External and Internal Defect Detection of Egg using Machine Vision

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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 egg shell and internal blood spots. Cracks usually have low luminance and thus the bottom hat transform is used to extract the cracks from the luminance component of the image after YIQ transformation. 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. The results are presented to demonstrate the validity of the proposed visual process on a wide sample of both defective and non-defective eggs.

Keywords: Poultry, egg defect, Crack detection, internal bloodspot detection

1. INTRODUCTION

In manufacturing, quality control is very important in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. Egg is one of the most important products because it’s nutritional value and egg grading is important in controlling its quality. A high quality egg will have a smooth, well-shaped shell free of blemishes and cracks. Occasionally an egg may contain a small blood spot. This may be due to the breed of the hen or it may occur if the hen is upset during the formation of the egg [1]. Such faults are generally detected during candling. The classification of defective eggs from qualified ones constitutes a fundamental issue of the poultry industry for both economical and sanitary reasons. The processing of poultry eggs for human consumption has four steps: collecting, washing, grading, and packaging. While the first, second and fourth steps have been mechanized, the eggs grading step, in which eggs are inspected for defects detection such as blood spots, cracks and dirt stains, is still done manually [2]. The early separation of defective and cracked eggs is a fundamental issue to be accomplished as stains and leaks degrade all the mechanical parts while progressing on the mechanized conveyor belts either at the farm or at the grader/packer sites. Poultry industry has to deal with much more defective eggs due to the lack of the washing stage and eggshell defects appear in a great variety of combination of the more common defects such as: blood spots, dirt stains and cracks.

At present in industries, conventional candling method is used to inspect eggs’ abnormalities for instance blood spot. Egg candling is a technique of using light to examine eggs by using naked eye to assess the potency of edible eggs. During candling each egg rotates over a strong light source which enables the inspector, who is a human being, to see inside the egg and look for any internal imperfections. The inspection and sorting process is currently performed by expert graders. The automation of the grading stage at the poultry farm constitutes a promising and innovative field to alleviate both the manual inspection and the early stage rejection of dirt and cracked eggs.

Some research has been performed in eggs based on image color planes analysis when the pursued defect had a unique dominant color. Thus, to differentiate blood spots, stain and cracks some studies have been undertaken by training neural nets with color histograms with a good performance on one defect eggs but unable to accurately work with eggs showing more than one defects. Thus as the frequency of isolated defects ranged from 1% for blood spots and for dirt stain to 5% for cracks, the probability of an egg with more than one defect was very small [3].

Various techniques including optical, mechanical, electrical and acoustical have also been used for classification and/or sorting of defected eggs. Garcia-Alegre et al. used machine vision system to detect defects in brown eggs [4]. The algorithmic process is to the detection of the egg shape to fix the region of interest. Color processing is then performed only on the eggshell to obtain an image segmentation that allows the discrimination of defective eggs from clean ones in critical time. Patel et al. trained neural networks with color histogram obtained from egg images [5]. The neural network model had an average accuracy of 92.8% for blood spot detection and 85.0% for dirt stained eggs. Usui et al. used near infrared (NIR) spectroscopy to detect blood spots in eggs [6]. The determination is made using wavelength absorbance data since the hemoglobin in blood mixed in eggs with blood spots has an absorbance band of 540 to 575 nm. Here, the normal egg discrimination rate was 100%, and the egg with blood spot discrimination rate was 83.0%. Mertens et al. developed a computer vision algorithm for dirt detect on brown [7]. Here, the focus is on the design of an off-line computer vision system to differentiate and quantify the presence of different dirt stains on brown eggs: dark (feces), white (uric acid), blood, and yolk stains. The designed vision system showed an accuracy of 99% for the detection of dirt stains. De Ketelaere et al. detected
blood spots using combined reflection-transmission spectroscopy method [8]. Pourreza et al. applied an adaptive threshold based on discontinuities determination the filtered images for detecting eggshell defects such as dirt and cracks [9].

Dehrouyeh et al. developed an algorithm to detect the defected eggs [9]. The hue histogram was used for blood spots detection, and maximum values of two ends of histogram were selected as criterions of defect detection. Eggshell dirt was detected using connected areas detection technique. Then total average of this algorithm was 85.66%.

This paper has been organized as follows: In section 2, the Proposed Methodologies for Crack Detection, Dirt Detection and Blood spot Detection are explained. Experimental results and discussion are given in section 3. Finally, concluding remarks are given in section 4.

2. METHODOLOGY

2.1 Crack Detection

Cracks in egg shell are one of the most prominent external and can be identified as the places with low luminance. Egg shell cracks includes, gross cracks which refers to large cracks and holes results in a broken shell membrane, hairline cracks, i.e. very fine cracks, usually run lengthwise along the shell and they are difficult to detect and star cracks are fine cracks radiating outwards from a central point of impact, which is often slightly indented. The block diagram of the proposed method for Crack detection is shown in Figure 2.1.

The brightest and the darkest pixel in the image are determined, i.e. the pixels with highest and lowest value. Let these values be vmax and vmin. Unless vmax = vmin, for each pixel p its value v is changed to

\[ v = \frac{v - vmin}{vmax - vmin} \times \text{Maximum/Minimum spreading ensures that the full range of brightness values is used in the image.} \]

The bottom-hat transform, also called closing residue, is used to extract valleys such as dark lines and dark spots. It is a process which is done by the subtraction of the original image from the closing result [11]. Therefore, the Cracks of the egg images, actually considered as dark lines are extracted by applying the bottom-hat transform. The goal is to reduce noise or useless details without introducing too much distortion so as to simplify subsequent analysis. The image is converted to binary image by selecting a optimal threshold value.

2.2 Dirt Detection

All or part of the egg shell may become stained by various substances. The stains on egg shell may be due to blood from a prolapsed cloaca, cannibalism or vent picking, Faecal contamination, Water stains, Sanitisers used in egg washing, Grease and oil stains etc. The severity of eggshell dirt is different in eggs, so for this case the severity detection of defects is important.

As long as not “artificial” images or images which have already been normalized beforehand are used, it is quite normal that the objects appear in different images under different lighting conditions. In order to get the normalized image Maximum/Minimum spreading technique is used [10].

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<tr>
<th>Input Egg Image</th>
<th>RGB to YIQ Transform</th>
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**Fig 2.1:** Block Diagram for Crack Detection

HSV color space is widely used in computer graphics, visualization in scientific computing and other fields. In this space, hue is used to distinguish colors, saturation is the percentage of white light added to a pure color and value refers to the perceived light intensity. The advantage of HSV color space is that it is closer to human conceptual understanding of colors and has the ability to

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**Fig 2.2:** Block Diagram for Dirt Detection
separate chromatic and achromatic components. Hence for dirt detection the RGB image is converted to HSV and the Hue component is filtered for further processing. During the thresholding process, individual pixels in an image are marked as “dirt” pixels if their value is greater than threshold value and as “clear” pixels otherwise. The threshold selection depends upon the histogram of the image.

2.3 Internal Blood Spot Detection

Internal egg quality relates in general to the quality of the albumen. Due to biochemical reactions, governed by complex internal and external factors such as, temperature, relative humidity, the presence of bacteria, this albumen quality decreases with storage time. Besides the freshness of the albumen, it may include dissolved blood, bloodspots and meat spots (i.e. inclusions other than blood). Blood spots vary from barely distinguishable spots on the surface of the yolk to heavy blood contamination throughout the yolk. Blood spots occur when blood or a bit of tissue is released along with a yolk. Each developing yolk in a hen’s ovary is enclosed in a sack containing blood vessels that supply yolk building substances. When the yolk is mature, it is normally released from the only area of the yolk sac, called the “stigma” or “suture line”, that is free of blood vessels. Occasionally, the yolk sac ruptures at some other point, causing blood vessels to break and blood to appear on the yolk or in the white.

The proposed algorithm for blood spot detection include, color enhancement and image filtering to improve the quality of the gathered image. The percentage of blood spot in the egg is evaluated by extracting the blood spot region in the image. The block diagram of the proposed method is shown in Fig 2.3.

![Diagram](http://www.cisjournal.org)

Fig 2.3: Block Diagram for Blood Spot Detection

The acquired images of the candled eggs are subjected to image enhancement which is considered as pre-processing. The four steps of image enhancement in internal blood spot detection algorithm are RGB enhancement, Gray scale Conversion, Image Filtering and Converting to Binary image. Image enhancement is to darken the image in order to distinguish between bloodspot with other elements that quite similar to bloodspot. The enhanced image is filtered by using 3x3 median filter. Finally, the filtered image is threshold to convert the intensity image to a binary image, white pixels representing object, black pixels representing bloodspots and background.

In Region of Interest extraction phase, the image is scanned to get the amount of black and white pixel. Boundary of the object is traced to separate the object from background. The background is removed and the blood spot still retained in the image. The amount of the black pixels (representing the existence of the bloodspot) in the white pixels (representing the object of the egg) can be counted. The percentage of the blood spot in the image is obtained by

\[
\text{Percentage of Blood Spot} = \frac{\text{Blood Spot Pixel} \times 100}{\text{White Pixel} + \text{Blood spot Pixel}}
\]

3. RESULTS AND DISCUSSION

The database consists of about 200 images, which includes, good quality egg images, cracked egg images, stained egg images and the egg images with internal blood spots. For blood spots detection, the hardware system consists of 500W Halogen lamp, Fully closed wooden box with a 0.5cm hole on its top and 12mp digital Camera. The fully closed wooden box with 0.5cm diameter hole on its top was illuminated by a 500W halogen lamp. Egg is placed on the top of this hole so that he blood spots present inside the yoke of egg is well illuminated, 12mp high resolutions NIKON digital camera is used to take images. Some of the sample images in the database are shown below.

![Sample Images](http://www.cisjournal.org)
3.1 Crack Detection

In the human's visual system, people are more sensitive to the lightness component than the hue component. Hence, the RGB image is converted to YIQ color space and the Luminance component is taken.

![Input Image (RGB)](image1)

![Y Component](image2)

![I Component](image3)

![Q Component](image4)

Fig 3.2: RGB Image and its YIQ Components

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 Fig 3.3.

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 Fig 3.3.

![Bottomhat Filtered Image](image5)

![Thresholded Output](image6)

Fig 3.3: Crack Detected Image

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.

The input egg image and the resultant crack detected image is shown in Fig. 3.3.

3.2 Dirt Detection

Computer vision, in trying to mimic human’s abilities, has found hue to be useful in various applications. 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.

![Input Image (RGB)](image7)

![H Component](image8)

![S Component](image9)

![V Component](image10)

Fig 3.4: RGB Image and its HSV Components

The next step of the dirt detection algorithm is image normalization. The Hue component and the normalized image is shown in Fig. 3.5.
The thresholding operation is used to change or identify pixel values based on specifying one or more values (called the threshold value).

3.3 Blood Spot Detection

The candled egg images are considered as input to the Blood spot detection algorithm. Image enhancement techniques are used to emphasize and sharpen image features for display and analysis. Image enhancement is the process of applying these techniques to facilitate the development of a solution to a computer imaging problem.

The median filter is often used to remove "shot" noise, pixel dropouts and other spurious features of single pixel extent while preserving overall image quality. The enhanced image is converted to binary image from which the number of pixels labeled as blood spot is counted.

![Input Image](image1)

![Enhanced Image](image2)

![Binary Image](image3)

![Image with Blood Spot](image4)

**Fig 3.5:** Dirt Detected Image

**Fig 3.7:** Blood Spot Detected Image

4. CONCLUSION

In this paper, image processing techniques were used to detect internal and external egg defects. From the analysis of the obtained results it is inferred that, the clean eggs and eggs with dirt’s and cracks were detected easier. In Bloodspot detection from the freshness of the egg the quality can be evaluated. In order to improve the functionality and flexibility of the system, the acquisition phase should be improved. Further, by increasing the number of images in the database grading of egg can be done.

**REFERENCES**


