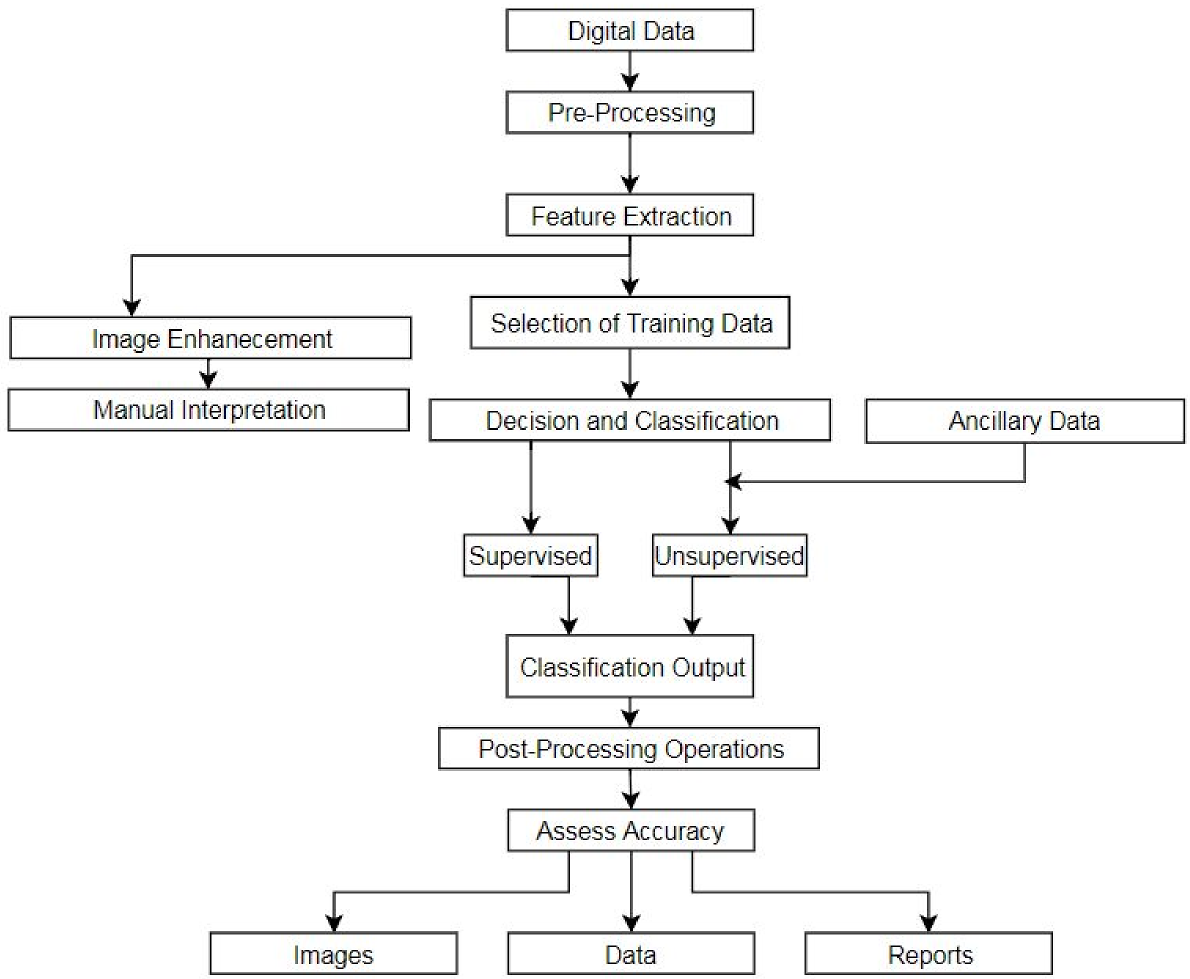

Figure 2.4 *Block diagram of digital image processing*

2.5 RGB Model

The RGB color model is an additive color model in which red, green and blue light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue (Tang S, Zhu Q, & Chen W, 2016). The RGB color model is based on a the science of the human eye perceives light and translates it into brain waves. This model is extremely common for TV and video displays, video game console displays, digital cameras and other types of light-based display devices. The computer monitor generates and displays color by varying the intensity of red, green, and blue light (RGB). This RGB color space, or color gamut, has a very large spectrum of color in which fluorescent greens and blues can be displayed very vibrantly(Suari Y, Brenner S, 2014). Color machine vision systems generally capture images in the red, green, blue (RGB) color system as 24-bit images. Each color axis is allocated 8 bits, resulting in 256 different values. This gives 16.7 million possible color combinations (256 × 256 × 256). Since it is difficult to handle 16.7 million colors it was decided to reduce the number of colors in the color space, and this was done by dividing each color axis (red, green, blue) into 4, 8, or 16 . In the three-dimensional color space this resulted in 64, 512, or 4096 "color blocks" (Balaban, Odabaşi, Damar, Oliveira, 2018).

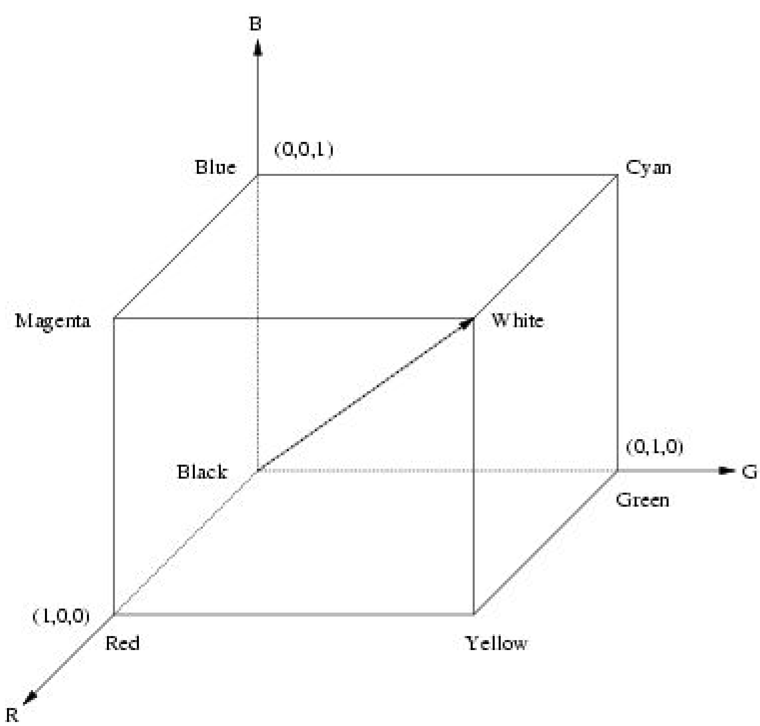

Figure 2.5 The RGB colour cube. The grayscale spectrum lies on the line joining the black and white vertices.

2.6 NI MyRIO

The word “RIO” is an abbreviation for Reconfigurable Input Output. The NI myRIO can be considered as one of the best products of National Instruments which can do image processing programs [17]. The NI myRIO has built-in processor, FPGA and Wi-Fi. Programming of processor and FPGA of NI myRIO allows the automatic monitoring and controlling of the pisiculture system. The built-inWi-Fi feature of NI myRIO is used to communicate the readings of all the sensors (Beena and KhajaMoinuddin, 2015). MyRIO is a real-time embedded evaluation board made by National Instruments. It is used to develop applications that utilize its onboard FPGA and microprocessor. It requires LabVIEW and it is geared towards students and basic applications (Arunrajan, S., Prakash, K., Nagaarjun, S. and Sivamanikandan, R., 2018).

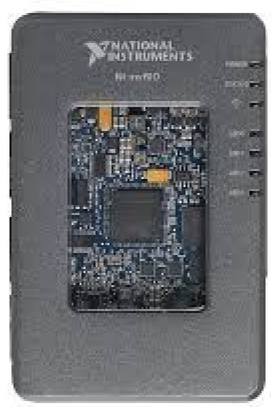

Figure 2.7 *NI MyRIO*

2.7 Image Segmentation

Image segmentation resulted into set of regions that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics [22].

An optimal value of threshold is to be chosen to separate one or more desired objects from their background and is application dependent. Determination of optimal threshold values remains as a challenging problem in image segmentation [23]. Color Segmentation will eliminate the color that is not on the range of RGB Color Channel Selection. Eliminated color will be change to black [24].

2.8 Confusion Matrix

Confusion matrix as the method to evaluate the performance of classifier. Normalized confusion matrix is normalized from the confusion matrix. Confusion matrix comprises of the numbers of each categories into which the images of our testing data set are classified, including both correct numbers and incorrect numbers [25]. It is the most common descriptor for assessing the classification accuracy. This provides *a* $n \times n$ matrix, where n is the number of classes, that is used to describe the performance of a classifier. This matrix is used to assess the mapping ability from the spectral reflectance to the semantic class [26].

		PREDICTED																				
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
ACTUAL	A	10																				
	B		9							1												
	C			10																		
	D				9						1											
	E		1			7		1		1												
	F						8	1				1										
	G				1			7											2			
	H						2		8													
	I					1				9												
	J										9			1								
	K					1					1	8										
	L												9				1					
	M											1		9								
	N														10							
	O										2			1		7						
	P											2					7			1		
	Q																	10				
	R										1								8		1	
	S												1				1			8		
	T																		1		7	2
	U											1				1						8

Table 2.8 Confusion Matrix

The Confusion Matrix shown in the table, shows the results of the initial test conducted using the created device with the implemented image processing algorithms.Twenty types were used and were coded using letters A to T for identification while code U was used for an unidentified type. Each type was tested 10 times. Initial results were very promising. Based on the collected data, there were incorrect recognitions due to the similarity of the types. From the table, the device's accuracy (ACC) is computed using Equation 2.8 [24].

$$ACC = \left(\frac{TP + TN}{TP + TN + FN + FP}\right) * 100$$

Eq. 2.8 Accuracy Formula

Chapter 3

Methodology

This section discusses the procedures that will be followed to conduct the study in the Classification of fertilized duck egg that is shown in Figure 3.1. The research methodology used Waterfall model because of its straight-forwardness and because it is easier to understand. The waterfall life cycle as shown in Figure 3.1, shows the actions needed in order to satisfy the given objectives and progress is more easily measured as the full scope of the work is known in advance. The process starts with defining the problem which is the potential inaccuracy of classifying the eggs. To further understand the problem and provide solutions, related concepts, theories, and past studies will be gathered which will widen the researchers' knowledge about the field of study. In designing the solution, the conceptual framework will be formulated in order to map out the actions required. The research will now move on to the construction of the device that will classify the duck eggs and includes gathering the materials needed, designing the system, and developing the algorithm. Testing will be performed in order to verify the accuracy of the system and to check if it satisfies the given objectives. If the objectives are met, the research will be concluded from the given data from testing. Further modifications of the device will be made if necessary in order to improve the quality if the data that can be obtained. After doing all the testing and modifications, the system will now be ready for deployment.

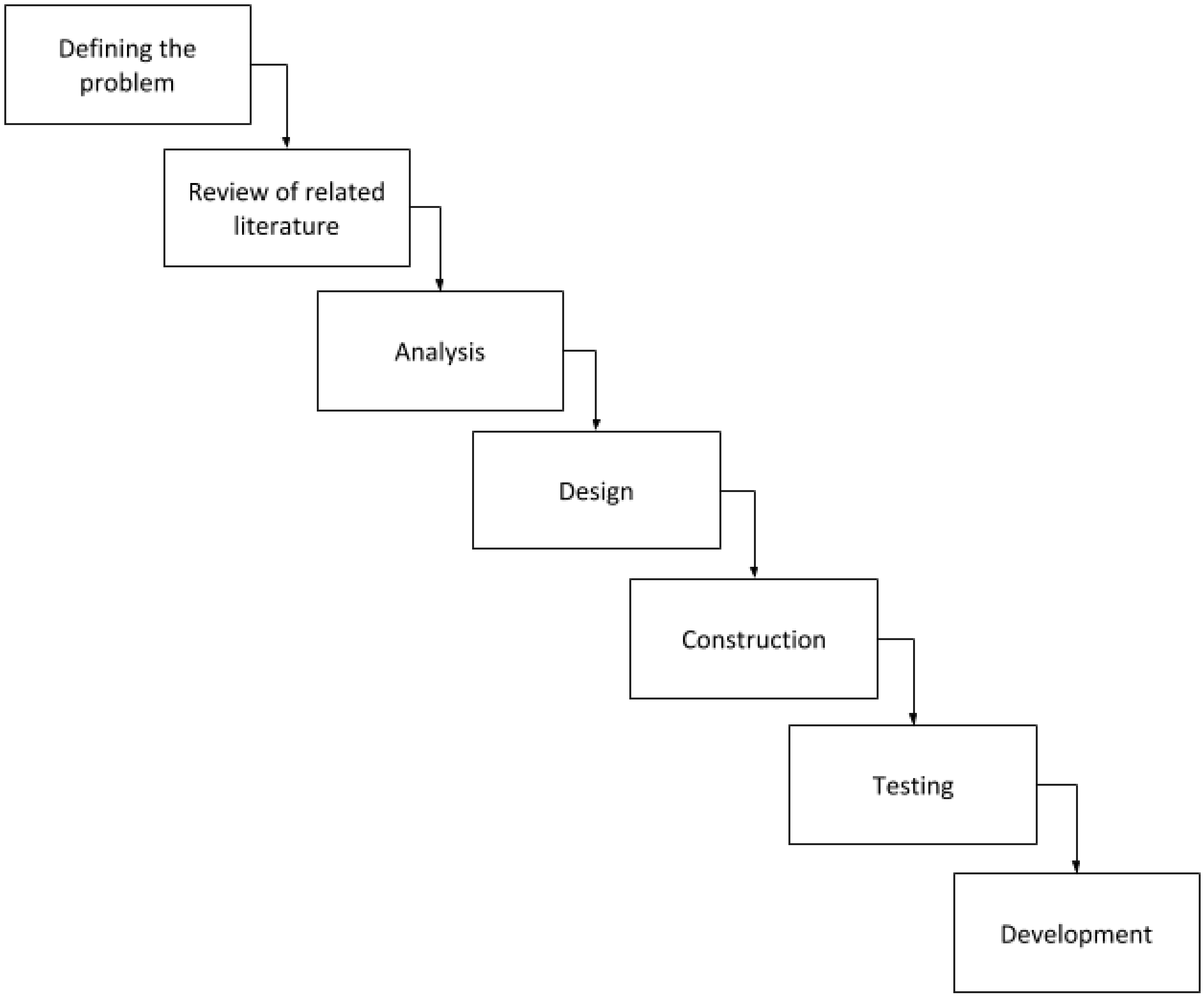

Fig 3.1 Research Methodology Using the Waterfall Method

Conceptual Framework

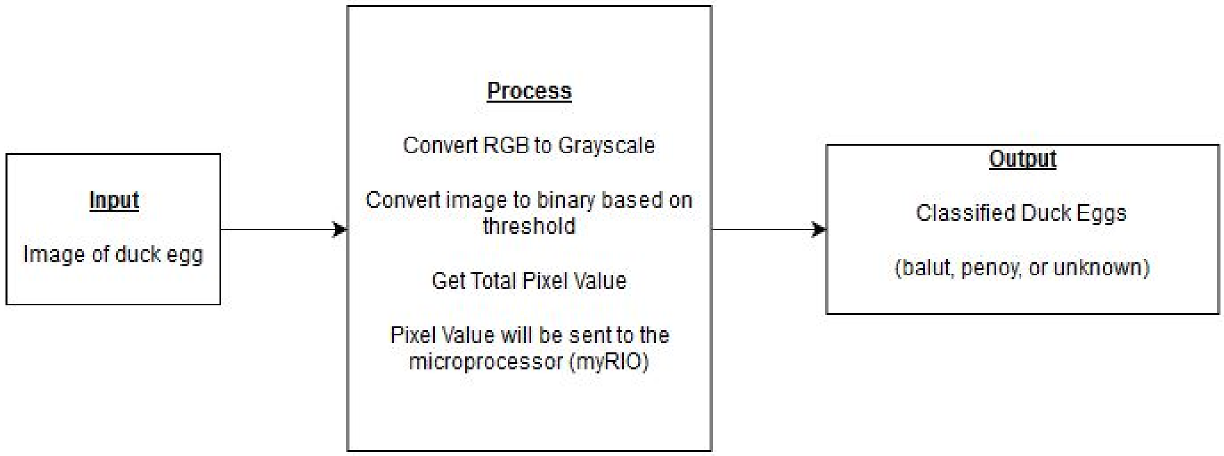

Figure 3.2 – Conceptual Framework of the System

The conceptual framework of this study is shown in Figure 3.2, the figure shows the idea for the IPO process of the system, which will be used for the process of identifying duck eggs with the use of image processing instead of doing the manual way. For the input, the image of the duck egg will be captured by the camera. The images will be processed using LabVIEW software first and will be converted from RGB to grayscale, then into binary based on threshold that will be defined after a series of tests to get the optimal threshold in getting better results. The pixel value will then be obtained and will be compared to the minimum and maximum threshold and will be identified as balut if it is more than the maximum threshold, penoy if it is less than the minimum threshold, or unknown if it does not fall on either threshold values. The results will be represented by the lighting of the LED; red for penoy, green for balut, and blue for the unknown.

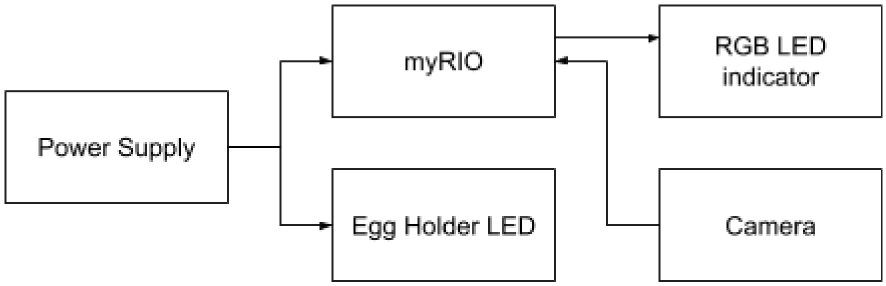

Figure 3.3 – Block diagram of the System

Figure 3.3 shows the whole connection of all the parts of the system in the form of blocks. The diagram shows the individual relationships of every component with each other to state a clear and brief description of how the whole system works. The process of the system starts by turning ON the switch in the power supply where it powers the camera and also the LED that lights up the duck egg on the holder which will illuminate the egg in order to view the growth of the embryo. The camera upon receiving signal from myRIO will capture the image of the illuminated egg which will be sent to the National Instrument (NI) MyRIO. The camera and MyRIO will work in order to process the image to identify the duck egg. After the image of the egg is identified, the result will be displayed in the multicolor LED – green light means the egg is “balut”, red light means the egg is “penoy”. An unknown identification is represented by blue light. An application created in LabVIEW program will be deployed to myRIO so that it will run on startup.

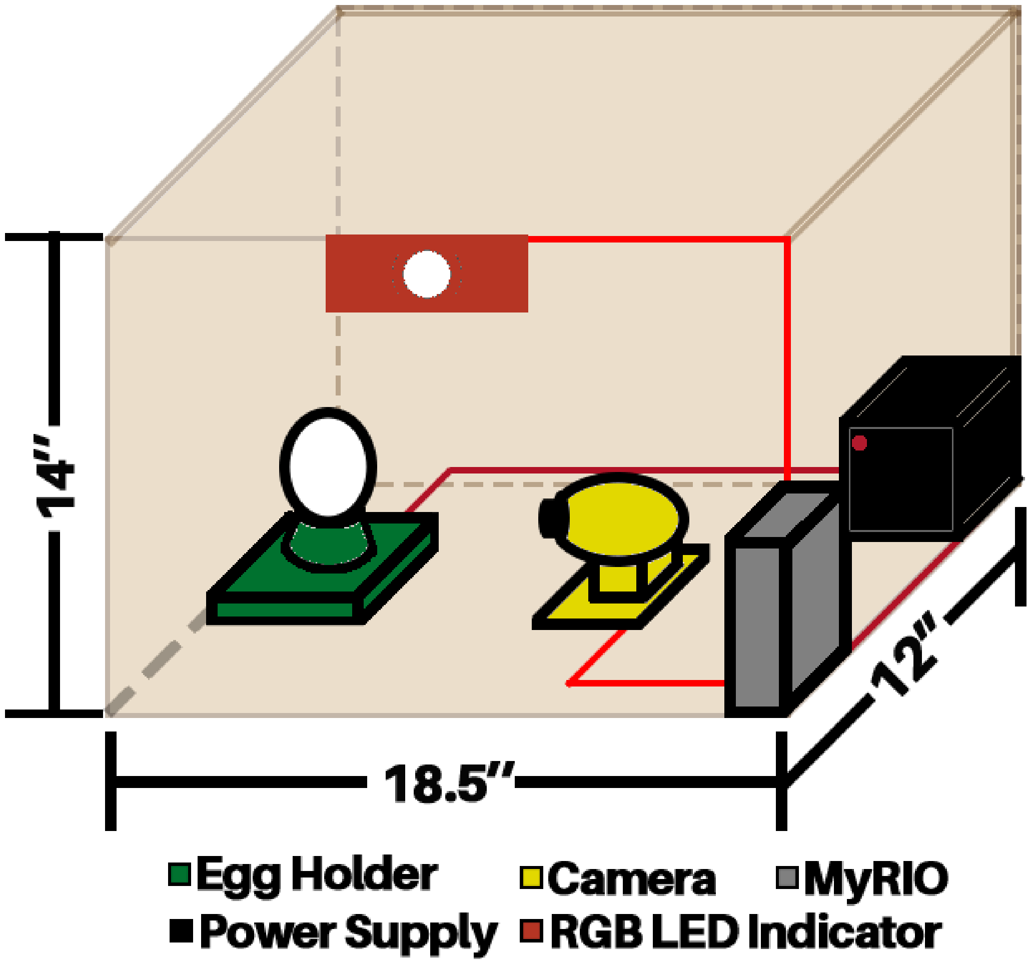

Figure 3.4 Conceptual Setup of the Device

Figure 3.4 shows the conceptual setup of the device. This shows the connections of the components as seen in Figure 3.3, Block Diagram of the System. It also shows that the system will include a box so that when capturing the image of the egg, the embryo can be seen better because of the dim environment where the only source of light is the LED from the egg holder. The box will be closed while the process is being done and the box must be made of an opaque material so that outside lighting will not affect the accuracy of the results. As seen in the figure, the Power Supply, NI Myrio, Camera, and Egg Holder will be placed inside the box while RGB LED will be placed outside the box for the testers to see the results.

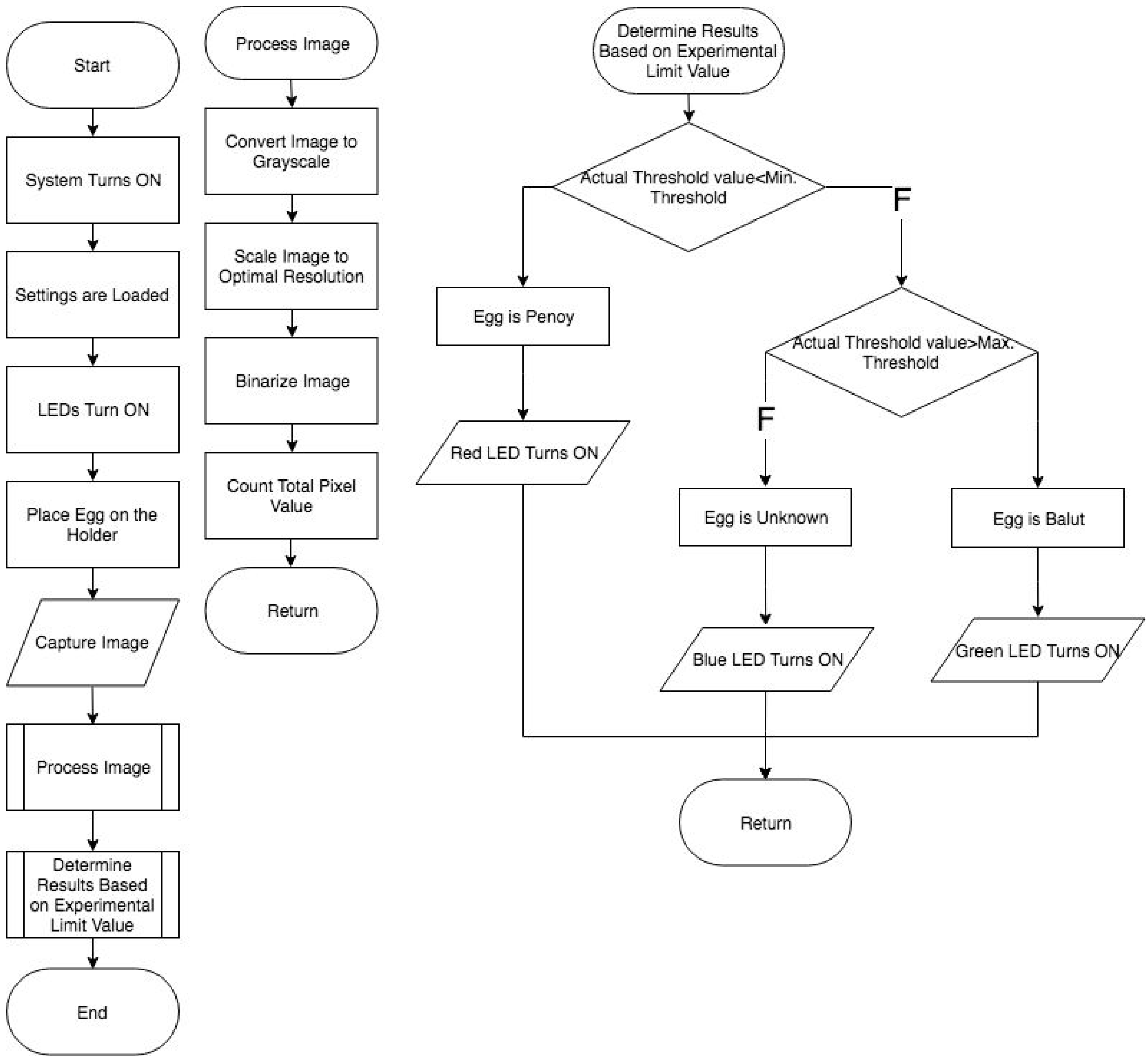

Figure 3.5 – System Flowchart

Figure 3.5 shows the flowchart of how the system works. When it starts, the system turns ON and loads the Settings and configurations both for the camera and the myRIO. The LEDs turns ON to show that the system is now ready for testing. The duck egg should be placed on the holder to be able to proceed to capturing the image. The image captured by the camera is gray-scaled in order to reduce the complexity of the process. In working with gray-scaled image, only one component is used and not RGB. The image will then be scaled to get the optimal resolution to get better results. After adjusting the optimal resolution for the image, the image will then be binarized depending on the defined threshold value that will be obtained through a series of testing to get the best value. After binarizing, the total pixel value will be obtained and will be compared to the minimum and maximum threshold value which will be the basis to determine the identification of the egg sample, whether the LED will turn Green for “balut”, Red for “penoy”, or Blue if the egg is unknown.

Calibration Procedure

1. Set the optimal distance of the camera and the holder.
2. Calibrate the camera using Chessboard Detection method to get the object points and image points to be able to get optimal camera settings.
3. Turn on the LED from the holder.
4. Place an classified duck egg on the holder making sure that the embryo can be seen by being illuminated by the LED.
5. Make sure that the lighting does not affect the capturing of the image.
6. Capture images of the illuminated egg
7. Identify the duck egg
8. If the if the identification is incorrect, modify the system and make the necessary adjustments.

Training Procedures

1. Place a classified egg on the holder.
2. Capture images of the illuminated egg in different positions and angles for the data set of the egg’s identification

3. Get the threshold value in pixels of the egg in each position.

4. Repeat the process for 36 more samples of the same type of duck egg

5. Get the threshold range from the recorded threshold values of the 36 samples.

6. Repeat the same steps for the data set of other types of samples.

Table 3.1 Iterations of Test for Balut Egg

Sample Number	Threshold Value in Pixels
Balut #1	
...	
...	
Balut # 36	

Table 3.2 Iterations of Test for Penoy Egg

Sample Number	Threshold Value in Pixels
Penoy #1	
...	
...	
Penoy # 36	

Table 3.3 Iterations of Test for Unknown

Sample Number	Threshold Value in Pixels
Unknown #1	
...	
...	
Unknown # 36	

Table 3.1, Table 3.2, and Table 3.3 show the threshold value in pixels for each sample balut, penoy egg, or unknown from the training procedures done. The researchers will conduct a series of tests on a number of those types to know the minimum and maximum threshold value required in order for the eggs to be identified respectively. The minimum and maximum thresholds range will be obtained from the summary of the results from these samples. For two identifications of duck eggs, there is a conversion of the black part of the egg into white and the clear part into black, which will be applied for image processing. After the photo underwent image processing, their identification will be determined. The number of samples may be more than what is shown in the table in order to get more accurate range of values for the thresholds.

Data Gathering Procedure

1. Connect the device to a computer through USB Drive.
2. Turn on the device and load the optimal configuration of the device.
3. Place the egg on the holder
4. Capture the image of the egg using the camera.
5. The egg will now be identified as “balut”, “penoy”, or “unknown”.
6. After identifying, the colored LED will light up depending on its classification.

Table 3.4 Threshold Range for Duck Eggs

Classification	Threshold Range
Penoy	
Balut	
Unknown	

For Table 3.4, it shows the summarized threshold range for both balut, penoy, and unknown obtained from the results in Table 3.1, Table 3.2, and Table 3.3. Using the threshold range, the duck eggs will be identified by comparing the threshold range to the obtained value from the sample. In getting more accurate threshold range, the researchers may test more samples for the said tables.

Table 3.5 Test Results

Sample Number	**Threshold Value in Pixels**	**Identification**	**LED(color)**
Egg #1			
Egg #2			
Egg #3			
...			
...			
...			
...			
...			
Egg # N			

Table 3.5 shows the test results from testing egg samples using the proposed system. It shows the threshold value of the egg sample, its classification(balut, penoy, or unknown), and the color of the LED that corresponds to its identification (green for balut, red for penoy, and blue for unknown). Getting correct results from this table will verify the accuracy of the system and

thus, completes this study's main objective. Otherwise, the researchers will need to make more adjustments and modifications to the system.

Statistical Analysis

Confusion Matrix is composed of data about the overall true recognition, overall false recognition, and the recognition rate for each of the classification or category. Confusion matrix table describes a classification model performance by using a set of test data having true values.

Table 3.4 Confusion Matrix of Results of Neural Network System

N= Number of Observations		Predicted		
		Penoy	**Balut**	**Unknown**
Actual	**Penoy**	TN	FP	A
	Balut	FN	TP	B
	Unknown	E	D	C

Table 3.4 shows the accuracy of the classifier which is in % on a number of observations. True negatives (TN) is the value when the classifier using image processing classified the duck egg as penoy, and it is evaluated as penoy. False positive (FP) is where the classifier using image processing classified the duck egg as balut, but it is evaluated as penoy. For false negative (FN) the classifier using image processing classified the duck egg as penoy, but it is evaluated as balut. On the other hand, if the classifier using image processing classified the duck egg as balut, and it is evaluated as balut, it is categorized as true positives (TP). Use Equation 1 for the accuracy wherein getting a high value mean a higher accuracy.

$$ACC= (TP+TN+C)/N$$

Eq. 3.1 Accuracy Formula

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