Internal and External Quality Inspection of Multiple Eggs using Image Processing

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***Abstract*— Automatic separation of defective eggs from qualified would lead to a great reduction on the graders visual stress as well as to an improvement on the quality control process. This paper presents image processing based non-destructive and cost- effective technique to detect various cracks, dirt in a egg shell and defective eggs. For estimating the freshness of the egg, the acquired candled images are enhanced to detect the bloodspots and then the number of pixels labeled as blood spots are counted. The database consists of acquired images from eggs under different illumination condition. With the use of our system the acquired images will be undergo in image processing techniques to state if the quality of an egg is qualified or not. The result shows that the egg's grade classification has achieved to detect the external dirt and crack 100% however due to the limitations sometimes the dirt and crack are overlapping and gives us a result 66.67%. For the internal part the result shows also achieved to find the yolk inside in each egg.**

***Index Terms*— Egg classification, Egg inspection, Image processing, RGB, HSV.**

I. Introduction

Egg is one of the most important products to humans because of its nutritional value. Eggs are a very good source of inexpensive, high quality protein. More than half the protein of an egg is found in the egg white along with vitamin B2 and lower amounts of fat than the yolk. Eggs are rich sources of selenium, vitamin D, B6, B12 and minerals such as zinc, iron and copper. Egg yolks contain more calories and fat than the whites. They are a source of fat soluble vitamins A, D, E and K and lecithin the compound that enables emulsification in recipes such as hollandaise or mayonnaise [1] Based on the standards of U.S. Department of Agriculture, a high quality egg will have a smooth, well-shaped shell free of blemishes and cracks [3]. Quality control is really a must not only in manufacturing egg but in other products in terms of vending. With this, those products nor the eggs will be much enjoyed by the consumer.

Checking and grading products, specifically eggs, is not a simple thing to do. It will require great effort as the way of checking and grading eggs is done manually one by one. But if done automated, it will be much more expensive. Also, checking and grading eggs is done only by one person, for the reason that chickens is not comfortable with many people that it stresses them to the point that they will not produce eggs unless they are now comfortable [4].

Egg grading is used in the egg industry to reduce waste, as well as customer confusion regarding egg quality. Using official standards for grading allows egg producers to conduct business and marketing through a common language, and ensures consumers of a consistent quality product. Here are various ways to grade such eggs manually. These are "Sink and Float test", "Shake the egg test" and "Egg candling test". These tests are simple to do and will definitely give you a result.

First one is "The sink and float test" that is not quite used by the poulterer. The process of which it is done is just by filling a bowl with cold water and place your eggs in the bowl. If they sink to the bottom and lay flat on their sides, they're very fresh. If they're a few weeks old but still good to eat, they'll stand on one end at the bottom of the bowl. If they float to the surface, they're no longer fresh enough to eat [6]. You can say that this way is easy to deal with and solely for crack detecting. So despite the difficulty on doing such way, it's still not the most efficient process given that the eggs that are capable with this process is only for the crack-free eggs.

For the next technique, it is the "egg candling test". It is a non-destructive procedure that consists on applying light against an egg to detect abnormalities. It is crucial to recognize the defects inside the egg, thus an analysis beyond superficial vision should be performed [9]. This process detects blood stains, spots, cracks, enlarged air cells and fertilized eggs [4]. This process is manually done one by one so it is not easy to do. But unlike the other test, this process is usually used, and done manually at small and medium poultry factories. And like the other tests, this process also has a flaw. This entails several health problems to the worker. It implies an exposition to a high-intensity light and to work in a dark room during long periods of time. As a result, the operator progressively damages his eye vision and develops other health issues [8].

Adapting the idea of manual egg candling which is widely used by poulterer, it is very hard to know if the egg is properly checked because there is no standard basis of the good quality eggs. Even though manual egg candling is known to be used in the Philippines to test the egg quality sold in the market, we all know that it is really hard to maintain a good result if we depend on the capacity of every worker. All workers have different point of views and it does make a big difference in the final output or the result.

The findings of this study will redound to the benefit of the workers in poultry. The system will play an important role in the process of manufacturing chicken eggs. Thus, workers that will apply the recommended system derived from this study will be able to handle the manual egg candling better and faster. This will also reduce the human mistakes and the quality of the eggs that will be provided will be good.

II. Methodology

A. External Dirt Detection Algorithm

Different substances are sometimes present on the eggs. Since egg is a food product, it is important in this case that the software can accurately display regions of potential stains. This way, users can increase the quality of the eggs by detecting which eggs are dirty. Since the software will take a live feed of the eggs from a camera, we can say that the algorithm takes effect on every frame of the feed to show the user and highlight the dirt on the eggs. The whole process is described in figure 2.1.

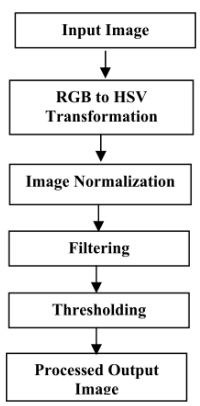

Figure 2.1: Dirt detection block diagram

1.) **Input Image** - The raw image obtained from the camera.

2.) **RGB to HSV transformation** - Converting the image from RGB color space to HSV color space.

3.) **Image normalization** - changing the range of the pixel intensity values to be more consistent with other pixels using a kernel (50, 50).

4.) **Filtering** - Reducing the effects of the background to the whole image itself with the use of median blur having a value of 3.

5.) **Thresholding** - Modifying the algorithm's threshold so that only the dirt will become apparent to the whole image with the use of Gaussian value (225) and binary threshold value (115,1).

6.) **Processed Output Image** - Output dirt detected image.

The reason the researchers converted the image into HSV; which required the image processed from RGB originally, because HSV provides the capability to separate color components from intensity which allows the researchers to optimize the algorithm from lighting changes and removing shadows. In this way, the dirt or unwanted materials can be easily highlighted and identified.

B. External Crack Detection Algorithm

The same approach is implemented by the researchers to detect cracks present on the surface of the eggs. The difference is, a different algorithm is required to acquire the desired result. The software will first accept a live feed of the eggs which will then be processed by the algorithm frame by frame. The whole process is described in figure 2.2

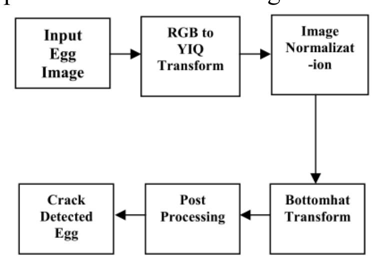

Figure 2.2: Crack detection block diagram

1.) **Input Egg image** - The raw image obtained from the camera.

2.) **RGB to YIQ transform** - Converting the image from RGB color space to YIQ color space.

3.) **Image Normalization** - changing the range of the pixel intensity values to be more consistent with other pixels using gaussian blur value of (3,3)

4.) **Post processing** - Enhancing the image so that the crack is more apparent with the use of canny edge value of (30,110).

5.) **Bottomhat Transform** - Isolation of the cracks from most of the parts of the image using the function from the morphology having a value of (50,50)

6.) **Crack detected Egg** - Output crack detected image

The researchers have decided that converting the image from RGB to YIQ will be optimal for the system. Using the YIQ color space; which is intended to take advantage of human color-response characteristics, have shown that when implementing it to the functionalities of the system will highlight and reveal even the smallest of shadows present on the surface of the eggs caused by the tiny cracks, breaks or damages on the egg. The rest of the processing as part of the algorithm are included to further highlight and assist the user in observing the eggs.

C. External Dirt and Crack Detection of Multiple Eggs Algorithm

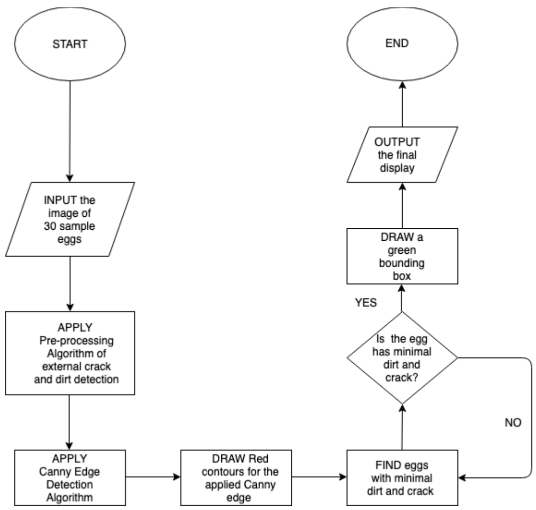

Figure 2.3: Dirt/Crack Detection of Multiple Eggs Flow Chart

A flow chart is a graphical or symbolic representation of a process. Each step in the process is represented by a different symbol and contains a short description of the process step. The flow chart symbols are linked together with arrows showing the process flow direction. The system flow chart above figure 2.3 will also have start, input, process, output and end. The process will apply the external and internal egg detection algorithm.

The first step is to input the image of the 30 sample eggs then proposed pre-processing algorithm will be applied. The Pre-Processing algorithm for external is External Dirt and Crack algorithm. The second step is applying the canny edge detection algorithm with a threshold value (30,110) and this will be useful to enhance the visibility of the dirt and crack then it will be drawn by a red lines or red contours. The final step is to find eggs with minimal dirt and crack then after finding it then it will be bounded by a green box labeled as good condition

D. Internal Egg Detection Algorithm

The same approach is taken by the researchers when implementing the detection of internal bloodspots inside the egg. The only difference between this algorithm and the first two described algorithm is that this algorithm is designed to process the frames of the eggs when the eggs are illuminated underneath with a light source. The whole process is described in figure 2.4

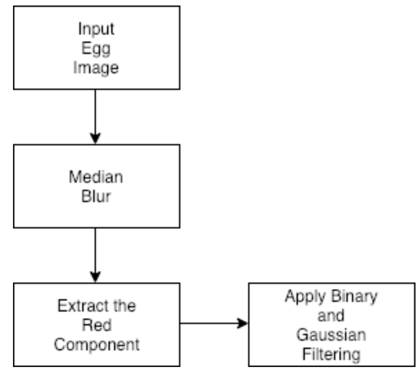

Figure 2.4: Internal detection block diagram

1.) **Input Egg Image** - The raw image obtained from the camera.

2.) **Median Blur** - Blurring the background from the rest of the eggs using a median blur value 19 and a combination of gray scale.

3.) **Extract the red component** - Blood spots are isolated and enhanced using the erosion with a kernel value (7,7). Yolk is now clearly visible if present.

4.) **Apply Binary and Gaussian Filtering** - Blobs are created which represents the yolks using the value of (255, 115). This part also shows the output of the internal detected egg image.

No special conversions will be applied to the frames of the feed; but enhancements to the images of the frames will be applied so that the software will be able to accurately. This will view the interior of an egg then the egg yolk is now clear visible. The applied algorithm will also show you the exact shape of the egg clearly. This will also help you to see better if there is a defect inside the egg.

E. Internal Detection of Multiple Eggs Algorithm

The system flow chart above will also have start, input, process, output and end. The process will apply the internal egg detection algorithm. The external and internal algorithms are separated because for the internal algorithm it need to turn on the light below the sample eggs.

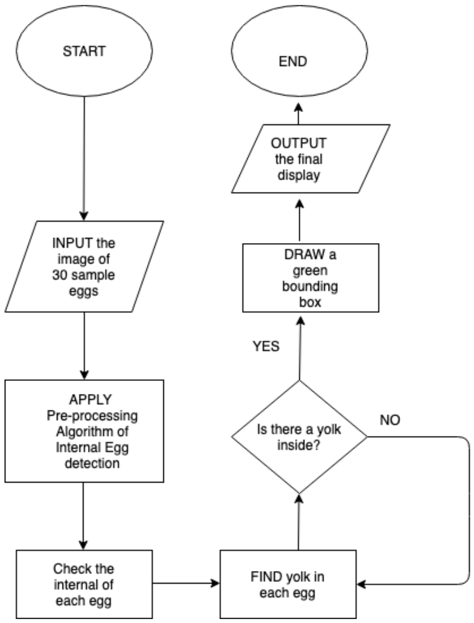

Figure 2.5: Internal Detection of Multiple Eggs Flow Chart

The first step is to input the image of the 30 sample eggs then proposed pre-processing algorithm will be applied. The Pre-Processing algorithm is the internal detection algorithm. The next step is to check the internal of each egg and find the yolk inside. After finding the yolk the egg with yolk will be bounded by the box.

III. Results and Discussion

A. *External Dirt Detection Algorithm*

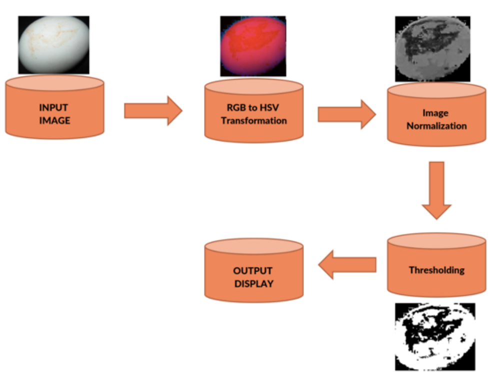

Figure 3.1: Result of Dirt Detection Algorithm

Hue provides a useful and intuitive cue that is used in a variety of computer vision applications. He is an attractive feature as it captures intrinsic information about the colour of objects or surfaces in a scene. Figure shows the RGB image and its corresponding H, S, V components. Since, the Hue component shows area appears to be similar to one of the perceived colours it can be used for dirt detection. The next step of the dirt detection algorithm is image normalization. The Hue component and the normalized image. The thresholding operation is used to change or identify pixel values based on specifying one or more values (called the threshold value). The result of applied algorithm is shown above figure 3.1 and the dirt is detected after applying all the process.

The reason converted the image into HSV; which required the image processed from RGB originally, because HSV provides the capability to separate color components from intensity which allows the researchers to optimize the algorithm from lighting changes and removing shadows. In this way, the dirt or unwanted materials can be easily highlighted and identified.

B. *External Crack Detection Algorithm*

Converting the image from RGB to YIQ will be optimal for the system. Using the YIQ color space; which is intended to take advantage of human color-response characteristics, have shown that when implementing it to the functionalities of the system will highlight and reveal even the smallest of shadows present on the surface of the eggs caused by the tiny cracks, breaks or damages on the egg. The rest of the processing as part of the algorithm are included to further highlight and assist the user in observing the eggs.

The RGB image is converted to YIQ color space and the Luminance component is taken. Normalization scales the brightness values of the active layer so that the darkest point becomes black and the brightest point becomes as bright as possible, without altering its information content. Original image and its normalized output is shown in Figure 3.1.

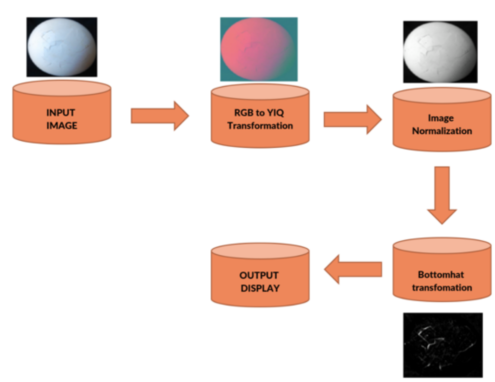

Figure 3.2: Result of Crack Detection Algorithm

The bottom-hat filter is used to highlight structures with defects and separate them from the background. This process consists of two stages: i) First, use the morphological closing operator on the original image, which allows the elimination of most hypothetical cracks, and as a consequence a background similar to that of the original image is generated, but without defects. ii) Second, use the subtraction operator between the original image and the modified image from the first stage. As a result, the smaller structures, which in general are cracks, are revealed because of their separation from the background. The resultant bottom hat filtered image is shown in Figure 3.1. Bottom-hat filter is the best algorithm for crack detection like the x-ray for human skeletal system.

The binary thresholding is applied to the result generated by the bottom-hat filter by defining a grayscale cutoff point. Grayscale values below the cutoff become black and those above become white. Hence the cracks are clearly visible.

C. External Dirt and Crack Detection of Multiple Eggs Algorithm

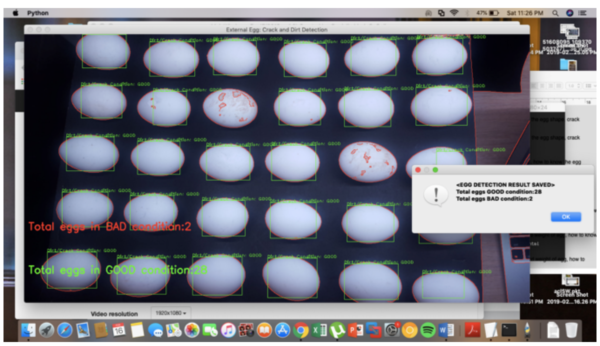

Figure 3.3: Dirt/Crack Detection Result of Multiple Eggs

The group conducted a testing for the external crack and dirt detection. The system will also detect if there are crack and dirt in each egg. The red contour will serve as the lines for crack and dirt in each egg to make visible. The system will find eggs with edible and GOOD condition. After detecting the good condition eggs it will be bounded by a green box and it will be classified as GOOD condition.

D. Internal Detection of Multiple Eggs Algorithm

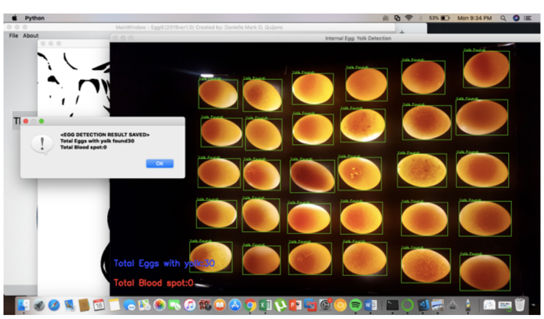

Figure 3.4: Internal Detection Result of Multiple Eggs

The group conducted a testing for the Internal Egg detection. The system will also detect if there is a yolk in each egg. The system will find eggs with a yolk inside. After detecting the yolk in each egg it will be bounded by a green box and it will be classified as “Yolk Found”. The system will generate a result with the total eggs with yolk and if there is a blood spot

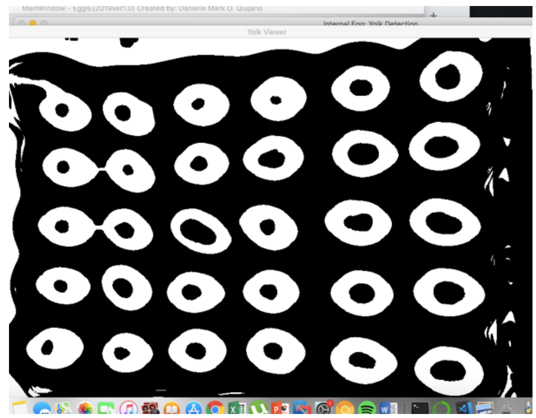

Figure 3.5: Internal Detection Result of Multiple Eggs

Lastly the system will also view the internal view this is for checking the yolk inside in each egg. The group observe that there is really a yolk inside in each egg.

E. Statistical Analysis

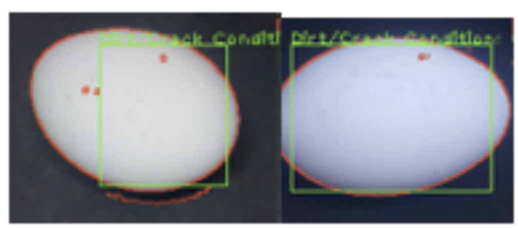

Figure 3.6 Sample eggs with low dirt

The figure shown above is an example of egg with low dirt. This is the basis for a low dirt egg that will be used for the legend marking. The canny algorithm threshold used for detecting the low dirt was from the numerical value 1-29. It will be bounded by a green box if it is still in good condition.

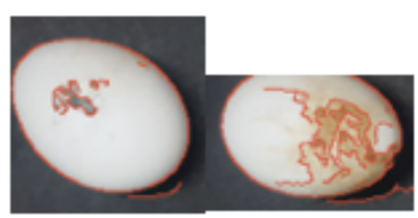

Figure 3.7 Sample eggs with high dirt

The figure shown above is an example of egg with low dirt. This is the basis for a high dirt and cracked egg that will be used for the legend marking. The canny algorithm threshold used for detecting the high dirt was from the numerical value 30-110.

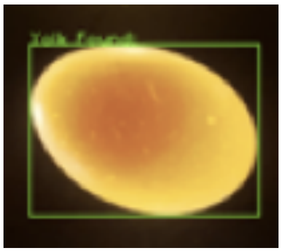

Figure 3.7: Sample egg with yolk

The figure shown above is an example of egg with yolk. This is the basis for an egg with yolk that will be used for the legend marking. The system will box the egg if it finds an egg yolk. The area threshold of the contour to find the egg yolk is approximately 6000 to 10000 in the system.

Figure 3.7: Sample egg with no yolk

The figure shown above is an example of egg with no yolk. This is the basis for an egg with no yolk that will be used for the legend marking. The egg is yolkless if the egg did not meet the specified area threshold of the contour.

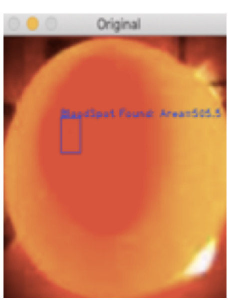

Figure 3.8: Sample egg with BloodSpot

The figure shown above is an example of egg with blood spot. This is the basis for an egg with bloodspot that will be used for the legend marking. Bloodspot will be seen if the yolk has a spot after applying the algorithm.

Legend for External:	**Legend for Internal:**
2= HIGH Dirt/Crack	
1 = LOW Dirt/Crack	1= Blood Spot Found / No Yolk
0 =NO Dirt/Crack	0 = NO Blood Spot / Yolk FOUND

Table 3.1: Testing results of External detection using multiple eggs

Egg#	External (Expected)		External (Actual)		External (Accuracy)	
	Crack	Dirt	Crack	Dirt	Crack	Dirt
1	0	0	0	0	100%	100%
2	0	0	0	0	100%	100%
3	0	0	0	0	100%	100%
4	0	0	0	0	100%	100%
5	0	0	0	0	100%	100%
6	0	0	0	0	100%	100%
7	0	0	0	0	100%	100%
8	1	0	1	1	100%	66.67%
9	0	2	0	2	100%	100%
10	0	1	0	1	100%	100%
11	0	0	0	0	100%	100%
12	0	1	0	1	100%	100%
13	0	0	0	0	100%	100%
14	0	0	0	0	100%	100%
15	0	0	0	0	100%	100%
16	0	2	0	2	100%	100%
17	0	0	0	0	100%	100%
18	0	0	0	0	100%	100%
19	0	0	0	0	100%	100%
20	0	0	0	0	100%	100%
21	0	0	0	0	100%	100%
22	0	0	0	0	100%	100%
23	0	0	0	0	100%	100%
24	0	0	0	0	100%	100%
25	0	0	0	0	100%	100%
26	0	0	0	0	100%	100%
27	0	0	0	0	100%	100%
28	0	0	0	0	100%	100%
29	0	0	0	0	100%	100%
30	0	0	0	0	100%	100%

The table 3.1 shown above is the testing results for external egg detection in multiple eggs. The group verifies that the system detected 28 eggs from the poultry farm that in good condition considering the external quality of the shell

Table 3.2: Testing results of Internal Detection using multiple eggs

Egg#	Internal (Expected)		Internal (Actual)		Internal (Accuracy)	
	Blood Spot	Yolk	Blood Spot	Yolk	Blood Spot	Yolk
1	0	0	0	0	100%	100%
2	0	0	0	0	100%	100%
3	0	0	0	0	100%	100%
4	0	0	0	0	100%	100%
5	0	0	0	0	100%	100%
6	0	0	0	0	100%	100%
7	0	0	0	0	100%	100%
8	0	0	0	0	100%	100%
9	0	0	0	0	100%	100%
10	0	0	0	0	100%	100%
11	0	0	0	0	100%	100%
12	0	0	0	0	100%	100%
13	0	0	0	0	100%	100%
14	0	0	0	0	100%	100%
15	0	0	0	0	100%	100%
16	0	0	0	0	100%	100%
17	0	0	0	0	100%	100%
18	0	0	0	0	100%	100%
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23	0	0	0	0	100%	100%
24	0	0	0	0	100%	100%
25	0	0	0	0	100%	100%
26	0	0	0	0	100%	100%
27	0	0	0	0	100%	100%
28	0	0	0	0	100%	100%
29	0	0	0	0	100%	100%
30	0	0	0	0	100%	100%

The table 3.2 shown above is the testing results for internal egg detection in multiple eggs. The group verifies that the system detected 30 eggs with yolk inside and no blood spot.

Formula for getting the accuracy analysis:

$$\%error = \frac{|Actual - Expected|}{Expected} x\ 100\%$$

$$Accuracy = 100\% - \%error$$

Legend equivalent percentage for External:

2= HIGH Dirt/Crack (33.34%)

1 = LOW Dirt/Crack (66.67%)

0 =NO Dirt/Crack (100%)

Legend equivalent percentage for Internal:

1= Blood Spot Found / No Yolk (50%)

0 = NO Blood Spot / Yolk FOUND (100%)

Sample Computation for Egg #8(Trial1):

1.) External Crack

$$\%error = \frac{|100-100|}{100} x100\%$$

$$\%error = 0\%$$

$$Accuracy = 100\% - 0\%$$

$$Accuracy = 100\%$$

2.) External Dirt

$$\%error = \frac{|66.67-100|}{100} x100\%$$

$$\%error = 33.33\%$$

$$Accuracy = 100\% - 33.33\%$$

$$Accuracy = 66.67\%$$

3.) Internal Yolk

$$\%error = \frac{|100-100|}{100} x100\%$$

$$\%error = 0\%$$

$$Accuracy = 100\% - 0\%$$

$$Accuracy = 100\%$$

4.) Internal Blood Spot

$$\%error = \frac{|100-100|}{100} x100\%$$

$$\%error = 33.33\%$$

$$Accuracy = 100\% - 0\%$$

$$Accuracy = 100\%$$

Legends and labels were also assigned for the condition of each egg. To get the result of each accuracy a sample computation was shown above. The computation will consist of External crack/dirt and Internal yolk/bloodspot.

IV. Conclusion

The group therefore conclude that the system can be used by the poulterers and it can reduce their labor. With the help of the system, the egg checking would be easier. Based on the result and testing of the system, the students can verify the external crack and dirt. Those are detected when the red lines are drawn in each egg. After drawing the red lines for the dirt and crack, the system will find the minimal crack and dirt then the system will draw a bounding box labeled as good condition in each egg with minimal crack and dirt. The group tested each using the external crack/dirt detection and the system found 28 eggs in good condition out of 30 eggs. For the internal egg detection, the system will find the yolk in each egg and will be labeled as yolk found. The group tested each egg and all of them have yolk inside using the system. Knowing that, the egg can be checked one tray at a time, and the results would be easily displayed on the screen. The system is user-friendly that's why the poulterers can easily use the system. The system uses common instruments that can be easily used and are being used at home like the camera, cellphone and the computer. Having the system in real time will make the workers' work faster and would not consume more time just by checking the egg one by one. Also, the workers don't need to expose themselves in a bright light inside a dark room because the only thing they are gonna need is a space for the computer and the system itself.

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