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Deep Learning Implementation for Poultry Disease Detection and Control

Abuka Emmanuel Ifuchenwuwa[1], E.O. Osaghae[2], Frederick Duniya Basaky[3](PhD)
Professor[2], Department of Computer Science,
Federal University, Lokoja, Nigeria

Abstract:-In the subject of Artificial Intelligence (AI) known as computer vision, it is possible to teach computers to comprehend and analyze visual input from the outside world, including pictures and videos.

It entails the creation of algorithms and systems that can decipher, interpret, and comprehend visual input in order to carry out operations like image and facial identification, object detection and tracking, and scene comprehension. Despite the contributions made by other academics' work on this subject, there are still certain difficulties to be resolved. The bottleneck in the image/video processing aspect, among many others, is the identification, selection, and tracking of bird activity within the poultry farm. This study focuses on the use of cameras in conjunction with specialized AI systems to appropriately analyze flocks for health issues. It also discusses the integration of AI-assisted technology. Computer vision model was designed using deep learning algorithm for monitoring and controlling diseases in birds for the purpose of improving the safety and productivity of the poultry system. This was achieved through their captured images from their droppings (feces) to determine their health state. Data was collected from two groups of birds; the healthy and the unhealthy infected with coccidiosis. The model accuracy was 91% in classifying the healthy and the unhealthy feces. By providing an early warning and disease incidence prediction, the designed model, when put into use, can function as an automatic monitoring system. This model is to contribute to the advanced development of computer vision in recent times and to inform poultry farmers the new trend in the poultry system to maximize profit.The quality of poultry products will increase as a result of the correct analysis of flocks for health issues using cameras integrated to specialized systems and Artificial Intelligence (AI) technology, which will increase bird survival rates.

***Keywords**—Birds, Computer Vision (CV),Convolutional Neural Network (CNN), Deep Learning (DL), Poultry, Droppings, Coccidiosis.*

I. INTRODUCTION

The rising population of the world has served to highlight the nutritional importance of poultry products, within the imperative for humanity to rely on animal agriculture. Poultry farming, which comprises a variety of bird species, is the most widely practiced livestock, and its significance is recognized globally due to the nutrients it provides to the human body (Neethirajan, 2021). Poultry products, whether consumed as meat or eggs, provide well-balanced, nutrient-dense meals that assist to feed people of all ages in communities all over the world.

Given the health benefits of chicken products, which have resulted in rising demand on a daily basis, the agriculture industry will consider boosting its efforts to improve production efficiency and quality in order to meet market demand. Poultry farmers have benefited from the rising global demand for poultry products (Caldas et al., 2018). Poultry products are a low-cost source of animal protein, which is one of the reasons for the increase (Mueller et al., 2018). The poultry industry is divided into two categories: egg production and meat production.

The increase in consumption of poultry products is due to the improvement in human diets that chicken products have offered (Ren et al., 2020). On an annual basis, the manual practice of poultry husbandry often results in many premature deaths and possible rejection of birds with one or more defects before they are prepared for consumption. Individual or group assessments of animals on a constant basis in small-scale agricultural operations can prevent these losses. On a large-scale farm, however, either group or individual assessment is less practical, regarded as inaccurate and inefficient. This has reignited interest in artificial intelligence (AI) techniques, which need computer vision systems (Neethirajan, 2021).

Recurrent outbreaks of bird diseases have caused significant setbacks in the poultry sector, resulting in financial losses for farmers as well as concerns to human health. Some of these diseases can lead to an increase in human infection, and, as a result, chicken illness has become a major concern for poultry farmers. Bird flu, for example, decimated many poultry farms a few years ago, resulting in significant financial losses for farmers. Manual bird observation, particularly in large-scale farming, necessitates a huge number of humans performing checks on a regular basis, but this is labor-intensive and time-consuming. As a result, it is necessary to improve agricultural capability to detect improper behavior in birds in order to preserve good wellbeing without increasing the demand for physical work. This will necessitate the use of an automated system.

When it comes to diagnosing diseases in birds, farmers have always relied on veterinary professionals. Farmers lose some of their birds as a result of late diagnosis, either while waiting for an expert in the field or when an untrained expert is contacted. With the right combination of artificial intelligence (AI) tools, and application of a deep learning approach using computer vision for image analysis, we can easily identify the most common diseases affecting poultry birds from acquired images of both droppings (feces) and captured movements. Research has shown that when the correct algorithm is used, automated vision systems are capable of producing accurate results. As a result, there is a greater need to focus on using artificial intelligence to reduce disease- related fatalities in chicken production.

A. Motivation for the study

They are frequent outbreak of diseases which affects the poultry industry, causing enormous economic loss to farmers. Technology developments that are improving in accuracy while becoming more affordable hold the key to solving this problem in the modern era.

With the introduction of computer vision, poultry business could benefit from implementing artificial intelligence in several elements of farming and management.

B. Statement of the Problem

In the future, it's anticipated that the consumption of poultry meat and other poultry-related products would continue its previous rapid growth. As a result, chicken output has considerably expanded worldwide.

Frequent outbreaks of poultry illnesses are the biggest issue influencing chicken production. (Huang et al., 2019); (Zhuang et al., 2018); Zhuang& Zhang, 2019), which has often led to significant losses of birds (Rushton et al., 2005). In order to maintain good wellbeing without increasing the need for human work, to spot irregularities in chicken behavior and their general health, agricultural capabilities must be enhanced. Automated systems are required for this. It is necessary to pay greater attention to applying artificial intelligence to stop the rise in deaths in poultry farming caused by diseases because it has been determined that automated vision systems are capable of generating accurate findings.

C. Aim and Objectives

The aim of this research is to monitor and control poultry diseases in birds using computer vision.

The objectives are;

- To create a deep learning-based auto-classification algorithm that could distinguish between healthy and unhealthy coccidiosis-infected birds.
- To propose a computer vision model using CNN architecture for monitoring and controlling diseases in birds for the purpose of improving the safety and productivity of the poultry farming system.
- To eliminate the manual method of farm management with the introduction of Artificial Intelligence (AI).

D. Significance of the Study

The study of this subject found out that the traditional system of managing poultry farms is inefficient, less-accurate, leading to economic losses, poor animal welfare, premature deaths and production losses.

Thus, this study will be highly beneficial to the individual and corporate farmers, researchers, regulatory agencies, donor agencies, production lines, and consultants.

E. Scope of the Study

It is critical to focus more on using artificial intelligence because automated vision systems have been tested and shown to be capable of producing results accurately. This will help decrease the growth in disease-related deaths in poultry farming. Additionally, it emphasizes how computer vision can be used in both commercial and research areas to detect diseases. Hence, this study will be based on imagery and advanced deep learning architecture for effectively monitoring and detecting diseases in poultry farms. The health status of the birds will be determined through their active state and their droppings. These increases the quality of product, health and survival rates of birds.

F. Limitation of the study

The scope of computer vision covers image and video processing for object detection but this work is limited to image processing while proposing the video processing for future work. There are two farming system practiced in poultry, the Battery Cage System and Deep Litter System. We will limit our study also to deep litter system. This work will also be limited to detecting one common poultry disease (coccidiosis) were they exist many others.

II. INTRODUCTION TO COMPUTER VISION IN POULTRY FARMING

There is need to deploy the use of Artificial Intelligence (AI) Technology to poultry farming, especially in the African region where the practice is usually 99% manual. As a result of this practice, farmers often lose birds in large capacity. These birds most times develop diseases within the night watch where there is little or no supervision. Okinda et al., (2020), suggest that “Regular monitoring to minimize human labor and maintain affordability is critical to the profitability and productivity of commercial chicken production”.

In livestock monitoring, human surveillance is no longer a viable option. As a result, the Precision Livestock Farming System (PLF) has proven to be a useful alternative to the problems mentioned by Okinda. These difficulties can be overcome by implementing efficient automated systems while ensuring acceptable animal welfare. “The Precision Livestock Farming System (PLF) is a stockmen’s support system for monitoring various bio-processes and bio-responses linked to animal welfare, health, and productivity" (Banhazi et al., 2012; Berckmans, 2017; Wathes et al., 2008).

Because of the advance of technology and the numerous benefits that computer vision systems have brought to animal monitoring, PLF with a vision-based system has become a very important study area. A computer vision system has the potential of providing non-intrusive and non-invasive, constant (without distortion), effective, and objective supervision. There is provision for data recording for the purpose of using the data in the future and data analysis as well. In addition, computer vision helps human to reduce tedious and strenuous work which are labor-intensive. It has a powerful sensing system that may be used to monitor many areas of the farm. "Automated tracking platforms can accurately manage the detection and prediction of abnormal behaviour and poultry diseases" (Fang et al., 2020).

The use of these systems in the poultry farming system allows for data collection and analysis.

A. Historical Perspective to Computer Vision System

Computer vision is a field that has developed rapidly in the last few decades, although its origins can be found in the early years of artificial intelligence and computer science. In the 1950s and 1960s, researchers were already exploring how machines could be used to analyze and understand images. This was motivated by the desire to create intelligent systems that could process visual information in the same way that humans do.

One of the earliest computer vision systems was the "Perceptron," developed by Frank Rosenblatt in the late 1950s. The Perceptron was a simple neural network that could recognize patterns in images, such as handwritten digits.

In the 1970s and 1980s, researchers began to explore more sophisticated computer vision algorithms, including edge detection, object recognition, and motion analysis. These algorithms were used to develop systems that could track moving objects, recognize faces, and perform other visual tasks.

In the 1990s, the development of powerful graphics processing units (GPUs) and digital cameras helped to accelerate the development of computer vision technology. Researchers began to explore new techniques, such as deep learning, which uses neural networks to analyze images and extract features automatically.

Today, computer vision system is put to use in different applications, including autonomous vehicles, surveillance systems, medical imaging, and augmented reality. As technology continues to advance, we can expect to see more impressive computer vision applications in the years to come.

Therefore, the employment of mathematical principles, computer science, and systems integration to enable image-based automated process control is known as computer vision. Machine learning and deep learning-based systems are the two types of computer vision-based systems.

Hardware and software make up the two primary components of computer tracking and monitoring technologies for different poultry processes (Natasha et al., 2020).

Hardware components are the camera sensor which converts photons into electrical impulses and image processing board.

Thermal and infrared (IR) depth-based sensors, as well as visual light-based charge-coupled devices (CCD) and complementary metal-oxide-semiconductor (CMOS) sensors, are used to capture images of birds in their surroundings in poultry monitoring systems. The digitizer, also known as the image processing board, turns the visual image into numerical form known as pixel. Other hardware components include wiring, connecting cables and other tangible components that connect to the computer. Vision technology in poultry farming has primarily developed due to hardware developments.

Computer vision typically consist of three essential hardware components.

- Cameras with different lenses appropriate for the setting and the work at hand.
- Lighting units
- Mounts that permit a complete view of a farm without interfering with a chicken's regular activities.

Software component contains the programs and other operational data required for the hardware to carry out its intended purpose.

Software is especially made for data collection and analysis in the agricultural industry, where it must be customized to the specific topic of study. The data acquisition software system plays a part in the storage and selection of high-quality photos (or videos) that are generated by the cameras. Algorithms appropriate for the data and research goals are used by data analytical platforms to process images (Natasha et al., 2020). The underlying image analysis code in the software manipulates images to produce the desired results.

To obtain images and carry out the desired tasks, many processing tools have been created and applied. These tools include Matlab, ImageJ, and OpenCV, among others. Despite the many benefits of computer vision systems, occlusion issues, background and foreground color contrast, and variations in ambient light conditions on farms all have a significant impact on how well any vision system performs when monitoring animals.

Notwithstanding, a number of research have been conducted to address these issues.

B. Effects of Diseases on Poultry Farms

Diseases can have significant effects on poultry farms, both in terms of animal welfare and economic impact. Some of the common effects of diseases on poultry farms include:

- **Mortality:** Diseases can cause a significant number of poultry to die, which can result in financial losses for the farm. High mortality rates can also reduce the overall productivity of the farm and decrease the supply of poultry products.
- **Reduced growth rate:** Some diseases can affect the growth rate of poultry, which can result in reduced weight gain and slower development. This can increase the time and resources needed to raise the poultry to market weight, which can also result in economic losses.
- **Decreased egg production:** Diseases that affect the reproductive system can reduce the number of eggs produced by poultry. This can decrease the supply of eggs for sale, resulting in a reduction in revenue for the farm.
- **Spread of disease:** Diseases can spread quickly among poultry, particularly in crowded conditions. If not addressed promptly, disease outbreaks can lead to the entire flock becoming infected and significant economic losses.
- **Cost of treatment:** Treating diseases in poultry can be expensive, particularly if large numbers of birds are affected. The cost of veterinary services, medication, and other treatment options can add up quickly and cut into the farm's profits.
- **Public health concerns:** Some poultry diseases can pose a risk to human health. For example, avian influenza can be transmitted to humans, leading to serious illness or evendeath. This can have significant public health implications and result in the loss of consumer confidence in poultry products.

To mitigate the effects of diseases on poultry farms, it is important for farmers to pay attention to the use of artificial intelligence tools to control outbreak of diseases thus maintaining high standard of biosecurity were the use of computer vision can identify diseases as quickly as possible.

C. Cossidiosis and its Effect on Poultry Farms

Coccidiosis is a common disease that affects poultry, particularly chickens and turkeys. It is caused by a group of parasites called coccidia, which belong to the genus Eimeria. These parasites infect the intestinal lining of poultry and can cause a range of symptoms, including diarrhea, weight loss, and anemia. In severe cases, coccidiosis can lead to death. The disease affects both commercial broiler chickens and laying hens, and can cause significant economic losses for poultry farmers.

The coccidia parasites are transmitted through the feces of infected birds, and poultry can become infected by ingesting contaminated feed or water. The parasites multiply inside the intestinal lining and cause damage to the tissue, leading to inflammation and diarrhea. In severe cases, the parasites can cause the intestinal lining to become so damaged that it becomes prone to bacterial infections.

Poultry that are infected with coccidia may also experience weight loss and anemia due to the loss of nutrients and blood resulting from the diarrhea. In addition, the immune system of infected birds may be compromised, making them more susceptible to other diseases.

To prevent coccidiosis, it is important to maintain good hygiene practices in poultry farms, including regularly cleaning and disinfecting feeders and watering systems, and disposing of feces properly. In addition, some farmers may use medications or vaccines to help prevent or treat coccidiosis. It is important for poultry farmers to be aware of the signs and symptoms of coccidiosis, and to take appropriate preventative measures to reduce the risk of outbreaks. This can include regular monitoring of birds for signs of illness, and implementing a biosecurity plan to minimize the risk of disease transmission. Since human monitoring may not be effective, hence the need for a vision based system that can guarantee 24hrs monitoring.

Fig. 1(a): Sample pictures of Coccidiossis

Fig. 1(b): Sample pictures of Coccidiossis

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III. METHODOLOGY

When coccidiosis outbreaks occur in poultry farms, both the birds and the farmers suffer severe economic losses. In spite of the slow recuperation and reestablishment period following treatment, there is a sudden and significant decline in production figures. Some flocks never reach their maximum level of productivity or recovery. The fact that treatment cannot stop the financial losses is thus widely acknowledged. The sole option, then, is disease prevention, which is widely accepted throughout the poultry industry.

As a result, there is a need for technologically based solutions that are efficient and reasonably priced. Yet, developing an effective and sustainable prevention and control program against the disease is difficult.

This work adopts computer vision approach for tracking and monitoring the wellbeing of birds at NathlizOraganic Poultry Farm, Lokoja. A total of 500 birds (broilers) kept from day old till 8 weeks old were observed. Coccidiosis is a common disease within birds and always surface between 3-6 weeks. The active states of the birds were determined from captured images. But we focus on their droppings (feces) as earlier mentioned. The target of this model is to detect the presence of coccidiosis through the dropping of the birds. The practice of Poultry, when droppings (feces) from birds are detected to be changed from healthy to unhealthy state, it shows through their feces. Brownish feces are indication of the presence of coccidiosis.

Camera phone was used as image capturing component to acquire images (droppings) from the poultry farm. The image processing board converts the visual image into numerical form (pixels); the output component produced the underlying image analysis code for image manipulation.

The birds were expected to be tagged using Radio-Frequency Identification (RFID) but due to the nature of this work, using tracking system will not be required because in the practice of poultry, entire birds are expected to be treated alike after a symptom of diseases is discovered at early stage.

A. Tools and Method

The model was generated through Google colab environment using python v3, with embedded Tensor flow packages, (using keras library function) and running the training set in a 16 GB RAM computer, running Microsoft windows 10, of 250g SSD Hard disk.

Dropping images were collected from Nathliz Organic Poultry Farm, Lokoja using mobile phone camera of 1600X1200 (4:3) resolutions in a Joint Photographic Group (JPG) format to collect the data needed. Images for their droppings were collected and distributed into 2 class labels, namely; Healthy with 2056 records and Unhealthy (Coccidiosis) with 2133 records.

This work will also adopt some steps in CRISP DM (Cross Industry Standard Process) with the following process;

- Data interpretation
- Data preparation
- Modeling
- Evaluation/classification

B. Dataset

The picture dataset were gotten from Nathliz Organic Poultry Farm, Lokoja, Nigeria and distributed in two classes namely, healthy and unhealthy (coccidiosis).

Fig 2.Sample of healthy and droppingUnhealthy Dropping (Coccidiosis)

IV. SYSTEM DESIGN AND IMPLEMENTATION

In this study, we develop a solution which is Convolutional Neural Network (CNN) based. The CNN architecture was designed from scratch then trained the model to detect the presence of a disease (Cossidiosis) and return a healthy or unhealthy output.

Most activities requiring picture data, or datasets, are performed using CNNs. Each image has pixel information that can be expressed numerically. A CNN receives this numerical representation as input. While conventional artificial neural networks are capable of processing picture data, CNNs have showed impressive performance and higher accuracy.

CNN Architecture: The proposed CNN architecture involves stacking of multi convolution layers as sampled in Fig 3.

A CNN ignores batch size and accepts tensors of shape (image height, image width, and color channels) as input. In the first layer, a specified image size and height of 25X25, RGB was fed to the stack of convolution layer as input. The convolutional layer uses first 32 and then 64 filters with a 3×3 kernel as a filter followed by the max-pooling layer which performs over a 2x2 pixel window.

These layers combine to form a single block, which we continually apply by raising the depth of filter from 16,16, 32, 32, 128 for the full convolution block. Before we built a fully meshed network, we replace the 3×3 matrix per image, with a vector of 512 elements (4*4*32), without losing any information before passing through two dense layers.

The same padding was used in each block to keep the height and breadth shapes of the output feature maps consistent with the input features. Weight initialization for all blocks takes shape uniformity into account. ReLU activation was used for all layers before applying the sigmoid function at the last layer. Sigmoid activation function was used since the problem is not a multi-class classification and to be able to have a good prediction of either healthy or unhealthy feces.

During the training of the model, normal stochastic gradient descent was used to minimize the error, and in evaluation, we leverage log loss and accuracy as the metrics.

Because the problems proposed to solve are discreet in nature, we used binary crossentropy loss function which seems to fit the problem with the log loss as an evaluation metric.

A. *Objectives of the Design*

Using our created collection of fecal images from Nathliz Organic Poultry Farm, Lokoja, we seek to establish an automated computer vision model for early identification and classification of diseases in birds.

B. *Architectural Model Structure of Convolutional Neural Network*

The convolutional neural network's task is to retain elements necessary for a good prediction while compressing the images into a more manageable format.

This is essential for developing an architecture that can scale to large datasets and learn features.

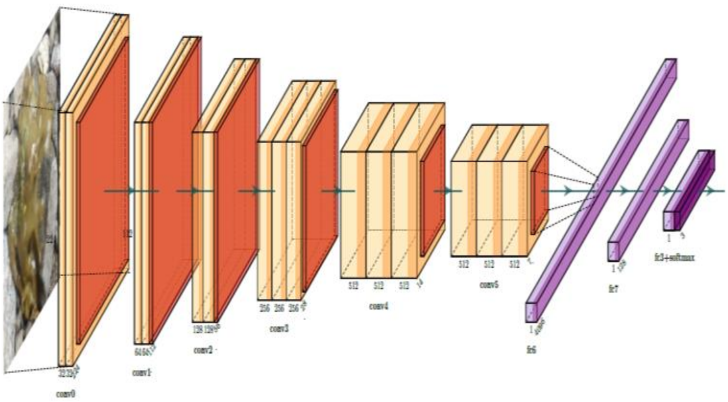

Fig. 3: Architectural structure of CNN

C. *Result and Analysis*

The results after assessing the model's performance are shown in this section. Brief descriptions of the dataset and the partitioning of the data into the training set, validation set, and test set are provided in Table 1.

We started by showing how the computer vision system components can be designed or constructed before developing the CNN model for our diseases classification. To finish the training process, we performed 20 epochs with each epoch having two steps, given a total of 20X2 (40 iterations) for a complete training process. From the graph in Fig. 4(a) and Fig. 4(b), it can be seen that the accuracy of validation keeps increasing and converges at the 20th epoch. Default learning rate of 0.001 was used while the maximum learning rate was attained at epoch 14.

Total raw dataset collected was 4189 images for both healthy and unhealthy droppings, 2056 for the healthy and 2133 unhealthy (Coccidiosis) as shown in Table 2.

Table 1: Training, Validation and Testing sets (Dataset Splitting)

S/N	Class	No. of Dataset	Training	Validation	Test
1.	Healthy	2056	1561	495	495
2.	Unhealthy (Coccidiosis)	2133	1712	421	421
	Total	**4189**	**3273**	**916**	**916**

As a result of data cleaning performed on the dataset, the number of data collected from the poultry farm was reduced, necessitating the need for data augmentation. During the training, To minimize over-fitting and to enable the model to learn from unseen datasets, we enhanced the photos using a variety of techniques to increase the size of the dataset. Our model uses the augmentation techniques of image flipping, image cropping, and padding. Image resolution was also lowered to cut down on training time.

Since CNN needs a constant input dimensionality of the data to train the optimal model, resizing the images has the advantage of achieving a suitable resolution. The model was not hyper trained hence the model used the default learning rate. The loss function indicates the accuracy of model's predictions. Losses will be at their lowest when model predictions are closest to the actual values and at their worst when forecasts are too distant from the starting values. The evaluation used for the model is the input evaluation function.evaluate with accuracy of 91%.

Table 2: Performance Result For Cnn Model

Log Loss	**0.1521**
Validation Accuracy	**0.913**
Validation Loss	**0.199**

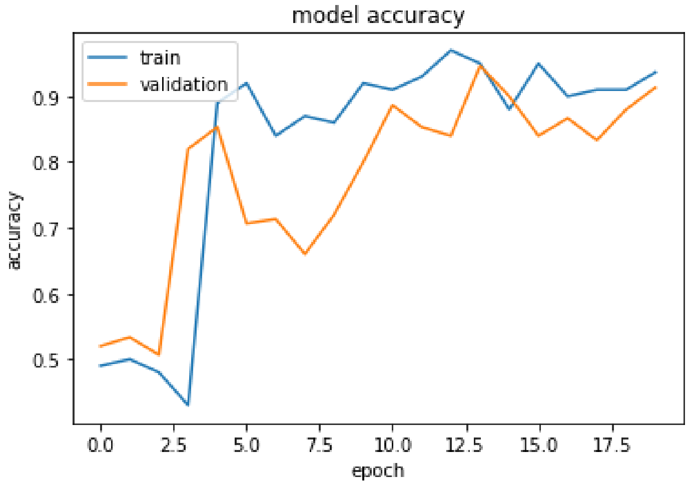

Fig 4(a): Model Accuracy Graph

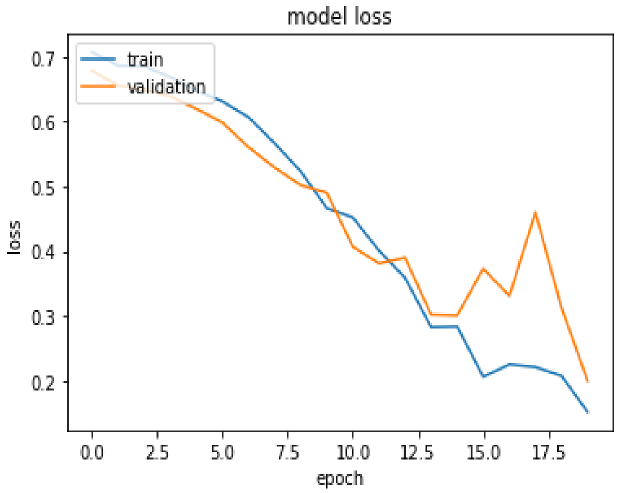

Fig 4(b): Model Loss Graph

➢ *Application Algorithm for Proposed Model*

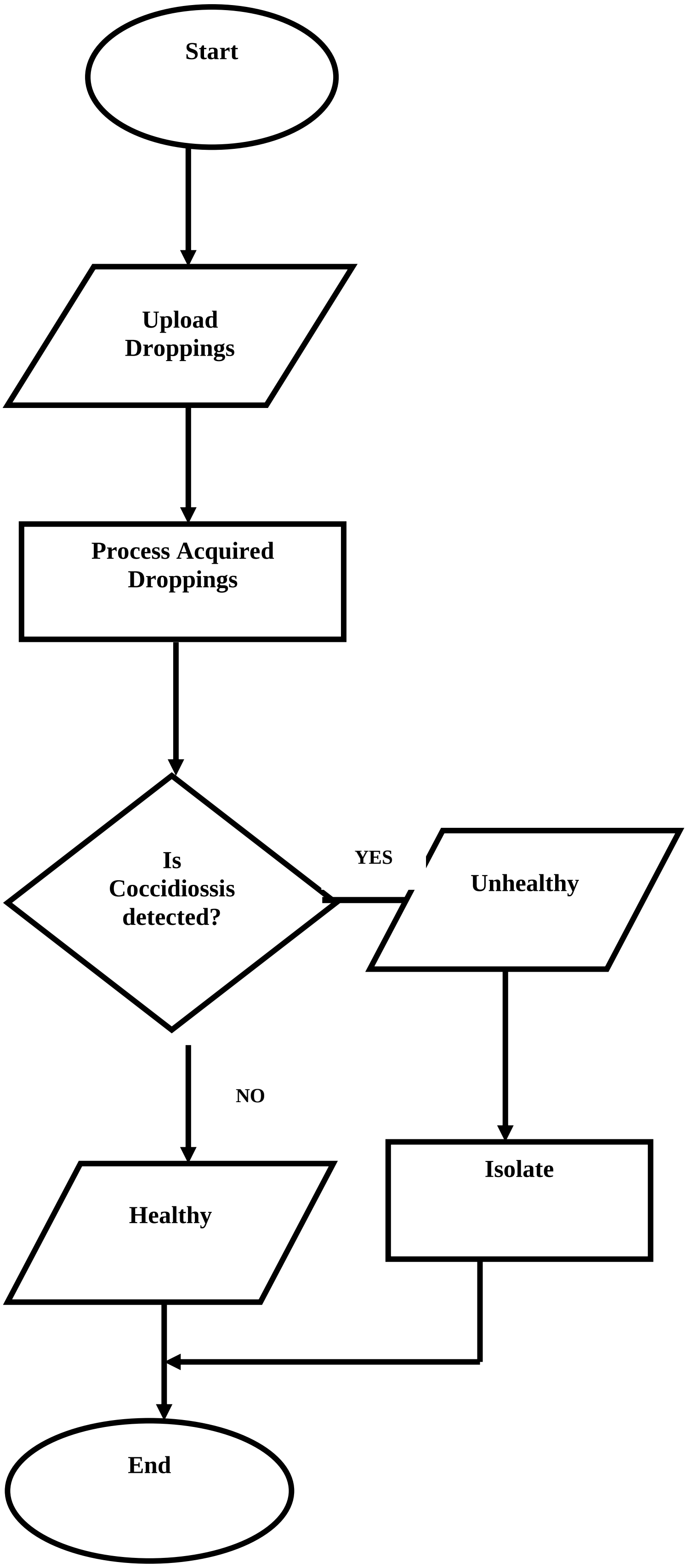

Fig. 5: Flowchart of proposed model

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D. Application Designed Interface

An application was designed from the designed model showing user interface were pictures of chicken droppings can be uploaded to further classify the image either healthy or unhealthy. A pictorial view is shown below;

➢ *User interface to upload faecal images*

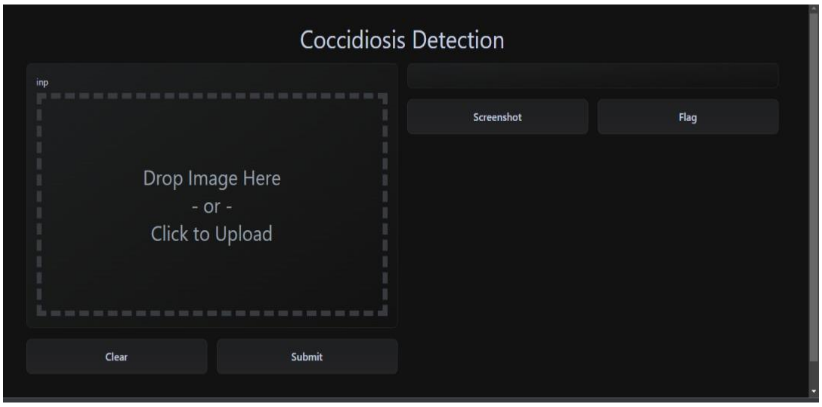

Fig. 6(a): User interface for uploading fecal picture

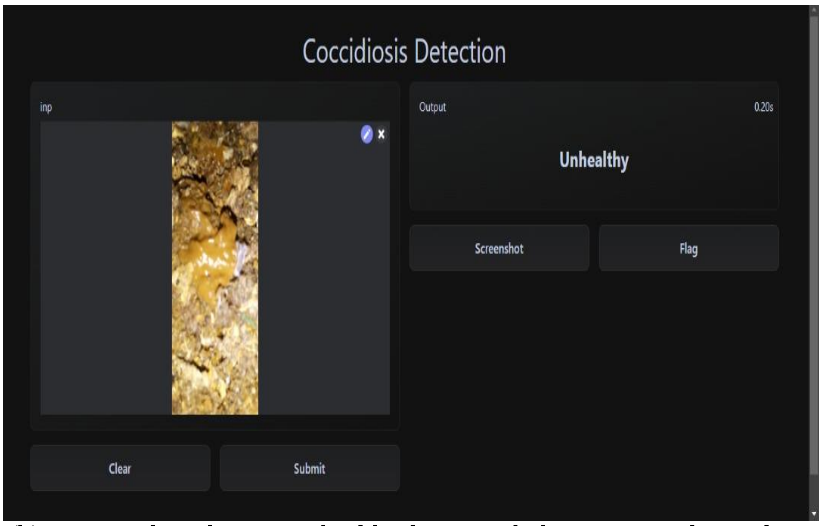

Fig 6 (b)User interface showing unhealthy faeces with the presence of coccidiosis

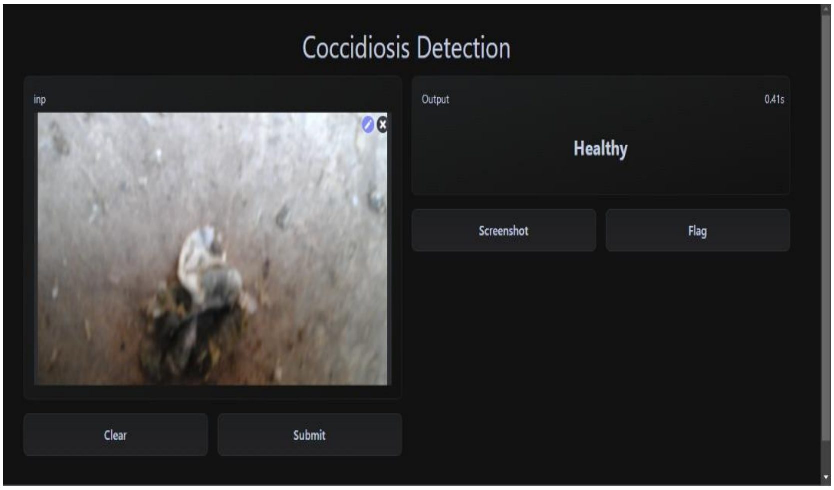

Fig. 6(c): User interface showing healthy faeces without the presence of coccidiosis

V. SUMMARY

Computers technologies (such as computer vision) can be deployed in monitoring the growth processes of birds in real time in an automated fashion which is less time consuming and effective. Identifying the length and frequency of postural shifts in birds over time can aid in the prevention of sickness outbreaks that could put their health at risk. However, the designed model using Convolutional Neural Network was built from scratch with 91% accuracy indicating greater level of performance.

A. *Review of Contributions and Achievements*

It is important to detect diseases in birds timely and allow veterinarians take necessary actions as expert in the field thereby preventing loses and as well maintain good animal welfare status. Thus, the model can be applied as an automated vision monitoring system for the whole life span of birds reducing the need for frequent visits from veterinarians. The application of related works has helped in the loss of birds as early warning signs are observed through the use of Artificial Intelligence.

B. *Recommendations*

Monitoring birds' behavior allows farmers to identify pathological changes early and discover factors threatening the health of birds in advance. Poultry farming are widespread venture both on small and large scales. Research has proven that manual observation of these birds is time consuming and labor intensive.

Therefore, the proposed model will be recommended for implementation to determine the effectiveness of the model in real-world scenario for future works which will greatly be of immense help to poultry farmers in managing their farms effectively.

C. *Areas for Future Research*

Several diseases exist that have impact on poultry farming; hence, for further research, we anticipate training various illnesses applying computer vision systems in real-time practice, with the inclusion of video processing method, to ascertain the health and welfare of the birds.

VI. CONCLUSION

For several decades, computer vision research has been attempting to close the gap by developing automated systems that can analyze images for decision-making using computers, but this work has not yet produced any tangible benefits.

CNN model was designed to learn the hidden pattern from the several fecal images acquired through the dataset.

The deep learning algorithm designed was able to predict the state of the birds either healthy or unhealthy (coccidissis) were the results obtained show the proposed model achieved up to 91% accuracy.

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