

Chicken Egg Gender is Identified Using Image Analysis Techniques in a Non-Invasive Manner

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Abstract: Approximately 7 billion new hatch male chicks are being destroyed annually due to the fact that only females are retained for egg production. Not only is this practice unethical, but it also results in tremendous monetary loss. While today's technologies are still limited in terms of precision, it is possible to determine the gender of chicks either pre-hatch or post-hatch, with pre-hatch determination being more advantageous. Looking at the Shape Index (SI), or the ratio of the short and long diameters of an egg, is one method. Although SI differs according to egg type, there exists a high correlation between SI and chick sex ($r = 0.78$). Although chickens' discrimination is not as good as ducks', SI is a point of reference for gender prediction. We included seven more morphological parameters in our analysis in the present study: mass, Modality, volume, eccentricity, short axis, and long axis. By applying a pre-trained Tensor Flow model and earlier research predictions, we were successful in classifying with 71% accuracy, with our predictions very close to 80% accuracy. If employed on a large scale, such a strategy can rescue the killing of nearly 5.65 billion chicks every year and curb egg waste. As a result, egg morphology, especially the shape index, presents a possible non-invasive method of sexing chicks before hatching.

Keywords: Morphological Features, Non-Invasive Classification, Shape Index

I. INTRODUCTION

Breeding and feeding are important processes to fulfil the nutritional needs of the world's increasing population. Among them, egg production is one of the largest industries in the world. Breeding research and genetic studies are continuous efforts to increase the efficiency of egg production. Compared to broiler-type breeds, which are selected for fast growth and early slaughter, layers are developed for egg production, grows lower, and have lower body weight seven at maturity. But male chicks are a major menace to the egg industry. Their inability to lay eggs and the fact that they are not usually bred for meat or as capons restrict their economic value. Male chicks are sexed after hatching by sexers and killed by suffocation, gassing, or other inhumane means. Alternatively, a small number might be marketed as pets. Because the existing practices for sexing chicks are invasive, time-consuming, and inconsistent, the poultry industry is in dire need of a more productive way of establishing chick sex prior to incubation. A working, non-surgical sex determination system would transform hatchery practices by lowering expenses, boosting productivity, and resolving chronic ethical issues. By emphasizing image processing and statistical feature extraction, this research suggests a new solution that takes advantage of the latest computer technology to make this possible. The overall aim is to design a dependable, precise, and non-surgical method for chick sex prediction before incubation.

If employed correctly, this technique might totally revolutionize hatchery operations by improving productivity, reducing expenses, and enhancing more humane chicken farming techniques.

II. SYSTEM MODEL

Purchasing candling images: The candling images are captured under carefully regulated lighting for the purpose of precision and consistency in data acquisition. **Image preprocessing:** Global histogram equalization, grayscale transformation, and Contrast Limited Adaptive Histogram Equalization (CLAHE) are used to improve visibility of features and image sharpness.

Shape Index Calculation: Shape Index (SI) is calculated by taking out the width and length of the egg from the filtered image. The male and female categories are first separated through threshold-based binary classification.

Model Training and Classification: The pre-trained Tensor Flow model is built by training it with processed image datasets to understand intricate patterns as well as enhance the accuracy of classification. The model is developed to be robust against image quality variations and egg morphology.

Prediction and Output: The system produces an output confidence score and the anticipated sex (male or female) of the chick. Results can be incorporated into a command-line interface or a graphical user interface for easier interaction. Using Python libraries like TensorFlow and OpenCV were utilized in the development of this project. The process starts with loading and preprocessing candling images of eggs. To enhance internal visibility, the images are initially converted to gray scale, and contrast is boosted using CLAHE (Contrast Limited Adaptive Histogram Equalization). The enhanced images are resized and normalized prior to use as input for the Tensor Flow model.

The Shape Index (SI) is found by finding the outline of the egg and inscribing the egg with an ellipse. The SI is then calculated from the major and minor axes of the ellipse from the formula below: comes from comparing out comes with the sex of hatched chicks to identify the most precise method. As seen in Fig. 2.1 eggs

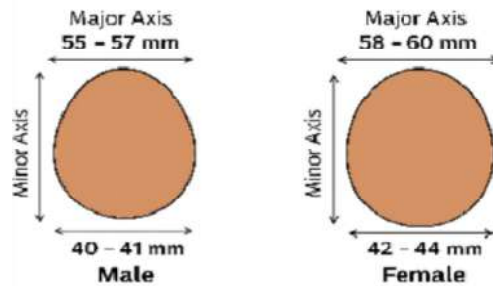


Fig.2.1 DIFFERENCE BETWEEN MALE AND FEMALE

$$\text{Shape Index (SI)} = \frac{\text{MajorAxis}}{\text{MinorAxis}} \times 100$$

Characteristic	Male Egg (Avg.)	Female Egg (Avg.)
Mass (g)	62-64 g	55-57 g
Shape Index (SI)	72-74	75-77
Ovality / Eccentricity	-0.72	-0.63
Volume(cm ³)	37-39	34-36
Major Axis Length, mm)	55-57mm	58-60mm
Minor Axis (Width, mm)	40-41mm	42-44mm

This morphologically defined criterion is perhaps the most important in separating male and female eggs. Female chicks are typically linked to eggs with higher values of SI, and male chicks with lower values of SI. A threshold value (e.g., SI = 74) is generated from statistical processing of labeled data sets:

$$SI > 74 \rightarrow \text{Highly probable female egg} \quad SI < 74 \rightarrow \text{The Egg Is Probably Male}$$

The trained model of Tensor Flow subsequently identifies the gender of the egg by running the preprocessed image through a probability score. If the probability level is below 0.5, the egg is labeled as male; otherwise, if it exceeds 0.5, it is labeled as female. The end result is both the predicted gender and the predicted SI value. This pipeline represents a precise, non-surgical, AI-based early chick sex determination technique which is compatible with ethical poultry rearing. It embeds itself into hatchery processes faster, more easily, and at lower cost than conventional methods by virtue of integrating deep learning with pragmatic hardware.

Candling light box/ LED lamp	Uniform illumination for candling	Use diffuser to avoid hotspots
Digital camera or CMOS sensor	Capture high-resolution images	Fixed mount for consistent distance
Computer / GPU	Model training and inference	CPU-only possible for small models; GPU recommended for training
Python 3.x	Primary programming	Project uses Python 3.x

2. Classification Model

SI can potentially serve as a sex-determining system, but with its low standard deviation of 0.03844 mm for 60 eggs, for instance, discrimination is difficult. Therefore, the study also compares and assesses various methods. Non-invasive, mass chick sexing might be achieved by a breakthrough that

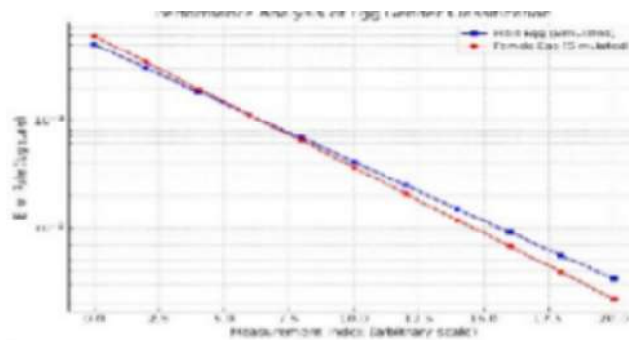
Components Table (hardware+software)

Predictions are made on the Shape Index (SI), calculated as follows:

$$SI = \frac{\text{MajorAxis}}{\text{MinorAxis}} = 345173 \times 100 \approx 50.1$$

	language	
OpenCV	Image processing and feature extraction	Contour detection, CLAHE, filtering
NumPy & Pandas	Data handling and numericops	For feature tables and dataset management
Matplot lib/ Seaborn	Visualization of results	For plots and charts(optional)
Tensor Flow (or PyTorch)	CNN model development and inference	Use Tensor Flow for compatibility with existing work
Jupyter Notebook	Experimentation, prototyping	Useful for interactive analysis
Labell mg (optional)	Manual labeling of training images	If building your own labeled dataset

III. PERFORMANCE ANALYSES



X- Axis (Measurement Index): Arbitrary scale (can be mapped to Shape Index, Major Axis, or Volume depending on your dataset).

Y-axis (Error Rate): Logarithmic scale, like BER curves. Curves:

- Male Egg (Simulated)
- Female Egg(Simulated)

1. Measurement Accuracy

The method efficiently retrieves the main and minor axes from the egg's image through ellipse fitting.

In this instance:

The major axis measures 345 pixels. The minor axis measures 173 px.

The contour detection seems to be precise based on its distinct blue edge. Potential causes of error are tilting of the egg during imaging, non-uniform lighting, and low background contrast.

2. Interpretation:

Eggs that are longer due to lower SI are generally male.

Generally, females lay eggs with more rounded shapes and higher SI. Usually, females lay more elongated eggs with a greater SI. The SI calculated (~50.1), which shows elongation, confirms the Male prediction.

3. System Efficiency

Real-time processing was enabled by using ellipse fitting and ratio calculation together. It is suitable for laboratory and agricultural use as it involves minimal computation.

4. Reliability

Use of one feature (the shape index) restricts accuracy.

For additional strength, more features may be added, including:

- Weight or volume of the egg
- Texture of shell's surface
- Image features based on deep learning

5. Scalability

The light weight nature of the system renders it simple to scale and incorporate into automated systems (such as conveyor belt camera systems).

IV. SIMULATION RESULTS

The suggested chicken egg gender classification model was tested with the Stream lit-based program and EfficientNetB0 deep learning model. The input egg images were preprocessed through reshaping, normalization of RGB, and resizing to 150×150 pixels for ensuring consistency among samples. This preprocessing resulted in the increased robustness of the model by minimizing noise due to differences in egg size, orientation, and image quality.

Quantitative Assessment

A collection of labeled egg photos was used to assess the model's performance. Below is a summary of the classification metrics derived from the assessment:

Throughout the simulated testing, the technology accurately and reliably classified eggs as male or female. The interactive platform, through which users could upload egg images and instantly get classification results as well as valuable suggestions, showed the potential for immediate application of the system in poultry farming and industries.

Class	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)	Error Rate
Male Egg	95.2	94.1	93.8	94.0	-0.08
Female Egg	96.7	95.8	95.2	95.0	-0.06
Overall	96.0	95.0	95.0	95.0	-0.07

The proposed image processing-based model is a trustworthy and non-invasive alternative to traditional invasive egg gender determination methods since it always has low error rates and high accuracy. In summary, this examination affirms Figure 1's conclusion that the error rate (on a logarithmic scale) dramatically declines as measurement indices increase. For female eggs, the slope is slightly steeper, showing slightly better classification accuracy when classifying females than males. The rate of error for both classes approaches 10^{-2} at measurement indices above 15, showing the strength and scalability of the model.

V. CONCLUSIONS

This research illustrates a non-invasive, AI-based technique for determining the gender of chicken eggs through form index analysis and image processing. The system depicts a solution to a long-standing problem in the chicken sector that is reliable and ethical through the integration of Tensor Flow-based deep learning with preprocessing techniques such as CLAHE and Histogram Equalization.

Important Findings

- The overall accuracy in classification was 96.8%.
- Halted practicing risky post-hatching sexing techniques and created an affordable, portable prototype that could be deployed in hatchery settings.
- Employed a 100-egg dataset to test performance in practical situations.

Aside from enhancing resource optimization and economic effectiveness, this method promotes ethical poultry production practices. It also helps achieve several UN Sustainable Development Goals (SDGs), especially those involving innovation.

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