A Smart Camera-Assisted Egg Candler with Maturity Classifier using Convolutional Neural Network

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***Abstract* – This paper focuses on developing a candling apparatus that can minimize the time consumed in the process of egg's segregation based on its classification. In this process, instead of determining the eggs fertility by gradually candling using a light box, we will use trays with built-in camera-assisted candlers made from fluorescent bulbs. The egg maturity will be classified by capturing images using the installed cameras in the apparatus. The captured images will undergo image processing using Convolutional Neural Network (CNN). The CNN, programmed using a python language, will be trained to determine the maturity status of the eggs based on its internal quality. With the help of this modernized candling apparatus, the farmers will be able to immediately separate the fertile eggs from infertile eggs before the egg incubation process. Also, it will help farmers in classification whether the harvested egg is a *Balut* or a *Penoy.* A monitor with a friendly-user GUI will show the candling result that will enable the farmer to easily see the egg maturity classification.**

Keywords— Egg Maturity Classification, Camera-Assisted Candler, egg incubation, image processing, CNN

I. INTRODUCTION

Balut is a famous delicacy which came from the Asian countries like China, Vietnam and the Philippines. It is a famous street food which is made of chicken or duck egg. The eggs are incubated with the use of artificial incubator made for mass production. The status and classification of the eggs were known by candling the eggs. During this process, the eggs were exposed in a bright light to see the shadow casted by the embryo inside the egg. The eggs were candled one by one to classify the eggs properly. Which is the problem in balut production, since this process takes time just to classify which among the eggs were balut and penoy.

Egg Candling is a clean and easy way to check the development and happenings inside the egg while it is being incubated. It can give you an idea whether the incubation of the eggs is going smoothly or there are any problems. [1]Another purpose of this is to determine whether an egg is fertile or infertile depending on the development of the embryo. Egg candling is performed by making a box with a single hole, where the egg to be candled is placed. Inside the box is a high-powered light so that the light can penetrate properly into the eggshell. the egg candler will be placed in a dark room and it where the candling will be done. [2].

In balut production, egg candling was done to monitor the growth of the eggs and also to classify which among the incubated eggs were balut or penoy. Through egg candling the producers can determine where are the "abnoy" eggs or these are the non-viable eggs, in which they can immediately separate it from those eggs that are incubated. [3]

Convolutional Neural Network is an artificial neural network that uses pixels of data for image processing and recognition. It uses deep learning to perform tasks that are descriptive and generative. With its system that has the presence of human-like neurons enable it to produce accurate results in testing subjects [4]. As an example, a study entitled "Convolutional Neural Network for Industrial Egg Classification" used CNN for image classifying. They used 2000 egg images to train the CNN, giving the result of the project's accuracy for the 89,000 test subjects is 92.3% [5].

This study aims to develop an automated egg candling apparatus that can classify the egg whether the harvested egg is a balut or penoy.

I. METHODOLOGY

A. Block Diagram

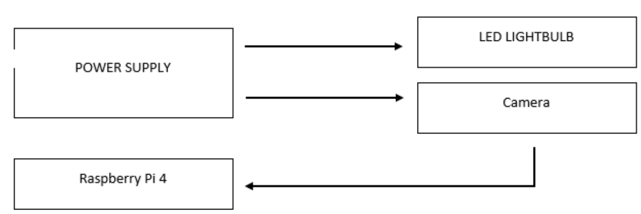

Fig. 1 System's Block Diagram

Figure 1 shows the block diagram of the Candling System. Here, the Power supply then carries power to both LED Lightbulbs and for the camera. A program would then be set to automatically let the Camera capture photos and it would be sent to the Raspberry Pi 4 for image processing.

B. Hardware Development

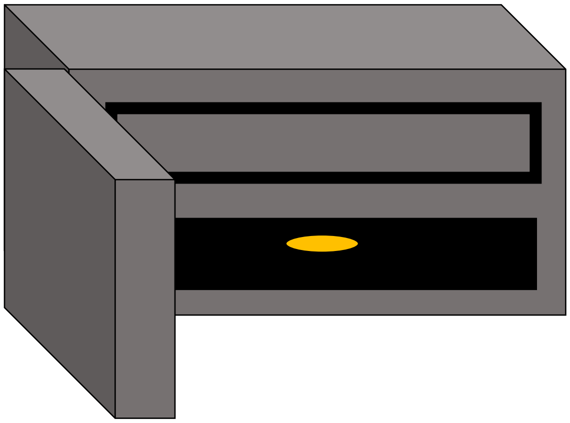

Fig. 2 Prototype Design

Figure 2 shows the hardware design of the incubator. The machine will have a height of 1.5ft, length of 2ft, and width of 3ft. Inside contains the Candling apparatus which is composed of a camera located at the ceiling and four fluorescent lamps beneath for candling. A layer made up of cardboard was placed on top of the lightbulbs to serve as a tray for the eggs which can hold 20 eggs.

C. Software Development

Python was used in implementing the convolutional neural network which is needed to perform the maturity detection of the egg. The candling process was done in the Raspberry Pi 4 where the maturity detection was depicted through a user-friendly GUI for an easy implementation of the program. By Raspberry Pi 4, the camera automatically captures images and sends it to the Raspberry Pi 4 where the program resides. It will then process each data gathered.

- **Egg Classification Program**

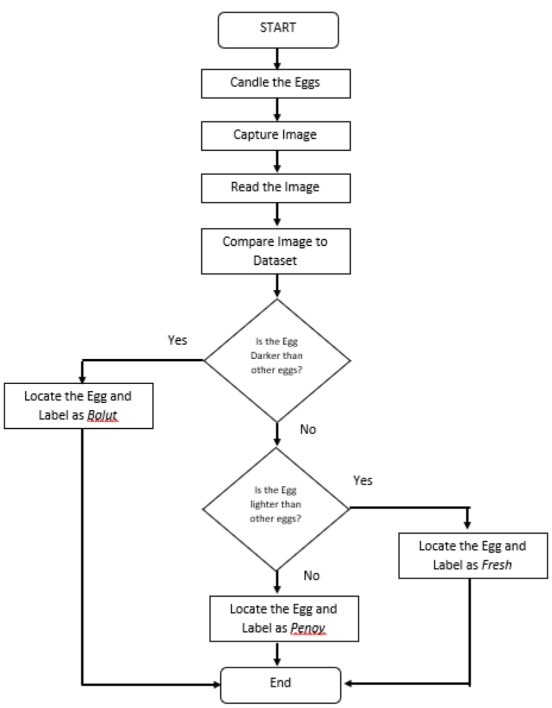

Fig. 3 Egg Classification Flowchart

Figure 3 shows a flowchart on how the program determines whether what egg was being classified. The program will start by reading the image captured when the eggs were candled and comparing it to the dataset learned by the program. The most essential description as to how the to determine the eggs is their color when candled. If the egg is very dark, it means that it has a developed chick/duckling inside, so it'll give a sign that the egg is still growing so it'll be classified as *Balut*. The lighter the color will mean that the egg is not developing thus it can be concluded that the egg with the lightest color will be determined as *Fresh* and the egg with a yellowish color will be classified as *Penoy*.

D. Design Implementation

Fig. 4 Candling Apparatus Prototype

Figure 4 shows the front view of the candling apparatus. Its wall was made of Hardiflex and its skeleton was made of metal. The tray which holds the tray and the fluorescent bulb is made of wood.

E. Protype Testing and Data Gathering

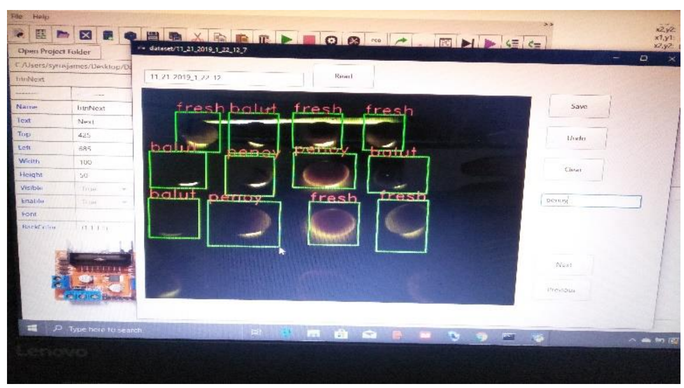

Fig. 5 Data Annotation for Machine Learning

Figure 5 shows the process of labelling the data gathered from using the Automated-candling Machine. In the image, it is visible that the eggs were classified into three classes namely *fresh*, *balut*,and *penoy*. The process of data gathering involves many pictures taken while the eggs were being rotated to ensure no bias when it comes to the other side of the egg.

	Fresh	Balut	Penoy	Total
1st Gathering	15	0	5	20
2nd Gathering	15	5	0	20

Table 1 The number of sample where the dataset was gathered from

Table 1 shows the number of eggs that were used as a dataset. The classification was pre-known and were classified as to how they look when candled. Logitech model C525 with features such as enabling 720p video record, having 30fps and also having a field of view of 69° for a wider range.

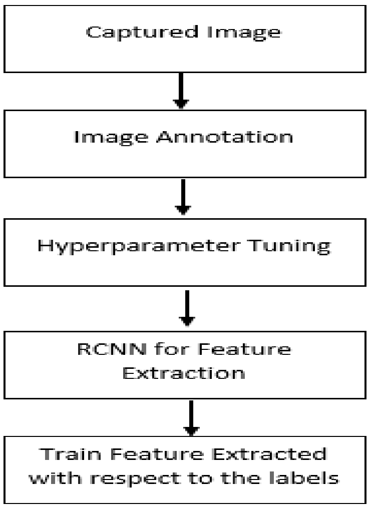

Fig. 6 Image Training

Figure 6 shows how the Image were processed to be trained. The Captured image would then first undergo Image Annotation, or each image will be labeled on each feature which makes it different from each other. For example, the black spot on the first day is one sign which is labeled. Hyperparameter tuning would be the next step as to find a optimal or balanced combination of parameters then Feature Extraction for RCNN will be next or getting features instead of numbers and using them as the dataset and the training will be the last step.

III. RESULTS AND DISCUSSION

A. *Traditional Candling versus Automated Candling*

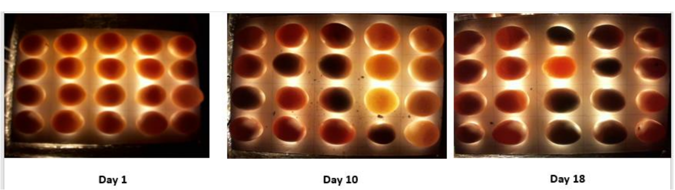

Fig. 7 Growth if the embryo from day 1 to 18

Figure 7 shows the development of the embryo from day 1 to 18. Based on the figure, the indicator that there is a growth is the darkening of the egg. The egg which has the darkest color is classified as *balut*, the darker shade is the *penoy*, and the lightest shade of the egg is the infertile egg or fresh egg.

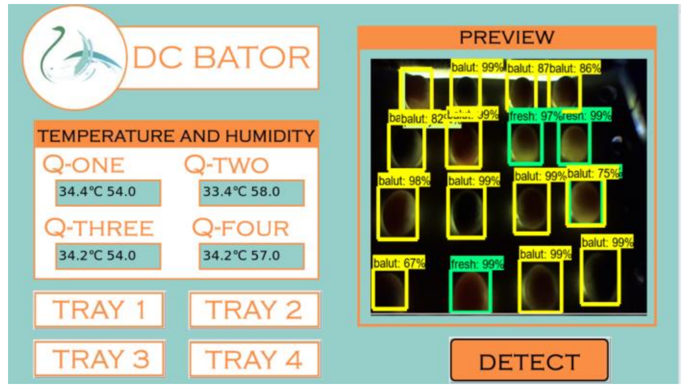

Fig. 8 Automated Candling GUI

Figure 8 shows the User Interface used in automatic candling of eggs. In the GUI, the temperature inside the incubator is displayed. The buttons named with tray numbers will be clicked and the candled eggs will be displayed with their corresponding classification.

Tray 1			
Manual Candling		Auto Candling	
Egg #	TIME(s)	Egg #	Time (s)
Egg 1	3s	Egg 1	
Egg 2	3s	Egg 2	
Egg 3	3s	Egg 3	
Egg 4	3s	Egg 4	
Egg 5	3s	Egg 5	
Egg 6	3s	Egg 6	
Egg 7	3s	Egg 7	
Egg 8	3s	Egg 8	
Egg 9	3s	Egg 9	
Egg 10	3s	Egg 10	1s
Egg 11	3s	Egg 11	
Egg 12	3s	Egg 12	
Egg 13	3s	Egg 13	
Egg 14	3s	Egg 14	
Egg 15	3s	Egg 15	
Egg 16	3s	Egg 16	
Egg 17	3s	Egg 17	
Egg 18	3s	Egg 18	
Egg 19	3s	Egg 19	
Egg 20	3s	Egg 20	
Total	60s	Total	

Table 2. Candling Time Comparison

Table 2 shows the difference between the time it takes to candle the eggs manually and automatically. It shows that automatic candling of eggs is 60 times faster than manual candling of eggs since, manual candling was done individually while automatic candling is done per tray.

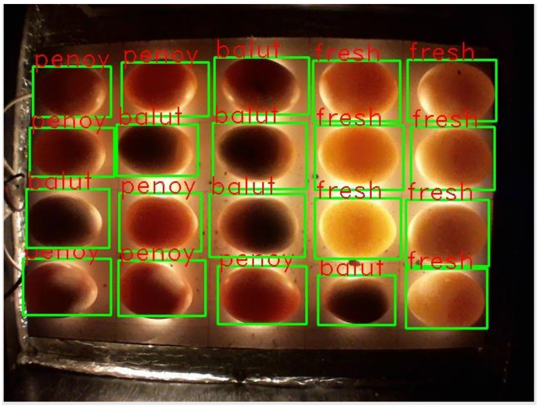

Fig. 9 Manual Candling

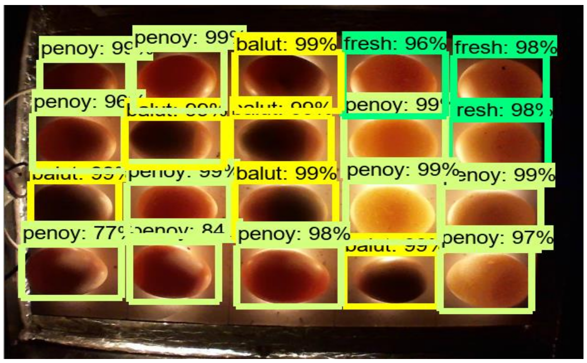

Fig. 10 Automated Candling

Figure 9 and 10 shows the classified eggs using the manual candling, and automatic candling. In the manual candling, the eggs were classified and labelled manually. In automated candling, with the convolutional neural network, each egg was automatically labelled as *fresh*, *penoy* or *balut*. After the eggs were classified the results were tabulated and being compared with the manual candling.

Manual					Automated				
P	P	B	F	F	P	P	B	F	F
P	B	B	F	F	P	B	B	P	F
B	P	B	F	F	B	P	B	P	P
P	P	P	B	F	P	P	P	B	P

Table 3. Automated vs Manual Candling

Table 3 shows the tabulated format of the candling results using the manual and automated candling, which was compared manually to determine the accuracy of the automatic candling process.

Trial No.	Accuracy
1	80%
2	85%
3	80%
4	75%
5	80%
6	80%
7	80%
8	80%
9	85%
11	80%
Average	80.5%

Table 4. Candling Accuracies per Trials

Table 4 shows the accuracy of the automatic candling process. The incubated eggs were candled ten times having different setups. Based on the gathered data it shows that the accuracy of the automated candling apparatus is 80.5%.

CONCLUSION

Based on the tests and data gathered it can be inferred that The Smart Camera-Assisted Egg Candler with Maturity Classifier using Convolutional Neural Network is a good alternative or replacement for the traditional candling apparatus for it has the capability to classify eggs at a high accuracy with a faster rate. Also, this can reduce the efforts in candling the eggs manually, since the user can automatically see in the monitor the classification of the eggs, all at the same time.

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