ADVANCEMENTS IN PRECISION AGRICULTURE: CUTTING-EDGE SOLUTIONS FOR COCCIDIOSIS DISEASE USING SMART DIAGNOSTIC SYSTEMS

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ABSTRACT

The poultry industry in Nigeria faces critical challenges from diseases like Coccidiosis, which severely hinder productivity. Traditional farming methods, limited access to veterinary services, and unreliable diagnostic information exacerbate this issue. To address these challenges, this study harnesses artificial intelligence (AI) and machine learning (ML) to develop a smart diagnostic solution for poultry diseases. Using Google Teachable Machine and a dataset of 4,880 faecal images sourced from an open-access Zenodo repository, this study applied advanced image augmentation, pre-processing, and segmentation techniques to enhance diagnostic accuracy. The dataset was split into 85% for training and 15% for testing, achieving an impressive 99% accuracy. The classification model was integrated into a mobile application built with Flutter and Python, enabling farmers to easily access diagnostic tools for proactive disease management. This innovation bridges the gap in veterinary services, providing an efficient and cost-effective solution for identifying and managing Coccidiosis in poultry. Future work will explore extending the application to other poultry diseases and validating its impact through real-world field trials. This study marks a significant advancement towards sustainable poultry farming in Nigeria, fostering economic growth and improved food security.

Keywords: Machine Learning, Precision Agriculture, Poultry Disease Diagnostics, Mobile Applications, Image Classification

INTRODUCTION

Nigeria is noted as having the second largest chicken population in Africa, with a standing stock of about 180 million birds producing more than 14 billion eggs and 454,000 tonnes of meat annually. The Nigerian poultry industry contributes approximately 25% to agricultural GDP (Makasi *et al*., 2020). However, poultry production has not kept pace with the rapid increase in domestic consumption because it is greatly affected by poultry diseases. Coccidiosis is a poultry disease ranked as one of the leading causes of death in poultry with *Eimeria tenella* among the most pathogenic parasite (Abbas *et al*., 2019; Williams, 2005). Without timely detection and intervention, outbreaks of coccidiosis can lead to substantial economic losses in the livestock sector.

The present and most common diagnostic techniques for coccidiosis rely on clinical indicators, such as determining if the diarrhoea is bloody or brown, counting the number of oocytes in the stool, and assessing the intestinal tract to get the lesion score. In addition to taking days to complete, all of these procedures are costly and time-consuming since by the time a diagnosis is obtained, the disease may have progressed, or a high death rate may have occurred.

Recent studies highlight how smart diagnostic systems—powered by sensors, machine learning, and data analytics—can offer real-time monitoring and early detection of coccidiosis in livestock, enabling farmers to implement timely interventions and reduce reliance on antibiotics (Ahmad *et al*., 2020; Su *et al*., 2018). These systems utilize data-driven insights to provide continuous health assessments, helping farmers address disease outbreaks efficiently while supporting sustainable livestock production practices. Hence, the present study explored the possibilities of cutting-edge solutions for Coccidiosis disease using Smart Diagnostic Systems in poultry production.

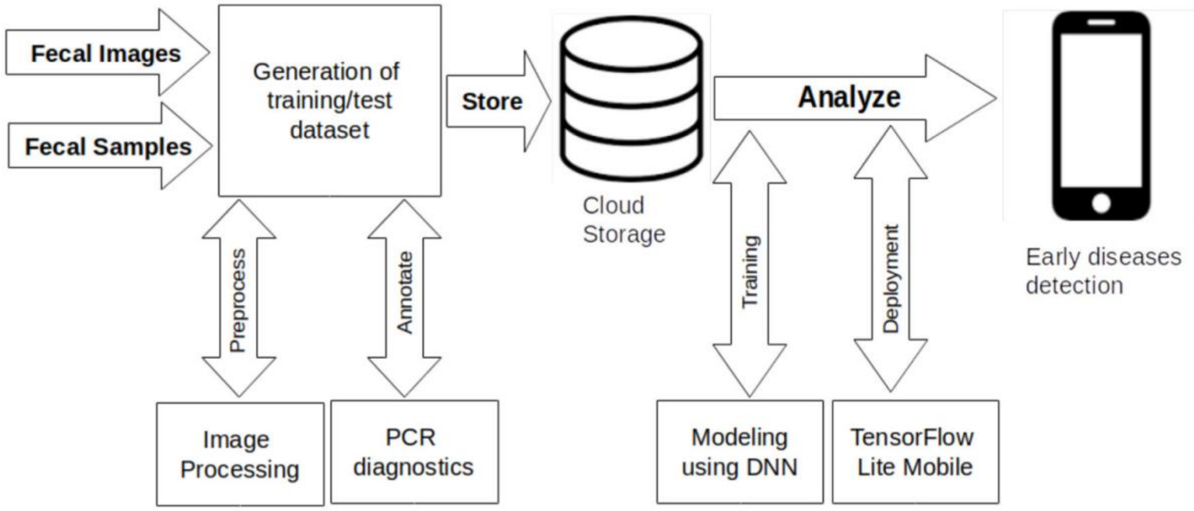
MATERIALS AND METHODS

The study utilized a comprehensive dataset of poultry faecal images, sourced from a Zenodo repository published by Machuve *et al.* (2021). The images, collected between February 2020 and February 2021 from farms in Tanzania, represented two categories: chickens affected by coccidiosis and healthy chickens. A total of 720 laboratory-labelled images were processed using Polymerase Chain Reaction (PCR) for disease confirmation, while 4160 farm-labelled images were annotated by veterinarians and field officers based on visual features like color and shape.

To prepare the data, the images were resized to uniform dimensions (224x224 or 512x512 pixels) and categorized into training (85.2%), validation (15%), and testing (14.8%) sets. Pre-processing involved manual labeling and data augmentation techniques, such as image flipping, cropping, padding, and saturation adjustments, to enhance the training set and prevent overfitting.

Model training was conducted using Google Teachable Machine, employing pre-trained deep neural networks. Key parameters included a learning rate of 0.001, 50 training epochs, and a batch size of 16. Performance was evaluated by monitoring training and validation accuracy and loss across epochs. Once trained, the model was exported as a TensorFlow Lite file for mobile application deployment.

The final system integrated the AI model with a Flutter-based mobile application, enabling efficient and portable diagnostics for chicken diseases. This framework provided farmers with an accessible tool to detect coccidiosis on-site using a lightweight, high-performing classification model.



Automated coccidiosis disease diagnostics research work-flow

RESULTS AND IMPLEMENTATION

The study evaluated the performance of a deep-learning model trained to diagnose coccidiosis in poultry using a dataset of 4880 labelled faecal images. The dataset included 2476 images of chickens affected by coccidiosis and 2404 images of healthy chickens. The model, trained using Google Teachable Machine, demonstrated exceptional accuracy, achieving 99% for the coccidiosis class and 100% for the healthy class. Performance metrics, including the confusion matrix, accuracy trends, and loss per epoch over 50 training iterations, confirmed the model’s reliability and effectiveness in classification tasks.

For practical implementation, the trained model was converted into TensorFlow Lite format to optimize it for mobile devices. This lightweight format ensured compatibility with devices having limited computing resources while maintaining the model's high accuracy. The conversion process included loading the model, preprocessing input images, running predictions, and postprocessing the output to generate class labels and their probabilities.

The integrated system was deployed as a mobile application developed with Flutter, providing a user-friendly interface for poultry farmers. The app allows users to capture or upload images of chicken faeces, which are classified in real-time using the embedded AI model. Results, including the predicted class (Coccidiosis or Healthy) and prediction accuracy, are displayed alongside expert-verified treatment recommendations. Treatment options, such as herbal and chemical remedies, are stored in a centralized database and accessed dynamically within the app.

CONCLUSION AND RECOMMENDATION

The mobile application developed for the detection of coccidiosis in poultry demonstrates the potential of leveraging artificial intelligence to support early disease diagnosis in agricultural settings. The integration of a highly accurate deep-learning model (achieving 99% and 100% accuracy for coccidiosis and healthy classes, respectively) with a user-friendly interface ensures a practical, scalable tool for poultry farmers. By enabling real-time analysis of faecal images and offering reliable treatment recommendations, the system addresses a critical challenge in poultry farming—minimizing disease-related losses. Its deployment as a lightweight mobile application ensures accessibility even for small-scale farmers with limited resources.

It is therefore recommended that efforts should focus on promoting the app's adoption through training programs and awareness campaigns to educate farmers about its benefits. Regular updates to the AI model are essential to enhance its robustness, ensuring accuracy across diverse regions and poultry breeds. Expanding the app's diagnostic capabilities to include other poultry diseases would further increase its value as a comprehensive tool for farmers.

To improve accessibility, offline functionality should be developed, to enable farmers in remote areas with limited internet access to use the app effectively. Additionally, integrating the app with veterinary services could provide users with expert guidance for advanced diagnosis and treatment. Data privacy measures must be prioritized to safeguard user information and ensure compliance with security standards. Finally, conducting economic evaluations to quantify the app's financial benefits—such as reduced disease-related losses and improved productivity—will highlight its value and encourage wider adoption.

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