Egg's Grade Classification and Dirt Inspection Using Image Processing Techniques

R. Ibrahim, Z. Mohd Zin, N. Nadzri, M.Z. Shamsudin, M.Z. Zainudin

Abstract—**Recently digital image processing techniques have been widely used in various types of application in particular in computer vision. A variety of these techniques are now being used in many types of application area such as object classification, robotics, biometrics system, medical visualization, image enhancement and restoration, industrial inspection, and human computer interfaces. This paper introduced an egg's grade classification and dirt inspection system using combination of image processing techniques. The works mainly focused on the development of the system, egg grade classification algorithm and dirt inspection process. The results show that egg's grade classification has achieved classification accuracy between 80% and 90%, and the system was also able to determine the cleanliness or dirtiness of the eggs.**

Index Terms—**Eggs, grade, classification, image processing, dirtiness**

I. INTRODUCTION

Egg is known as a source of food that is rich in nutrients. Due to a high demand of eggs by the consumers, the egg production industry has become one of among large industries in many countries. This high demand comes with a high expectation and requirements in having good quality of eggs. This is proven in a way that many production companies are competing to produce eggs not only well in shaped but also with extra nutrients such as DHA, Omega 3 and etc. In the production of the commercial eggs, egg grading is one of the important processes that need to be done in order to control the quality of eggs produced [6]. In fact, the performance of egg grading is affected by the eggs internal and external quality [7]. Usually, good quality eggs have smooth surfaces, well in shapes and free from cracks [7][3].

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Currently, the technique of acoustic and optical method mentioned in [7][3], also known as candling method as described in[6] [4] for bloodspot, hairline crack on the shell and rotten eggs detection are some of several techniques that have been used by some industries to check the quality of eggs. These techniques are actually a manual handling method where human worker or labour will rotate and observe eggs under the light, turn eggs to bump into each other as well as listen to the voice of the eggshell [3]. However, the techniques can also lead to large errors [6] due to low efficiency of labour, in other word, the determination of the quality of the eggs depend largely on human being capability. Therefore, the performance of this technique is mainly influenced by the attention, physical strength, experiences and work attitude of the workers.

There were some works that tried to use machine vision capability in particular image processing technique to perform the egg grading or classification [4][5][6]. In [11], the authors have introduced egg's grade classification using some image processing techniques such as image filtering and image enhancement. However, even though the classification result was good, the process was only done on static captured images of eggs. Meanwhile, an automatic inspection system has been developed to detect broken or damage egg [10]. The system consists of mechanical and electrical model that includes MCU as the main controller of the system. There were also some image processing techniques that have been applied to detect eggshell crack and egg's bloodspot [4][5][6]. In this paper, image processing techniques have been applied to determine the grade and size of eggs, and also used to inspect dirt on eggshell.

II. METHODS AND SYSTEM DEVELOPMENT

The main works in this paper were mostly involved in the development of egg's grade classification and dirt inspection system. This system has been developed with purpose to perform egg classification and dirt inspection tasks using its vision system and image processing techniques. An overview of the system is shown in Fig 1.

For sampling purpose, eggs in different sizes from small, grade E to large, grade AA were used. A total of 180 grades AA until E eggs were selected from commercial packing stations. Each grade consisted of 30 eggs. In addition to that, the dirty eggs were also collected for this sample. The eggs were then placed in our system's prototype. The more specific features of this system were as follows:

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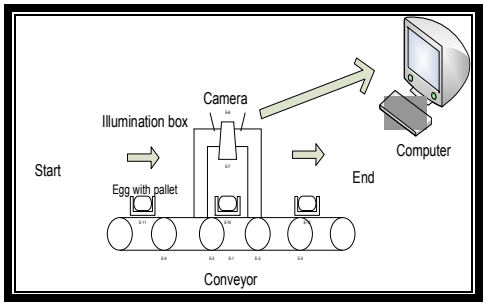

Fig 1: Overview of the system

a) *The illumination box with dimensions of 10×10×10 cm had been built to provide the possibility of light adjustment and light noises removal.*
b) *A webcam camera used to capture egg image with the distance between its lens and egg was approximately 200mm.*
c) *The mini conveyor for placing the eggs*
d) *Two bulb lamps with yellow light were attached on top of the illumination box.*

In our case too, the first step to classify the eggs is to create a database that should consist the different range of diameters of eggs according to their grades. The pre-processing took place to create this database of 120 eggs is shown in Fig 2.

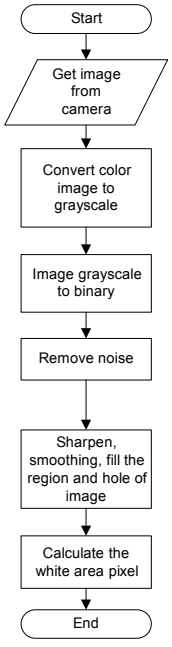

Fig 2: Pre-processing steps used for database and classification rules

At the first place, 20 eggs samples images from each grade AA to E have been captured, converted into greyscale and binary before noise removal process was done. After that, these images have been sharpened, smoothed, filled with region and holed of image. The example of these eggs' image after these processes is shown in Fig 3 where the image consisted only of black and white pixels. The shape of the egg was clearly visible in this image.

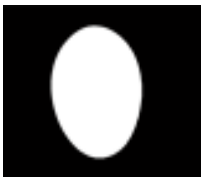

Fig 3: Image of egg after sharpening, smoothing and filling

All 120 eggs from 6 different grades of AA to E have been classified according to their respective grades based on the number of white pixels as shown in Table I. It was noticed that the grade of the eggs depend on its size. The AA grade represents largest size of eggs while grade EE represent the smallest ones. These rules or relations have been implemented as our egg's grade classification decision algorithm.

Table I: Grade based on area of white pixels

Grade	Area of white pixels
AA	79000 – 83000
A	72000 – 78999
B	66000 – 71999
C	61000 – 65999
D	56000 – 60999
E	48000 – 55999

Meanwhile, beside the system classify the grades of the eggs; it also should be able to inspect the dirty eggs. In the later, some additional image processing techniques have been applied. The combination of egg's grade classification and dirt inspection system is represented by the complete process flow as shown in Fig 4.

In the task of egg's grade classification, the process of capturing image until transform it into black and white pixels are has been performed in a similar way as in the preparation of our egg's dataset previously for grade classification decision (Fig 2). However, this time, the image taken has been compared with our dataset and algorithm in order to classify its grade. In fact, during this process, the image white pixels area was compared to each of the white pixels are in Table I and their errors were calculated. The classification of egg's grade was then done by choosing the smallest error among all.

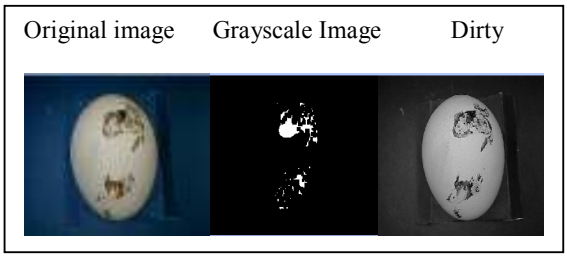

Fig 5: Steps to determine the dirt on an eggshell

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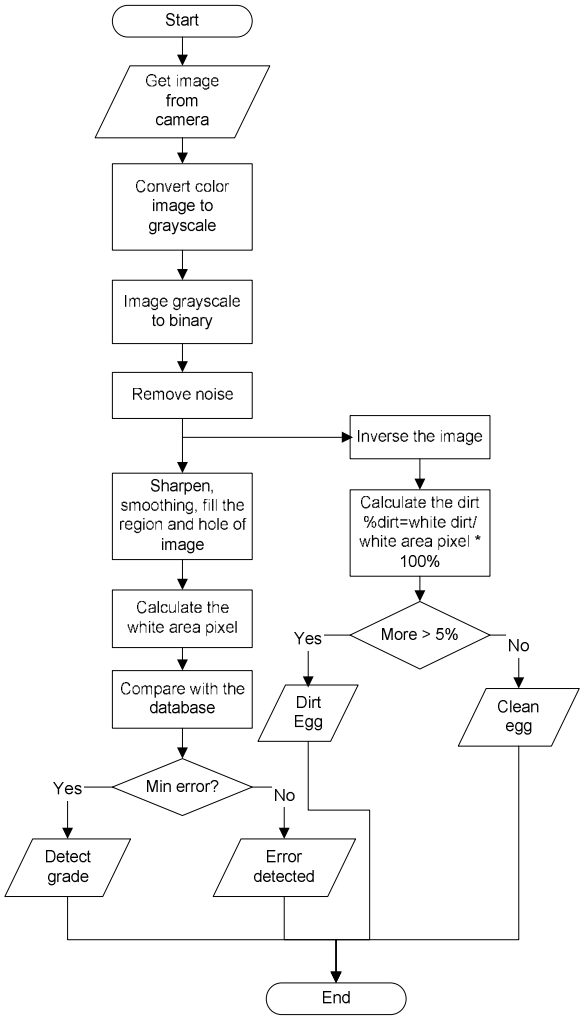

Fig 4: Process flow of eggs' grading and dirt detection

On the other hand, another task of the proposed system is to inspect the dirty eggs. In this task, image capturing process until noise removal process has been done similarly as in the previous tasks of dataset preparation and grade classification (Fig 2). However, for dirt inspection, captured image was inversed after noise removal process. Fig 5 shows an example of dirty egg image that has been processed until only dirty area was visible. From here, the proportion of dirty area against egg's white pixels was calculated in percentage. In our case, an egg was considered as clean egg if the percentage of dirt was below than 5% and was considered dirty egg otherwise. The development of the system was done using Matlab software.

III. EXPERIMENTAL RESULTS

In the experimental works, the real size or diameter of eggs have also been measured and compared with our egg classification rules. This comparison is shown in Table II where the larger the diameter, the higher the grade is. This was consistent with our classification rules in Table I previously.

Table II: Comparison egg diameter vs. pixel area

Grade	Diameter (cm)	White pixel area
AA	>= 15.0	>= 79000
A	14.5 – 14.9	>= 72000 - < 79000
B	14.0 – 14.4	>= 66000 - < 72000
C	13.5 – 13.9	>= 61000 - < 66000
D	13.0 – 13.4	>= 56000 - < 61000
E	12.5 – 12.9	>= 48000 - < 56000

For egg's grade classification, 10 eggs from each grade AA to E were selected. The total of these 60 eggs were placed into our system and their images were captured. The classification of grades has been done on each of these images using the steps mentioned in the previous section. For each grade, the percentage of correct classification was calculated and their results are shown in Table III. From this result, the classification of grade AA, A and C has higher accuracy of 90% while only 8 out of 10 eggs have been correctly classified for grade B, D and E.

Table III: Grade Eggs' classification results

Grade	Classification (%)
AA	90%
A	90%
B	80%
C	90%
D	80%
E	80%

On the other hand, the cleanliness and dirtiness of an egg has also been tested using our system. In fact, this task was done in parallel with the egg grade classification process as shown in our process flow in Fig 2. By using a Graphical User Interface (GUI) and image processing techniques to inspect cleanliness or dirtiness of the eggs as explained in previous section, the system was able to classify egg's grade and categorize an egg as dirty or clean. Fig 6 shows a snapshot of our system where the egg was classified as AA grade and a dirty egg.

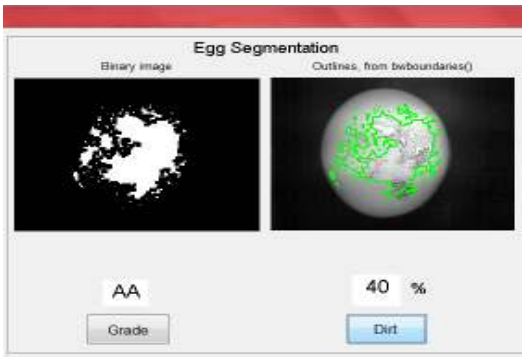

Fig 6: Dirt detection

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IV. CONCLUSIONS

In this paper, image processing techniques have been used to classify commercial eggs into their respective grades and to check the cleanliness or dirtiness of the eggs. The development of the system involves review of some literature related to egg's grade classification and quality inspection, study and analysis of different commercial egg grades, build the prototype of the system, implementation several image processing technique, integration of hardware and software and also analysis of the results obtained. Based on the experimental results, the system has been able to classify the sample of commercial eggs into their respective grades with performance accuracy of 80% to 90%. Utilization of Matlab software with image processing tools has provided an enhancement to the image taken using webcam. Image processing techniques such as greyscales conversion, image filtering and black and white pixels conversion have been used to improve the quality of the image and also to perform calculations. However, one of the main challenges in this work would relate to the quality of the image captured. In our case, the background is controlled by using a specific design box. Like a common problem in object recognition and classification, illumination can become primary factor that will affect the quality of image captured in this system. In this case, image processing technique such as the conversion to black and white image and the calculation of egg's diameter could produce poor results. This shall decrease the performance of the system. On the other hand, this prototype system can be further improved such as the implementation of colour based object recognition or integration with sensors or Peripheral Interface Controller (PIC) or application of artificial intelligence technique such as fuzzy logic for decision algorithm.

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