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by Teguh Herlambang 87

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DEVELOPING DESIGN OF AUTOMATIC EGG QUALITY DETECTOR USING ROI AND RGB TEMPLATE METHODS

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Abstract. *The eggs of purebred chickens always become the major choice for satisfying people's needs for nutrients. The way to process them is easy, and the prices are relatively cheap for all people. Since the eggs of purebred chickens are in high demand, a device that can detect their qualities more correctly and accurately is needed, compared to the conventional method. Objective: An automatic egg quality detector was developed through a camera module of pixy cmucam5 by employing ROI and template RGB methods. The implementation of the ROI method could optimize the system performance, thereby accelerating the process of egg quality detection carried out by the preprocessor of the pixy camera. ROI analyzed the egg image only on the desired pixel area, not the whole pixel. As a result, the ROI method yielded a device and system that could detect the egg quality within the average speed of detection time -/+ 2ms per egg out of 4 trial categories. Meanwhile, the template RGB method was able to improve and ease the ability of the pixy camera module in detecting the egg quality. When the RGB index of the egg was < 234, then the egg was of good quality. Contrarily, when the RGB index of the egg was > 234, the egg quality was in a bad category. The contribution of this paper is to develop a low-cost automatic egg sorting and detection system with the advantages of flexibility in device placement, due to the use of camera modules and object detection accuracy, as well as better response time than using color sensors. Accordingly, the template RGB method produced a device and system which could detect egg quality with average accuracy of 90 % and average error of 10% out of 4 trial categories. And, the results of the trials upon the detector system indicated success in detecting the egg quality.*

Keywords: *conveyor, egg quality detector, pixy CMUcam5, purebred chicken egg, RGB, ROI.*

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1. INTRODUCTION

Eggs have been the main choice of meeting the nutritional needs of people. The reason for this is that the processing is easy and the price is relatively low, compared to other animal protein sources. Currently, the national demand for chicken eggs is 65%, dominated those under the category of purebred chicken eggs [1]. It can be estimated that the national demand for eggs keep increasing until 2021 by 4.87% with a consumption rate of 4.18% per year [1]. But, with the need for so many eggs, the selection of quality types of eggs from producers, sellers, and to consumers is still done conventionally, with no guarantee whether the eggs are fine for consumption. Therefore, a new, more efficient method is required to detect good egg quality.

To overcome this matter, various innovation tools have been developed so as to make it easier for producers, sellers, and consumers to detect quality eggs. The first study used sensors BH1750 and MQ-2 as parameters in determining rotten eggs. The results of the study were very dependent on the sensitivity of the BH1750 sensor as the main medium for capturing the intensity of light emitted by the flashlight [1]. Then in another study, a good or bad egg detector was made by using an LDR (Light Dependent Resistor) sensor, a type of resistor of which the resistance changes with changes in the intensity of the light received. The results of the second study showed an accuracy of 87% out of 8 eggs tested in 4 tests. There was a discrepancy between the input and output in the second study, due to the egg with paint or dirt on it affecting the sensitivity of the LDR sensor [2].

The previous studies on egg quality detection still had weaknesses, including the inability to detect egg quality automatically in large quantities. In addition, the accuracy of detecting egg quality was still low due to the dependence on the accuracy of light, the strength of the human sense of sight, and the sensitivity of the sensor. The contribution of this paper is to develop a low-cost automatic egg sorting and detection system with the advantages of flexibility in device placement, due to the use of camera modules and object detection accuracy, as well as better response time than using color sensors.Based on the 2 studies conducted above, the author chose the title "Developing Design of Automatic Egg Quality Detector Using the ROI Method and RGB Template".

2. RESEARCH METHODS

Purebred chicken eggs are one of the sources of animal protein in great demand. Almost all people can consume purebred chicken eggs to satisfy their nutritional needs. This is due to the fact that purebred chicken eggs are relatively cheap and easy to obtain for the fulfillment of their expected nutritional needs. Eggs are composed of 3 main parts, that is the egg shell, the clear liquid (albumen), and the yolk [3].

The criteria for good quality eggs are as follows:

1. When viewed with a lamp, it looks clear, and the yolk is still intact in the middle position. That is because the light can penetrate the egg shell and liquid in it.
2. It doesn't smell bad
3. It sinks if put in water
4. The egg shell condition is not cracked / broken.

Whereas, the criteria for eggs with low quality are as follows:

1. yolk is not right in the middle position, it even tends to break
2. It smells bad if the egg shell is cracked.
3. When viewed with a lamp, it looks dark or not bright. This is because the light cannot penetrate the liquid in the egg.
4. If put in water, it floats.

Figure 1. Egg quality condition.

Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. The Arduino Due is the first Arduino board based on a 32-bit core ARM microcontroller with 54 input/output pins. Arduino Due can be programmed with Arduino Software (IDE) [4].

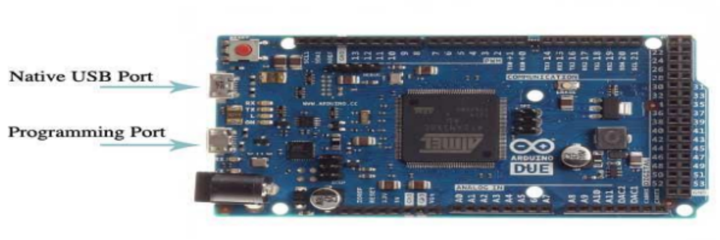

Figure 2. Arduino Due [4]

Pixy cmucam5 is a fast, low-cost camera module. Pixy cmucam5 can be connected directly to arduino and other controllers. The speed of Pixy cmucam5 is very fast (frame rate 50 Hz) [5]. For the colors commonly used in the pixy module algorithm, it uses 3 main RGB colors (Red, Green, Blue) as color representation [6].

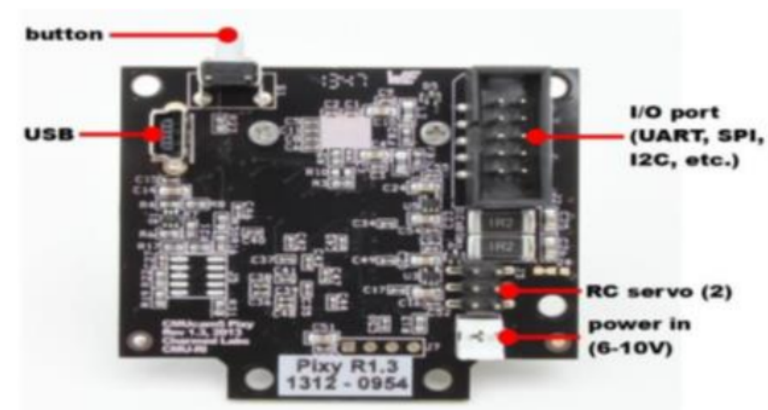

Figure 3. Parts of Pixy cmucam5 [5]

DC electric motor is an electromagnetic device that converts electrical energy into mechanical energy. A DC motor is more often used for purposes requiring speed regulation than AC motors [7] .

The motor driver is a circuit used to regulate the direction of rotation of a DC motor. The circuit consists of logical transistors (TTL) with nand gates that make it easy to determine the direction of rotation of the DC motor. The market has provided IC L298N as a DC motor driver and a pin is provided for input from PWM to regulate the speed of the DC motor. IC L298N uses 3 pins to control the rotation of the DC motor, namely: pin In1 (Input 1) and pin In2 (Input 2) to determine the direction of rotation of the DC motor being controlled, whether rotating clockwise (CW) or rotating counterclockwise. (CCW). The EnA (Enable A) pin is used to enable or disable the L298N motor driver [5].

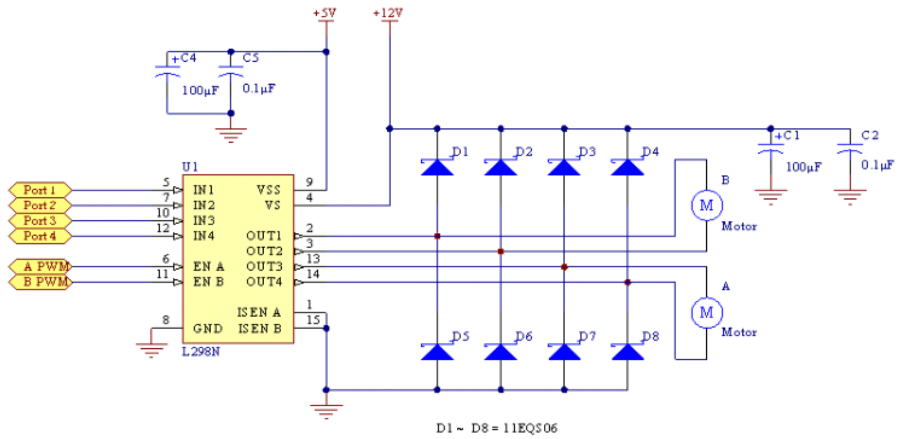

Figure 4. Schematic IC L298N as DC motor driver [5]

One way to adjust the rotational speed of a DC motor is by means of pulse width modulation or PWM (Pulse Width Modulation). PWM is a way to manipulate the pulse width in one period. PWM signal has a fixed frequency band, but with varying duty cycle (between 0% to 100%) [5].

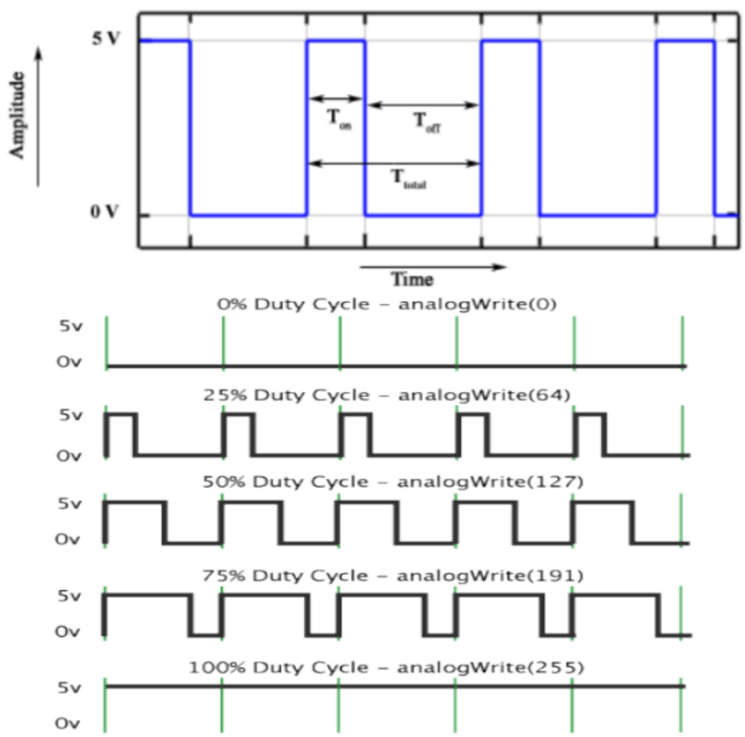

Figure 5. PWM Signal and Graph [5]

Conveyor is a mechanical system functioning to move goods from one place to another. The conveyor is driven by a drive / head pulley using a motor. Then, the head pulley will pull the conveyor [8]. Image processing is the processing of images by using a computer so that they become images with better quality. Image processing aims to improve image quality so that it is easily interpreted by humans or computers [9] . Digital image is a matrix of square or square pixels (picture elements) consisting of rows and columns. An image is represented by an object. Image is divided into two kinds: analog image and digital image. Digital images, according to their intensity, are divided into 3 types: color images, grayscale images, and binary images [10]. Region of Interest (ROI) is a part of the image selected for processing. Region of Interest (ROI) is one of the segmentation techniques as an image processing process where users are able to process images containing the desired image data information. In this study, ROI was used to get the RGB value of the image object in the area desired by the author [11].

ROI is used to optimize the algorithm by limiting certain areas of the frame so that the process is carried out only on the ROI part, not on the whole frame. The ROI implementation process can be carried out as follows:

1. Declaring the ROI function. There are 2 ways to declare ROI, firstly by representing it in the form of program lines and secondly by using the user interface, with the help of pixymon software.
2. Implementing it on the frame to be processed. To call the function from ROI is by using the following command on Arduino:

```
Pixy2 pixy;
Uint8_t r, g, b;
Pixy.video.getRGB (50, 75, & r, & g, &
b); // to get RGB value di location x =
50, y = 75 form figure oject
```

Using the above command, the author can get RGB value is in the area x = 50, y = 75 only. The area is the coordinates of the image pixels taken to be processed to get the RGB value of the image object

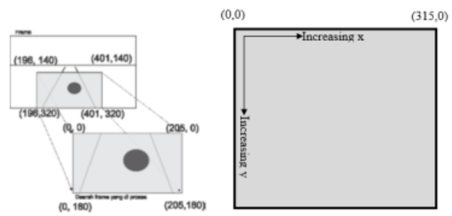

Figure 6. ROI projection on the frame [11]

In this study, in addition to using the ROI method and the RGB template, the Color Connected Components Algorithm will also be used. Color Connected Components (CCC) is a very popular algorithm because it is fast, efficient and relatively powerful. How this CCC Algorithm works is by calculating the color (hue) and saturation of each RGB pixel from the image sensor [6]. The formula for calculating space conversion from RGB to HSV images is as follows:

$$r = \frac{R}{(R+G+B)}, g = \frac{G}{(R+G+B)}, b = \frac{B}{(R+G+B)} \quad (1)$$

$$V = \max(r, g, b) \quad (2)$$

$$S\begin{cases} 0, & if\ V = 0 \\ 1 - \frac{\min(r,g,b)}{V}, & V > 0 \end{cases} \quad (3)$$

$$H\begin{cases} 0, & if\ S = 0 \\ \frac{60*(g-b)}{S*V}, & if\ V = r \\ 60 * \left[2 + \frac{b-r}{S*V}\right], & if\ V = g \\ 60 * \left[4 + \frac{r-h}{S*V}\right], & if\ V = b \end{cases} \quad (4)$$

$$H = \mathrm{H} + 360, \text{if H} < 0 \quad (5)$$

RGB color is the main color of an image, consisting of three main colors, that is, red, green, and blue. RGB images have a range of values in each pixel, that is, 0 to 225 [12] . The color space can be shown by the histogram graph h(i) below. With the range of values owned by RGB, if the occurrence of the value of h(i) <= 0, then the image is called dark. However, if the value of h(i) >= 255, then the image is called bright.

Generally, thresholding is used in the image segmentation process [13]. In the thresholding process, a value is needed as a limiter and comparison in a program. In this study, thresholding was used to threshold the value of the RGB color index so that it can be used as a parameter in determining the expected research object. LED is a semiconductor that converts electrical energy into light. LED is a special kind of semiconductor diode. In contrast to incandescent or fluorescent lamps, LED has polarization [14].

Pixymon v2 is software used by users to see what the pixy camera module sees, and at the same time it is used to declare ROI and configure the Pixy camera module so that it can process images and detect objects as desired by the user. Pixymon v2 can be connected to the camera's pixy module by using a small USB cable [6].

SArduino IDE 1.8.5 Software

Arduino IDE is an open source software written in Java. Arduino IDE is used to program Arduino Due boards. Arduino IDE consists of:

1. Program editor, a window that allows users to write and edit Arduino board programs.
2. Compiler, a module that converts program code (processing language) into binary code.
3. Uploader, a module that loads binary code from a computer into memory on the Arduino board [6].

This incandescent or Bohlam dimmer is used to adjust the lighting level of the incandescent lamp. In this dimmer module set, there are 3 important components that regulate the work of this module. They are TRIAC, DIAC, and VR components [15].

Figure 7. Dimmer set module [15]

Incandescent lamp (bohlam) is an artificial light source obtained through the process of distributing electric current through a filament, which then heats up and produces light [16]. Proximity sensor is a sensor or switch that can detect objects without physical contact [17]. This E18-D80NK proximity sensor is used to detect egg objects moving through the conveyor. This sensor has a detection distance of 3 – 80 cm. There are three configuration wires on the E18-D80NK sensor, that is, the brown wire for +5VDC input voltage, blue for ground, and black for digital output.

Figure 8. Proximity sensor E18 D80NK

This LM2596 step down module has specifications, among others, having an input capacity of 3.2v to 40v and an output LM2596 step down module has specifications, among others, an input capacity of 3.2v to 40v and an output capacity of 1.25v to 35v. The LM2596 module uses a potentiometer to adjust the output voltage, so that the resulting output can be accurate and stable [18].

LCD or Liquid crystal display is an electronic component used to display output in the form of characters by utilizing liquid crystals [19]. Inside the LCD module there is a microcontroller equipped with memory and registers as a regulator of the character display on the LCD.

After testing the tools and systems, analysis and calculations are carried out based on the test results data. Calculations are done to determine the error rate of the tools and system made. Therefore, it is necessary to have a formula to find out the error value. The formula for the error percentage calculation is as the equation below [20].

% error = (original value – measure ment value / original value) x 100% (6)
% accuracy = (measurement value/ original value) x 100% (7)

To develop and design the device in systematic and structured steps, a system block diagram is made describing the designed tools.

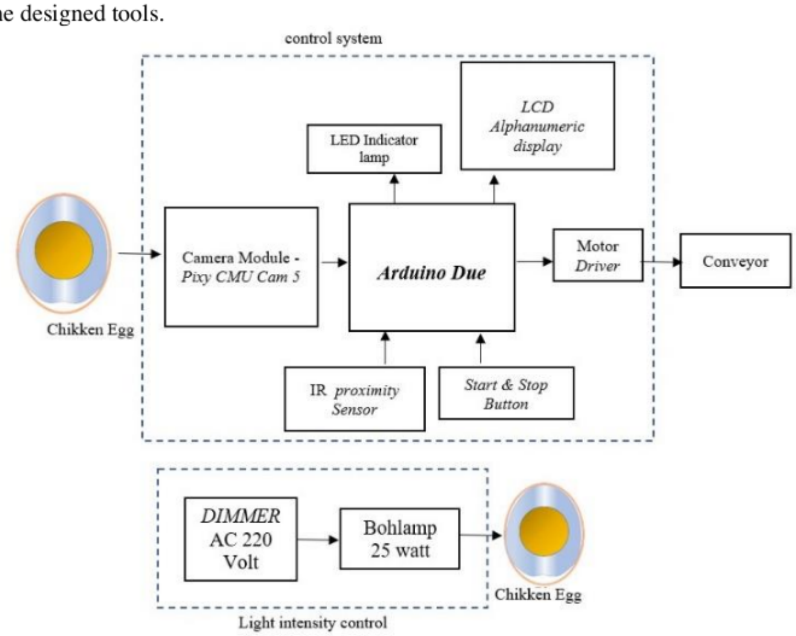

Figure 9. Diagram Block Diagram

The schematic drawing of the circuit is shown in the image below.

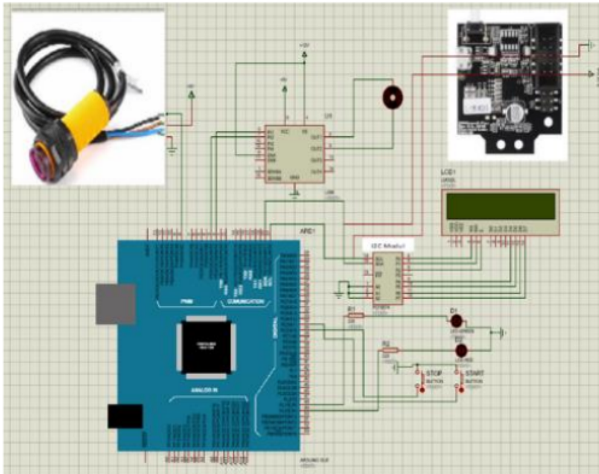

Figure 10. Schematic drawing of A*rduino* circuit

In the design and make of research tools, there are 2 flowcharts explaining how the pixy and Arduino due camera modules work. The flowchart is as follows:

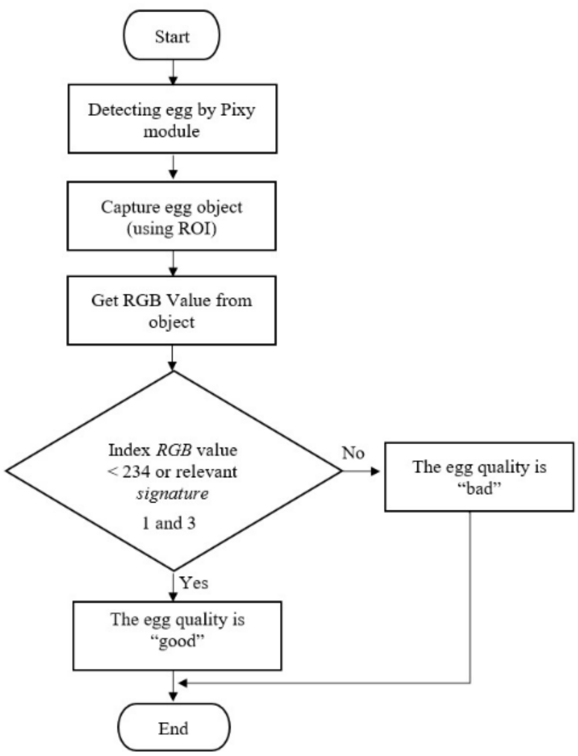

Figure 11. System Flowchart of pixy camera module

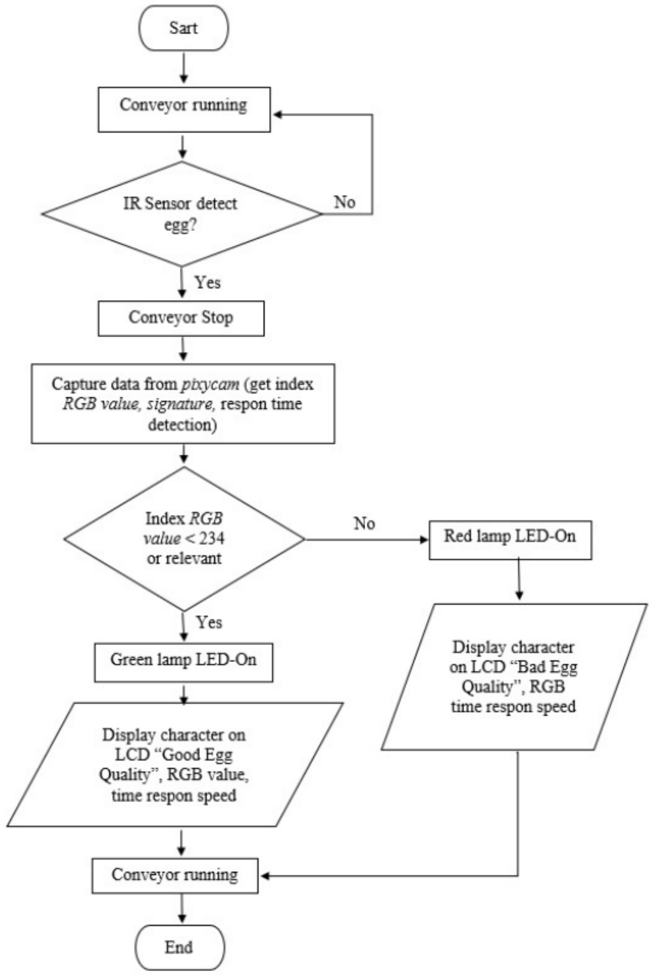

Figure 12. System flowchart of Arduino due

3. RESULTS AND DISCUSSION

Numerical computation in this paper makes the missile model a platform in missile trajectory estimation because the missile model is a nonlinear model. So, the use of UKF is one way to obtain a high accuracy.

In this paper, two simulations are compared, covering a simulation on the missile trajectory for going upwards and then plunging downwards, while the second simulation is a missile shooting a target at an altitude of about 1000 meters. The first simulation is represented in Figure 2 – Figure 5, and the second simulation is represented by Figure 6 – Figure 9 of error value for two simulations is in Table 2.

The tools and system testing were carried out 20 times, divided into 4 experimental categories. The four categories are the first experiment with a bulb light intensity of 100% carried out during the day, the second one with a light bulb intensity of 75% carried out during the day, the third one with a light bulb intensity of 100% at night, and the fourth one with the light intensity of the bulb of 75% at night. The egg objects used were 10 good eggs and 10 bad eggs. The following are the test results as shown in the table below.

Figure 13. Mechanical testing of the tools

Figure 14. Egg objects of material testing

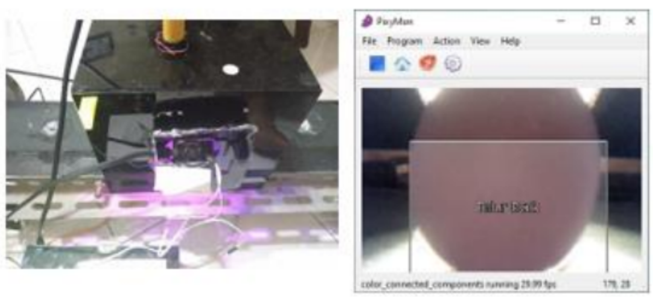

Figure 15. Pixy camera module testing

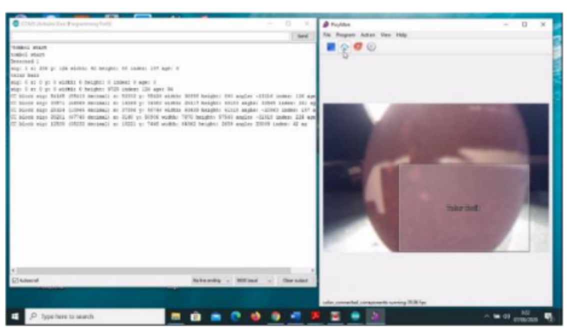

Figure 16. Software monitoring display when the camera module detects an egg object of good quality

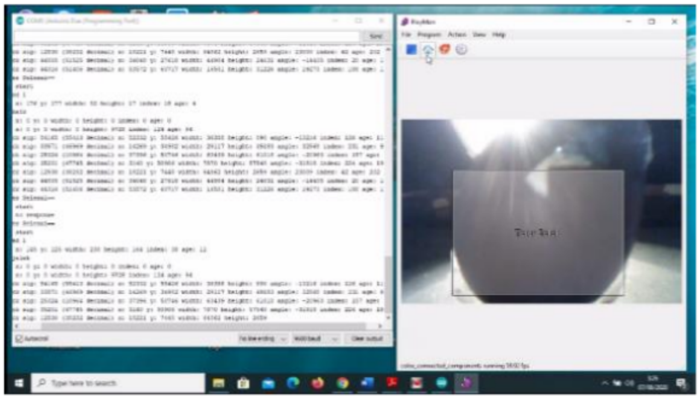

Figure 17. Software monitoring display when the camera module detects an egg object of bad quality

Table 1. Experimental Data of Category 1 (Day Time with Bulb Light Intensity of 100%)

Egg No	RGB Value			Egg Standard	Output Indicator	Explanation	Time Response (ms)
	R	G	B				
1	255	152	160	Good	Good	detected	12
2	222	225	255	Bad	Bad	detected	12
3	255	204	230	Good	Good	detected	12
4	219	228	255	Bad	Bad	detected	12
5	255	157	187	Good	Good	detected	12
6	255	227	241	Bad	Bad	detected	12
7	255	193	196	Good	Good	detected	12
8	255	229	238	Bad	Bad	detected	12
9	255	188	201	Good	Good	detected	12
10	0	0	0	Bad	Miss Detected	Not detected	12
11	255	181	190	Good	Good	detected	12
12	255	236	252	Bad	Bad	detected	12
13	255	179	203	Good	Good	detected	12
14	255	241	238	Bad	Bad	Not detected	12
15	255	218	229	Good	Bad	detected	12
16	255	232	227	Bad	Bad	detected	12
17	0	0	0	Good	Miss Detected	Not detected	12
18	255	239	239	Bad	Bad	detected	12
19	255	185	208	Good	Good	detected	12
20	255	236	252	Bad	Bad	detected	12

Table 2. Experimental Data of Category 2 (Day Time with Bulb Light Intensity of 75%)

Egg No	RGB Value			Egg Standard	Output Indicator	Explanation	Time Response (ms)
	R	G	B				
1	255	176	180	Good	Good	detected	12
2	255	238	252	Bad	Bad	detected	12
3	255	175	175	Good	Good	detected	12
4	246	244	255	Bad	Bad	detected	12
5	255	215	220	Good	Good	detected	12
6	255	236	236	Bad	Bad	detected	12
7	255	202	212	Good	Good	detected	12
8	255	236	247	Bad	Bad	detected	12
9	255	188	195	Good	Good	detected	12
10	255	244	238	Bad	Bad	detected	12
11	255	225	225	Good	Bad	Not detected	12
12	255	241	232	Bad	Bad	detected	12
13	255	182	178	Good	Good	detected	12

Egg No	RGB Value			Egg Standard	Output Indicator	Explanation	Time Response (ms)
	R	G	B				
14	255	237	246	Bad	Bad	detected	12
15	255	227	224	Good	Bad	Not detected	12
16	252	234	255	Bad	Bad	detected	12
17	255	167	181	Good	Good	detected	12
18	235	215	255	Bad	Bad	detected	12
19	255	168	194	Good	Good	detected	12
20	248	235	255	Bad	Bad	detected	12

Table 3. Experimental Data of Category 3 (Time with Bulb Light Intensity of 100%)

Egg No	RGB Value			Egg Standard	Output Indicator	Explanation	Time Response (ms)
	R	G	B				
1	255	176	180	Good	Good	detected	12
2	255	238	252	Bad	Bad	detected	12
3	255	175	175	Good	Good	detected	12
4	246	244	255	Bad	Bad	detected	12
5	255	215	220	Good	Good	detected	12
6	255	236	236	Bad	Bad	detected	12
7	255	202	212	Good	Good	detected	12
8	255	236	247	Bad	Bad	detected	12
9	255	188	195	Good	Good	detected	12
10	255	244	238	Bad	Bad	detected	12
11	255	225	225	Good	Bad	Not detected	12
12	255	241	232	Bad	Bad	detected	12
13	255	182	178	Good	Good	detected	12
14	255	237	246	Bad	Bad	detected	12
15	255	227	224	Good	Bad	Not detected	12
16	252	234	255	Bad	Bad	detected	12
17	255	167	181	Good	Good	detected	12
18	235	215	255	Bad	Bad	detected	12
19	255	168	194	Good	Good	detected	12
20	248	235	255	Bad	Bad	detected	12

Table 4. Experimental Data of Category 40(Night Time with Bulb Light Intensity of 75%)

Egg No	RGB Value			Egg Standard	Output Indicator	Explanation	Time Response (ms)
	R	G	B				
1	255	165	167	Good	Good	detected	12
2	234	230	255	Bad	Bad	detected	12
3	255	165	177	Good	Good	detected	12
4	252	238	255	Bad	Bad	detected	12
5	255	201	199	Good	Good	detected	12
6	226	223	255	Bad	Bad	detected	12
7	255	225	222	Good	Bad	Not detected	12
8	255	240	230	Bad	Bad	detected	12
9	255	223	221	Good	Good	detected	12
10	255	238	231	Bad	Bad	detected	12
11	255	230	243	Good	Bad	Not detected	12
12	255	246	243	Bad	Bad	detected	12
13	255	222	218	Good	Good	detected	12
14	255	243	231	Bad	Bad	detected	12
15	255	238	236	Good	Bad	Not detected	12
16	255	240	237	Bad	Bad	detected	12
17	255	214	206	Good	Good	detected	12
18	252	245	255	Bad	Bad	detected	12
19	255	195	216	Good	Good	detected	12
20	255	236	226	Bad	Bad	detected	12

From the total experiments of categories 1 to 4 and referring to the equations of formulas 6 and 7, the average error and the average accuracy of the tools and systems are as follows:

% average error = (total number of eggs tested – number of eggs detected) / total number of eggs tested x 100%
% average error = (80 – 72) / 80 x 100 %
% average error = 8 / 80 x 100 %
% average error = 10 %

That is, the reliability of the tools and system in detecting egg quality is,

% average accuracy = (number of eggs detected / number of eggs tested) x 100 %
% average accuracy = (72/80) x 100 %
% average accuracy = 90 %

4. CONCLUSION

After the tools and system testing as well as the data analysis, the conclusions drawn were as follows:

1. Designing and making an automatic egg quality detector based on the RGB color index obtained an average error of 10% and an average accuracy of 90% under the 4 categories of experiments.
2. The obtained error value of the category 1 experiment with 20 trials reached 15%, that of the category 2 experiment with 20 trials reached 10%, and that of the category 3 experiment with 20 trials reached 0%. And, the average accuracy of the tools or system reached 90%. Thus, based on test results, the egg quality detection system was effective or successful in detecting egg quality.

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