SPEKTA
(Jurnal Pengabdian Kepada Masyarakat: Teknologi dan Aplikasi)
ISSN 2723-8016 (online) | 2723-8008 (print)
Vol 4, No. 2, pp. 267-276

The Use of a Vision System for Monitoring Chick Embryos in Incubator

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ARTICLE INFO

Article history
Received : June 24, 2023
Revised : July 21, 2023
Accepted : July 30, 2023

Keywords
Image Analysis;
Incubation;
Chicken Embryos;
Candling;
Technical Sap;
Piece neuron mesh

ABSTRACT

Background: Determine the quality of hatching eggs and control the process of their embryonic development, it is necessary to perform candling of eggs, which makes it possible to identify and eliminate the causes of low hatching of chicks.
Contribution: The proposed vision system for processing images of chicken eggs makes it possible to distinguish fertilized eggs from unfertilized ones, which makes it possible to change the parameters of the incubator in the event of a large number of dead embryos.
Method: With the help of the National Instruments Vision Assistant module, which simplifies the collection, reproduction and storage of images recorded using a video camera connected via a FireWire interface, an incubator vision system has been developed.
Results: The yield of healthy chicks is increased due to the periodic automatic candling of eggs and the timely regulation of parameters during the incubation process.
Conclusion: Being able to monitor embryo development more closely allows you to determine the optimal time to change incubation parameters, such as humidity, to create the best conditions for egg hatching, leading to more efficient chick production. Similarly, the ability to use different light and temperature conditions to influence chick hatch time can allow for a faster incubation process and hatch healthy chicks in a shorter period of time.

INTRODUCTION

Monitoring the development of chick embryos is an important part of the incubation process, which allows you to determine when the egg is not developing, as well as when the egg is close to hatching. The ability to determine that an egg is no longer developing allows the removal of dead eggs from the incubator to prevent wasted time and energy incubating eggs that are not

fertile and to prevent the spread of bacterial infection from eggs that are no longer developing [1]-[3].

Being able to monitor embryo development more closely allows you to determine the optimal time to change temperature and humidity parameters to create the best conditions for egg hatching, leading to more efficient chick production. Similarly, it is possible to use different light conditions to influence chick hatch time, which can also speed up the incubation process and hatch healthy chicks in a shorter amount of time.

In most incubation centers, the process of separating fertilized and infertile eggs is done by hand using expert vision before the eggs are loaded into the incubators. After loading into the incubators, the eggs are periodically ovoscoped using ovoscopes and mirage tables in order to make sure that they are really fertilized [4]. However, the candling process is labor intensive and not very efficient due to the fatigue and visual errors of the operators who have to check thousands of eggs a day. Due to the low efficiency of manual candling, unfertilized eggs left inside the incubator can become infectious, which creates a problem for other healthy embryos. Thus, the development of an accurate, fast and cheap vision system for the timely detection of unfertilized eggs is relevant for the hatchery industry [5]-[9].

To determine the embryonic development of eggs during the first 12 days of incubation, a spectrophotometric method is used by illuminating the eggs with light after 108 hours of incubation [10], [11]. Known methods for determining the fertility of eggs using equipment such as MRI, infrared hyperspectral imaging or thermal imaging cameras [12]. Based on thermal information and a fuzzy system, the correct threshold value can be obtained, which was used to identify and filter fertilized eggs and evaluate whether a given egg is fertilized or not. However, the use of such expensive equipment is uneconomical for mass application. In addition, the possible radiation generated by such equipment can harm the embryos. When choosing the lighting power of the light source, you need to take into account its energy consumption and the effect on the temperature inside the incubator. Given the physical and chemical structure of the egg, excess heat can change its contents and damage the embryo. Normally, embryos cannot tolerate temperature rises of more than 2° C. A promising method for determining the fertility of chick embryos is the use of artificial neural networks [13]-[15].

The use of monitoring chick embryos in incubators has become an invaluable tool in modern poultry farming and research [16]. This state-of-the-art technique allows for precise control and observation throughout the incubation process, ensuring optimal conditions for embryo development [17], [18]. Advanced monitoring systems utilize high-resolution cameras to capture real-time images of the developing embryos, enabling accurate tracking of growth and behavior patterns. These systems are equipped with cutting-edge software that can analyze various parameters such as heart rate, vessel formation, and movement patterns [19]. Additionally, wireless sensors provide continuous measurements of temperature, humidity, and gas levels inside the incubator. Such comprehensive monitoring capabilities aid in identifying potential issues early on, facilitating prompt interventions to mitigate risks such as malformations or chick mortality rates. This technology provides a valuable insight into embryonic development trends like genetic abnormalities or stress response analysis, driving more efficient breeding practices and vital research advancements in avian biology [20].

The aim of this work is to develop a vision procedure for the efficient determination of the fertility of hatching chicken eggs with high accuracy using an appropriate light source and webcam. The contribution of this research proposed vision system for processing images of chicken eggs makes it possible to distinguish fertilized eggs from unfertilized ones, which makes

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it possible to change the parameters of the incubator in the event of a large number of dead embryos.

METHOD

Monitoring chick embryos in an incubator is a crucial aspect of successful poultry farming. The best method to monitor the progress and health of chick embryos involves utilizing advanced technology and precise environmental control [21]. Incubators should be equipped with high-resolution cameras to capture clear images of developing embryos without disrupting their environment. These cameras can be connected to computer systems that provide real-time monitoring and analysis of vital parameters such as temperature, humidity, and oxygen levels inside the incubator [22]. Additionally, installing a system for continuous data logging helps maintain accurate records for future reference and analysis. It is also essential to conduct regular manual inspections to ensure that all equipment is functioning correctly and identify any potential issues early on. By employing a combination of state-of-the-art technology and diligent manual checks, farmers can effectively monitor chick embryos in incubators, thus optimizing hatching rates and ensuring healthy poultry production [23].

For collecting video images, it is promising to use the NI 1744 intelligent camera, which combines backlighting and advanced technical visual control functionality. It is also possible to use the Logitech WebCam C210 webcam, which allows you to take photographs with a resolution of 1.3 megapixels and provides automated precision technical control of the development of chick embryos. The webcam is initialized using the Measurement & Automation Explorer (MAX) from National Instruments. MAX specifies all configuration parameters for devices and channels, and also assigns a logical number to each device, which is used in the LabVIEW software environment as a reference to the device [24]. Initialization process webcam Logitech WebCam C210 is shown in Figure 1.

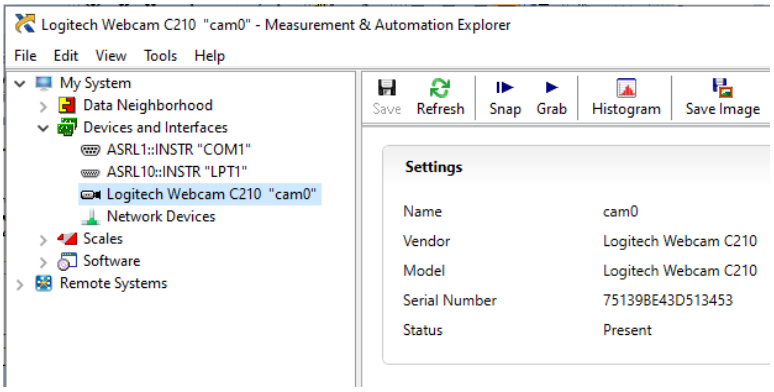

Figure 1. Connecting a webcam to collect video images

RESULTS AND DISCUSSION

For quick selection, analysis of individual characteristics and determination of the temporal dynamics of the object under study, it is necessary to create its compact information image. To determine the structure and parameters of elements in the image of complex objects, the image analysis functions implemented in the NI Vision Assistant module are used. To process images of chicken eggs obtained using an optoelectronic system on the 7th, 11th and 20th days of incubation, a sequence of actions was applied - the script shown in Figure 2.

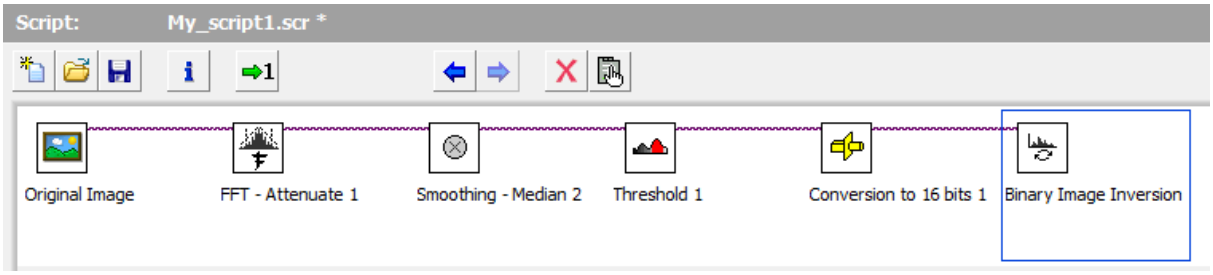

Figure 2. The sequence of actions for processing video images

First, the frequency filtering of the image is performed using the FFT - Attenuate function and the image is smoothed using the median filter Smoothing - Median. To simplify the procedure for identifying and evaluating image fragments, using the Threshold function, its threshold binarization is performed, i.e. splitting the image into two regions, one of which contains all image elements with a value below a certain threshold, and the other contains all image elements with a value above this threshold [17]. The Threshold function from an input image p generates a binary output image q, with the transition level given by the threshold value t, this function is determined by How:

$$q = \begin{cases} 0 & if \quad p \le t \\ 255 & if \quad p > t \end{cases} \tag{1}$$

Threshold binarization is done in order to distinguish embryo pixels (dark dots) from other areas (light parts). When performing a threshold task, the embryo and its blood vessels are indicated by black pixels, and the rest of the parts are indicated by white pixels. The Conversion to 16 bits 1 function converts the current image to the specified type. The Binary Image Inversion function inverts a binary image.

Images of hatching eggs of chickens on the 7th, 11th and 19th days of incubation, transformed at different stages of the scenario shown in Figure 2 are shown in Figure 3, Figure 4 and Figure 5, respectively. To increase the contrast using the Multiply Constant function, the images are multiplied by a constant of 255. As seen in Figures 3, Figure 4, Figure 5, black pixel areas increase with increasing incubation period. Counting the combination of black and white pixels inside an egg in a binary image can be used to classify eggs. The process of development of chicken chick embryos during 21 days of incubation can be observed in Figure 6 from images obtained after binarization.

Figure 3. Images of hatching eggs of hens on the 7th day of incubation

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Figure 4. Images of hatching eggs of hens on the 11th day of incubation

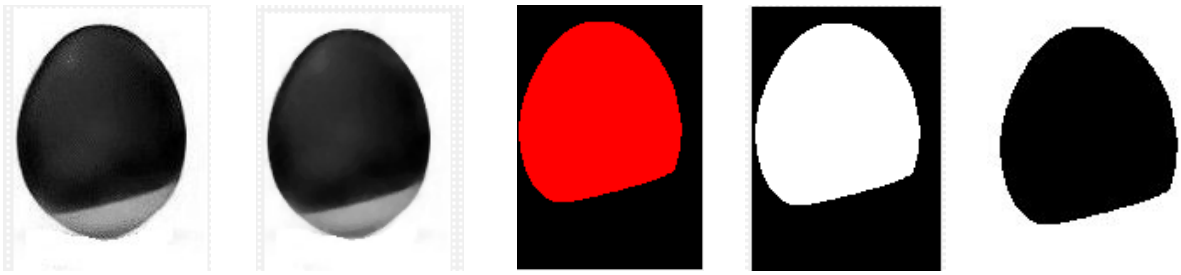

Figure 5. Images of hatching eggs of hens on the 19th day of incubation

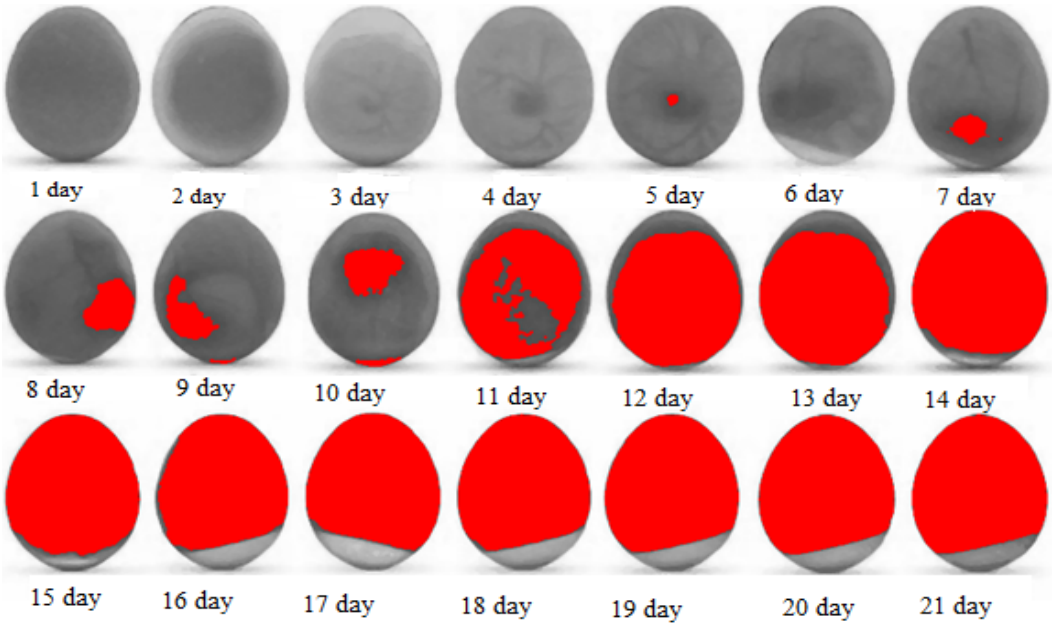

Figure 6. The process of development of chick embryos

The average value $\bar{X}$of the sample X 1, …, X n is estimated by the formula.

$$\bar{X} = \sum_{\frac{i-1}{n}}^{n} X_i \tag{2}$$

The sample standard variation is estimated by the formula:

$$SD = \sqrt{\sum_{\frac{i-1}{n-1}}^{n} (X_i - \bar{X})^2} \tag{3}$$

Of the NI Vision Assistant module was used to obtain the sampling parameters of the studied images, which measures the statistics of the intensity of one or more areas of the image [25], [26]. Using this function, inverse binary images of hatching eggs were analyzed, multiplied by a constant of 255. In this case, the degree of pixel color gradation takes the value of either 0 or 255, with light pixels in the inverse image corresponding to code 255, and dark pixels to code 0. For 3 control days of incubation using the Quantify function on the images shown in the right cells of Figures 3, Figure 4, Figure 5, the average values and standard variations in pixel values are obtained, shown in Table 1.

Table 1. Egg image pixel values

An object	Square, %	Average value	Standard Variation	Minimum value	Maximum value
7 rez_8. jpg	100	244.83	49, 89	0	255
11rez_8. jpg	100	145.16	126.27	0	255
19rez_8.jpg	100	120.78	127.32	0	255

After analyzing the data given in table. 1, we conclude that if the average pixel value tends to 255, then this corresponds to the presence of only light pixels in the inverse image, i.e. the chick embryo froze [27]. You can set the maximum allowable threshold for the average pixel value. Since the embryos differ on different days of incubation in some physical properties, such as color, size, and blood streaks, therefore, the use of a general threshold to determine the normal growth of embryos throughout the incubation period is not applicable. We accept the statement that embryos on the 7th, 11th and 19th days of incubation with the average pixel values in the sample indicated in Table 1 develop normally. We assume that with an increase in the average pixel values by 3%, the embryos also develop normally, then the task of classifying eggs for three days of incubation is performed based on the equation:

$$\forall i \in \overline{1,3} \;\; f(\overline{X_i}) \in \begin{cases} \text{fertile} & \overline{X_i} \le \beta_i \\ \text{infertile} & \overline{X_i} \in \beta_i \end{cases} \tag{4}$$

Where $\beta = \overline{X_i} * 1.03$ is the threshold average pixel value for the i-th day of incubation. The Vision Assistant module allows you to quickly and easily try various processing methods, as well as view the results of the operation of certain filters and functions on images of various types [28]-[31]. To continue working on the project, National Instruments provides the ability to export the finished Vision Assistant project to LabVIEW. To do this, select Create LabVIEW VI from the Tools menu. As a result, the corresponding virtual instrument (VI) will be created, while the block diagram in LabVIEW will contain virtual instruments similar to those used in Vision Assistant.

The use of a vision system for monitoring chick embryos in an incubator offers significant advantages in ensuring optimal conditions and enhancing the success rate of hatching [32]-[35]. With its high-resolution cameras, image processing algorithms, and machine learning capabilities, this technology enables real-time and non-invasive monitoring of various parameters crucial for embryo development [36], [37]. By continuously analyzing key indicators like temperature, humidity, movement patterns, and even heartbeat rates, the vision system can detect potential issues at early stages and automatically alert breeders to take corrective actions to maintain ideal conditions [38]. Moreover, it provides valuable insights into embryonic behaviors and responses to environmental changes that were previously inaccessible. This detailed information empowers scientists to better understand developmental processes while enabling precise adjustments to optimize incubation settings [39]. Ultimately, the use of a vision system revolutionizes chick embryo monitoring by offering unprecedented accuracy, efficiency, and data-driven decision-making capabilities for breeders within professional settings.

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CONCLUSION

The structure of the vision and image processing system for the detection of fertilized and unfertilized eggs in the incubation industry has been developed. A reliable vision algorithm has been developed for processing the obtained images and distinguishing between fertilized and unfertilized eggs.

However, for greater efficiency in separating fertilized eggs from unfertilized ones, an artificial neural network consisting of eight neurons can be used. It is proposed to use the binary code of the generated average pixel values as the input data of the network. The following numbers should be used as threshold values: B 7 = 252, B 11 = 149, B 19 = 124, respectively, for the 7th, 11th and 19th days of incubation.

Monitoring chick embryos in an incubator has significant implications for poultry management and research. By closely observing the development of the embryos, one can ensure optimal conditions for hatching and identify any potential problems early on. Monitoring key variables such as temperature, humidity, and ventilation ensure that the incubator environment remains suitable for embryonic growth. Furthermore, monitoring chick embryos allows professionals to track important developmental milestones and assess overall embryo health. This information can be used to make informed decisions regarding incubation timeframes, as well as potential interventions if abnormalities are detected.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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