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Internet of Things Based Intelligent monitoring and Controlling of Poultry System on using Artificial Intelligence

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Abstract: The poultry business in contemporary India is one of the most important and rapidly expanding sectors of the country's agricultural economy. Increases in chicken production can be attributed to better manufacturing methods and more efficient agricultural methods. The importance of automation in the current world cannot be overstated, and neither can the rapid development of the Internet of Things (IoT) idea with Artificial Intelligence (AI). Using a certain method, manual tasks may be made fully automatic. Poultry farms can benefit from IoT-based operations when remote monitoring and repair are required, transforming them from traditional to cutting-edge operations that make extensive use of automation. In order to maintain and enhance chicken health, it is necessary to constantly check for changes in a number of variables. In this study, we propose and construct a low-cost Internet of Things (IoT)-based system for monitoring environmental factors in a chicken farm in real time, including temperature, humidity, ammonia levels, and light intensity. Information gleaned via sensors and continuous monitoring. By putting the planned system into action, we were able to evaluate its viability. Temperature and humidity levels, as well as their management, are the most important climatic parameters for a poultry farm's output. The purpose of this project is to automate the operation of a chicken farm by utilising Internet of Things (IoT) technologies. Chicken health is maintained by careful monitoring of environmental conditions like temperature, humidity, light, and ammonia gas, as well as through the supervision of routine tasks like feeding, watering, and cleaning.

Keywords: *Artificial Intelligence, Deep Learning, Image Processing, Internet of Things, Poultry System, Machine Learning.*

1 Introduction

Standardized farming management and good manufacturing practices, along with rising consumer awareness of the importance of keeping food animals like chickens healthy, have helped boost chicken output throughout the world in recent decades, driving up demand for high-quality poultry feed. Due to its high protein content, low cholesterol content, and low fat content chicken is the most widely eaten agricultural produce in the world [1]. Both large and small-scale operations deal with poultry. The amount of effort needed to maintain a chicken farm can be reduced by automating a number of processes. The chicken's health and output are affected by its surroundings [2]. Temperature, humidity, ammonia gas and light intensity levels are all regulated automatically, and routine tasks like feeding, watering, and cleaning are handled without human intervention. Chicken productivity and quality both improve under these conditions [4-5].

Automation has come to play a crucial part in today's society. The automation process is aided by the Internet of Things (IoT). IoT is a relatively new technology, yet it is becoming increasingly significant in many fields. It is a network of physical devices that are used to automate different tasks and exchange data via the internet [10, 12]. One option for improving the poultry industry is to implement a smart poultry farming system based on IoT. To increase the level of innovation and technology in the field, the IoT idea is introduced to increase the connectivity of field sensors to information systems. Depending on its intended use, the sent data may be kept in the cloud, acted upon by other IoT devices, or both. With the use of IoT, farmers can raise their productivity without hiring more workers, which boosts their poultry harvest. All farmers can benefit from using IoT devices because they are affordable and widely available [13, 14]. Artificial intelligence (AI) has emerged as a pivotal innovation that may streamline complex challenges across several industries to meet the shifting needs of this industry. The capacity of a machine to execute activities normally performed by people, but which need human knowledge and discernment, is what we mean when we talk about artificial intelligence (AI). Automation of animal identification and weighing can improve accuracy and efficiency in the poultry business, and AI can help with issues of environmental impact, animal welfare, and production efficiency [16-18].

The increasing need for chicken production has brought to light the importance of preserving optimal conditions for optimising chicken production in terms of both productivity and quality. The IoT and AI should be combined for optimal agricultural management [22–25]. Today's poultry farms use AI systems to better keep tabs on their flocks and ensure the chickens' well-being. AI

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has the potential to dramatically alter agricultural practises by boosting the effectiveness, durability, and general effectiveness of poultry production [30, 31]. In this article, we replace conventional poultry farming methods with smart and intelligent farming that makes use of IoT and artificial intelligence-based technologies. This helps farmers manage and track metrics in their context that are sensitive to environmental factors in real time via corresponding regulating devices such as humidifiers, exhaust fans, and lights. In poultry farming, this method will increase output and quality by creating a conducive environment for the chicks' development. The main contributions of this article are outlined below:

- Design of smart poultry farm management system based on IoT with AI for sustainable environment management for large indoor monitoring system in a poultry farmhouse.
- Develop efficient and low-cost management of poultry farms for controlling the actuators based on environmental conditions using AI techniques.
- Use of supervised deep learning and machine learning techniques to predict the actuators control signal.
- Examine and analyze the proposed work with state of art models.

The remaining sections of this article are organized as follows. Section II discusses the existing research work related to poultry farm management system. Section III discusses the material and methods related tp proposed system provides implementation details. The experimental result and discussion is discussed in section IV with result analysis with comparative analysis. And finally the article is concluded at the last.

2 Related Works

Smart poultry farming has attracted the attention of more academics in recent years. Using the IoT, imaging analytics, and other technologies, some researchers aid farmers in managing and monitoring chicken health discussed below.

A low-cost IoT-based remote poultry management system for small to medium size farmers is proposed and implemented [3]. The monitoring of various environmental factors in chicken farms is detailed [4], along with a low-cost hardware and software solution. It is hypothesised [5] that a wireless sensor network and open-source software may be used to scaleably monitor a chicken farm. The study's primary objective is to determine the feasibility of automating chicken farm management processes by means of the Internet of Things. [6]. An AI-powered approach to sensor detection is suggested [7]. To maximise output, automated poultry farms can leverage the IoT platform [8]. Artificial intelligence will aid livestock farms in collecting and analysing data to accurately predict customer behaviour, such as purchase habits, top trends, etc. [9]. At [10], we introduced a low-cost Internet of Things (IoT) monitoring solution for poultry farms that relies on two crucial meteorological parameters: temperature and humidity. In [11], we see an IoT-based smart system designed to keep tabs on the weather and other environmental factors in chicken farms. Goat welfare monitoring using machine learning and the internet of things is detailed [12]. A approach for the automated identification of chicken feeding activity based on a time sequence and audio analysis model was suggested [14]. Due to the unprofitability of poultry farming and the lack of advanced data management in China, a secure and effective poultry farming data management system was developed [15]. The IoT has enabled the automation of chicken farm management tasks [17].

The layout is based on a very effective method of chicken farming that boosts output and earnings [18]. The Internet of Things is demonstrated by its application to the automation of chicken farm management tasks [19]. To help veterinarians distinguish between normal and diseased faeces, researchers trained a deep Convolutional Neural Network (CNN) model [20]. The action plans for poultry management result from the systematic collection and preparation of data from the production environment, where a sensor network is used to record poultry management data [21]. Using an embedded system and the Internet of Things, we can keep tabs on and manage a chicken farm. For monitoring environmental factors in a chicken farm, [23] presents a smart monitoring system built on a star-type sensor network. As a result of the need to reduce manual monitoring and boost poultry farm output [24], a system based on the IoT was created so that the farm may be accessed and run remotely by the farmers using their mobile devices. Regardless of time or location, the IoT solution prioritises keeping tabs on environmental factors like temperature and humidity [25]. Predicting illnesses in livestock by data analytics and inexpensive consumables [26] is the goal of an automated Environment Controlled Poultry Management System (ECPMS) that has been designed and integrated with Biosensors. Effective management and operation of a poultry farm is made possible by the presented [27] smart solutions, which are easily employed and have low operational and production costs based on IoT with environmental parameters monitoring for the poultry farmhouse. Within the context of a poultry farm equipped with a Kinect sensor, an automated CNN-based technique for recognising chicken behaviour was proposed [28]. The IoT-based chicken farm controlling and monitoring system was demonstrated [29]. It is recommended that the temperature in poultry be controlled by regulating a variety of environmental factors, such as purification, freezing, lighting, ceiling covering, etc. [30-31]. The IoT technology was used to create a low-cost system for monitoring environmental factors in real time at a chicken farm [32].

3 Method

A. Proposed four-layered framework system

In the proposed framework system, smart poultry farming system is presented based on IoT with AI with all standards considering IoT layer architecture to monitor the sensor parameters and apply data analytics to sensor data for intelligent control of actutors devices considering factors in the farm system that promote healthy growth and development in order to boost chicken output and product quality. This method requires fewer workers, boosts hens' well-being and productivity, and enhances the number of eggs they lay.

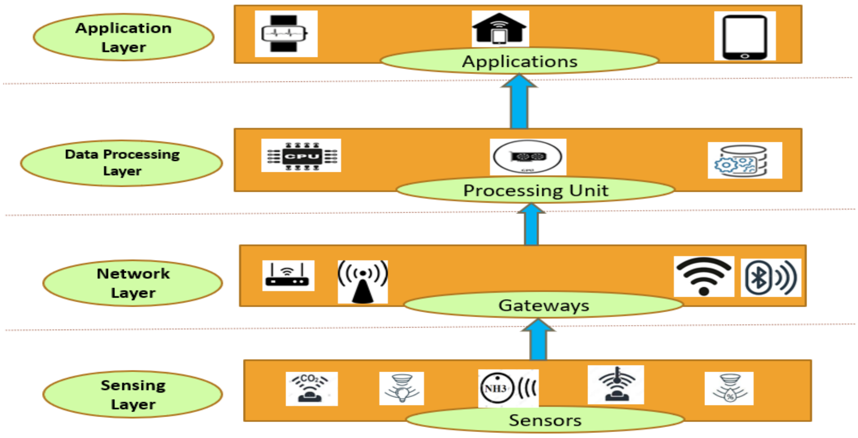

Fig 1: Proposed four layered smart poultry farming system

An overview of the system's architecture is depicted in Fig 1. The tiers of the system are as follows: the application layer, the data processing layer, the network layer, and the sensing layer also known as the bottom layer, which includes hardware facilities in the poultry farm.

i. Sensing/Perception Layer

The sensing layer's primary function is to detect and characterize events occurring at the devices' peripheries and to collect information about the physical environment. Multiple sensors are located at this layer. This layer comprises of multiple sensors and it is the physical layer of the architecture. Because each project requires a unique set of inputs, this is where sensors and networked gadgets come into play. Sensors and actuators located in the network's periphery are examples of such devices. A microcontroller receives input from the sensors and actuators and then regulates them according to predetermined thresholds. Actuators installed in a chicken farm adjust temperatures, humidity, and other factors to optimize bird development. The sensors and actuators used in poultry farm system are described in table 1 and 2.

Table 1: Sensors Used in Poultry Farm System

Sensors Parameters	Purpose
Temperature Sensor	Used to measure ambient temperature
Humidity Sensor	Used to measure ambient humidity
CO2 Sensor	Used to measure the levels of carbon dioxide
NH3 Sensor	Used to measure concentration of ammonia
Light Intensity	Used to measure ambient illuminance

Table 2: Actuators Used in Poultry Farm System

Actuators Parameters	Purpose
Light	Used to increase ambient temperature
Ventilation Fan	Used to reduce the CO2, NH3 concentration
Humidifier	Used to maintain the ambient humidity

ii. Network Layer

The network layer facilitates communication between nodes and transmits information gathered at the sensing layer. The network layer in IoT devices facilitates the exchange of information between nodes in the same network through the use of a variety of communication technologies (such as Bluetooth, Wi-Fi, Z-Wave, Zigbee, cellular network, LoRa, etc.).

iii. Data Processing Layer

The primary data processing unit of IoT devices is located in the data processing layer. The sensing layer's output is sent on to the data processing layer, where it is analysed and choices are made. The intelligent model is developed at this layer for effective predictive control/signal in smart poultry farm management system using artificial intelligence approach. After certain age of poultry birds, it is essential to monitor the health of poultry birds as most of birds are infected by skin disorders. So, predictive model is presented to build intelligent system for effective smart poultry farm management system in which development of predictive model for effective actuators control so as to maintain ideal environment for better growth of poultry birds.

iv. Application Layer

The application layer is responsible for putting the results from the data processing layer into action and presenting them to the user. The application layer is the layer that really does something for the users.

B. Data Analytics System for Smart Poultry Farm Management System

The data analytics model based on artificial intelligence techniques for smart management system in poultry farm is presented in figure 2 which is deployed at data processing layer that redices the burden on cloud layer for fast processing of data.

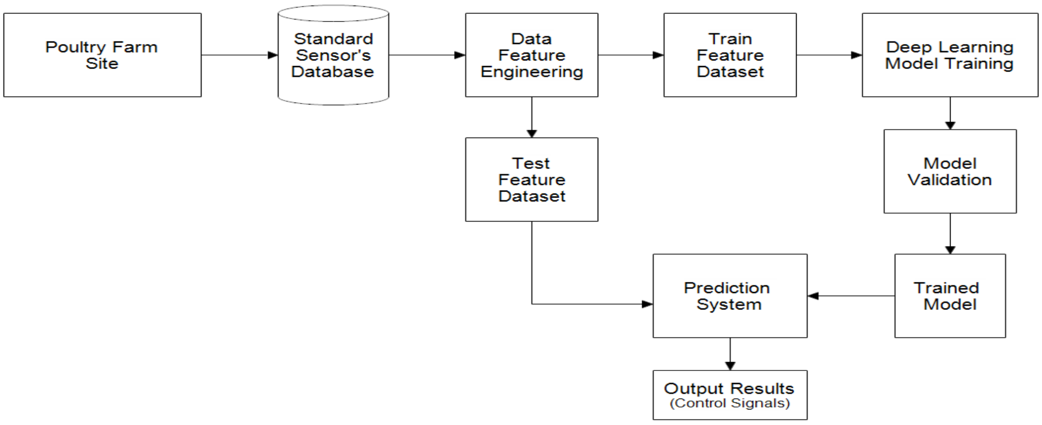

Fig 2: Data analytics model using AI techniques

i. Standard Sensor's Database

In proposed framework, data analytics model is built on standard benchmark dataset [32]. This dataset is based on experiments in Department of Agriculture Science's research chicken farm in Naresuan University, Phitsanulok, Thailand. The proposed chicken farm was split into thirds so that the system could be tested in three separate areas, with each area being watched over by three motes. The local climate in each zone is determined by the number and distribution of chickens in that area. Three motes are placed in a chicken farm during the monitoring phase to gather data on the effects of climate change. Every particle's exposure to light, NH3, CO2, temperature, and relative humidity are recorded at regular intervals. At the same time, actuators are observed and control for ideal environment parameters required in poultry farm. All these observations are logged in excel sheet with timestamp values for further analysis.

ii. Data Feature Engineering

The acquired raw dataset sample values are available in *.csv format and retrieved for feature extraction operation. This process assists to grab data and to implement analytics model based on supervised learning techniques using artificial intelligence technique. Feature Extraction is a method for discovering new features by selecting and combining existing ones to produce a smaller feature subset, all the while maintaining a precise and complete relationship between the dataset without losing any information. In feature engineering, data scaling, data missing value check, data transformation is performed. Feature selection is a process for selecting the dimensions of features in a dataset that provides a mode to AI algorithms, and it is applied after data feature extraction. The suggested scenario makes use of univariate feature selection, which selects the most informative characteristics using a single statistical measure.

iii. Feature Dataset Splitting

Feature dataset splitting divides information into train and test sets. It is recommended to divide data in order to increase the quantity of training data in each data set. In this experimentation, 70%-30% split ration is used.

iv. Classification Modelling

In our proposed experimentation, machine learning and deep learning models are used in which K-Nearest Neighbour (KNN), Naïve Bayes (NB), Support Vector Machine (SVM), machine learning classifier and Bidirectional Long Short-Term Memory (Bi-LSTM), deep learning classifier models used. The proposed experimental use the cross-k-fold validation strategy. A method for testing the accuracy of prediction models, k-fold cross-validation. k folds, or subsets, are created from the original dataset. The model is trained and evaluated across k folds, with each fold using a unique fold for the validation set. Estimating a model's generalization performance is done by averaging the results of the several fold-level metrics. Improved model evaluation, selection, and hyperparameter adjustment are all possible with this technique. Grid Search was used to search through every possible combination of hyperparameters, as each ML classifier has its own unique set of tuning parameters. The optimal feature space reduction technique for each adjusted learning classifier was tested in a series of tests.

v. Bi-LSTM Network Structure

Layer (type)	Output Shape
Input Feature Vector	(None, None)
Embedding	(None, None, 64)
Bidirectional	(None, None, ,128)
Bidirectional_1	(None, 64)
Dense (activation='relu')	(None, 64)
Dense_1	(None, 1)

vi. Predicted Results

Intelligent control system to maintain the required environment of poultry system to provide the control signals to actuators to operate on/off.

C. Algorithm for Classification Modelling

Input:

Si – Benchmark dataset with various sensor’s attribute with features and labels

Output:

Predicted output

Pi - Classes: [0 - 1]

```
Procedure:
Feature Engineering
Step1: Extract and pre-process the sensor's data as feature data Fd.
Step2: Eliminate the unwanted features attributes.
Step3: For in range of Fd
            Use a scaler transform on all the feature samples.
            Class-based normalisation of the data set features
      End
Step 4: Make ready the ML/DL parameters
Epochs/Neurons/Performance Parameters/Training Algo/Data Division
Make ready ML/DL with training and target Data
Extract Features layers from network
Predict the model with train data to get feature data
Classification
Step 5: Define ML/DL Model Training Parameters
Step 6: Use of Grid Search Optimisation to locate the hyper parameters of the training model.
Step 7: Model training using well-chosen hyper parameters.
Step 8: Verify the model's accuracy by achieving a low training loss.
Step 9: Save the learned model.
Testing
Step 10: Load user test data.
Step 11: Use the step1 to step 3 process of feature engineering.
Step 12: Upload the learning model
Step 13: Classify the control signals data to get control actuators in system.
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4 Results and Discussion

A. Experimental Setup

The goal of our experimentation is to build analytics model using artificial intelligence techniques for controlling the actuators considering the best environment conditions for better poultry birds' growth. In this study, deep learning and machine learning model is used to train the data to classify actuators event into on and off conditions. In deep leaning model, Bi-LSTM model is used with machine learning model KNN, NB and SVM. The proposed experiments are achieved on a machine with Intel i7 processor, 12GB RAM and windows operating system. The standard benchmark dataset [32] of smart poultry monitoring system based on IoT, is used for classification experiments to perform actuator control classification. The experiments were carried out using the Pycharm IDE software with Anaconda Distribution implemented with Python programming. We used open-source library platform Scikit-learn, Keras, and Tensorflow on the classifier's implementation and evaluation. The dataset was then divided into a 70% training and 30% testing portion for the subsequent studies.

B. Evaluation Metrics

Measures of performance such as accuracy, precision, recall, and f-score were taken into account for this study. The metrics of Pr, Rc, and F1 were weighted and averaged in this study.

- Precision (Pr): Precision or Predictive value positive is the rate at which positives (alerts) are generated when the control signal condition is present.
- Recall (Rc): Recall or Sensitivity is a percentage that indicates how often a test correctly identifies the presence of the control signal condition.

- F1-Score (F1): It's a measurement by harmonising the Pr and Rc. For classification issues involving many classes, it uses a weighted version of these measures.

C. Results Evaluation

Using the benchmark dataset, we performed experiments to learn more about the efficacy of the low-dimensional features retrieved by our technique and to test the performance of our proposed framework in classification system. In Figure 3, we can see the histogram analysis plot for input and output features of dataset which are preferred for model learning and validation.

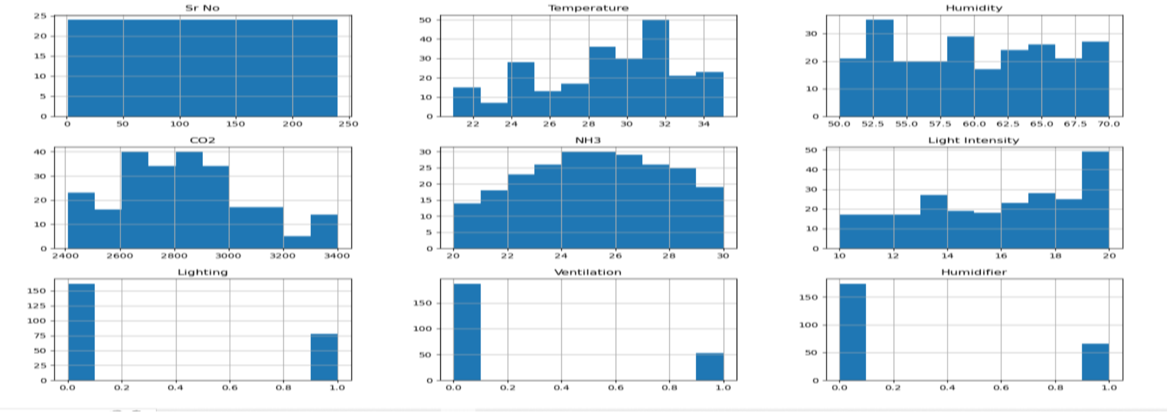


Fig 3: Histogram analysis of input and output features dataset

The figure 4 shows the correlation matrix of feature attributes which indicates the relationship between the variables and their importance with scale range in between 0-1 in which dark color shows the no correlation between the variables.

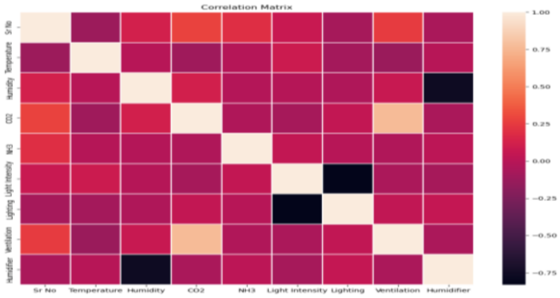
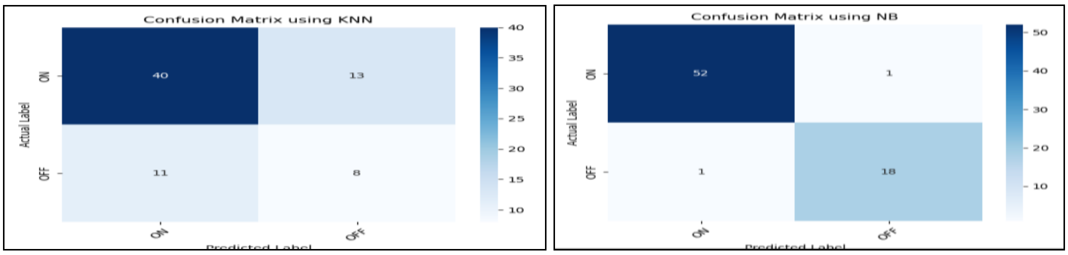


Fig 4: Correlation matrix of feature attributes

Our proposed model can distinguish between two different classes, on/off as 1/0 and its performance was measured in terms of recall, accuracy, and F1 score. Five-fold cross validation was used to determine the model's efficacy. For each of the 5 subsets, we use 70% of the data for training and 30% for testing. Each of the 5 cross-validation splits generated a confusion matrix that informed the metrics we used to evaluate our model. All three learning models are used to simulate the proposed framework and assess its performance on the confusion matrix. The confusion matrix performance of the four classifiers algorithm using KNN, NB, SVM and Bi-LSTM classifier is shown in figures 5, 6, and 7 for three actuator controls lighting, ventilation and humidifier device. From results, it is observed that deep learning model results are performed better as compared to other three machine learning model.



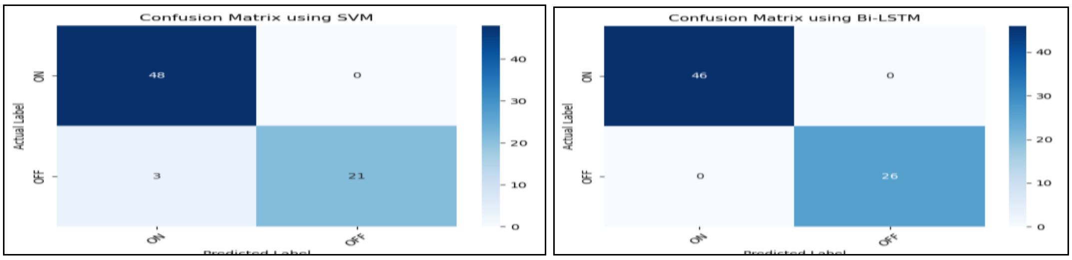


Fig 5: Confusion matrix results for lighting actuator control

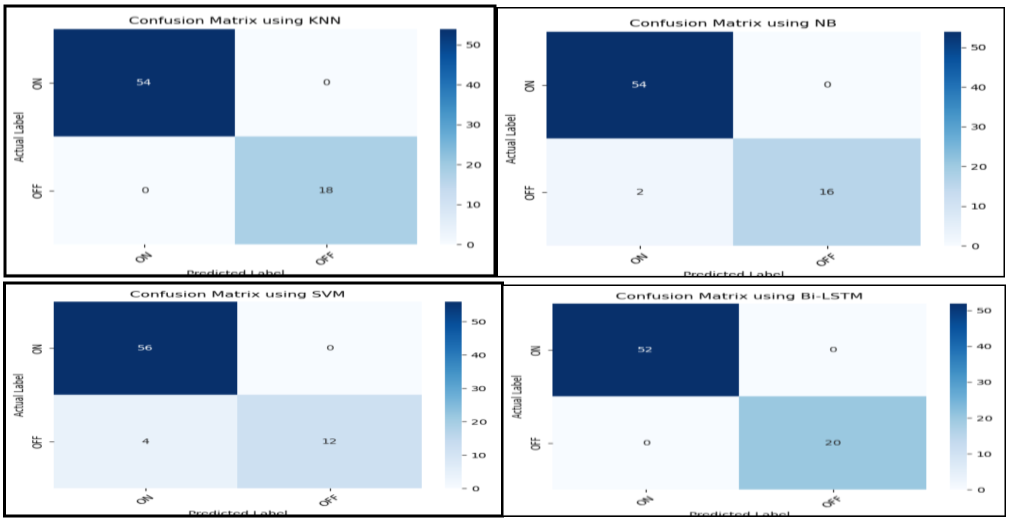


Fig 6: Confusion matrix results for ventilation actuator control

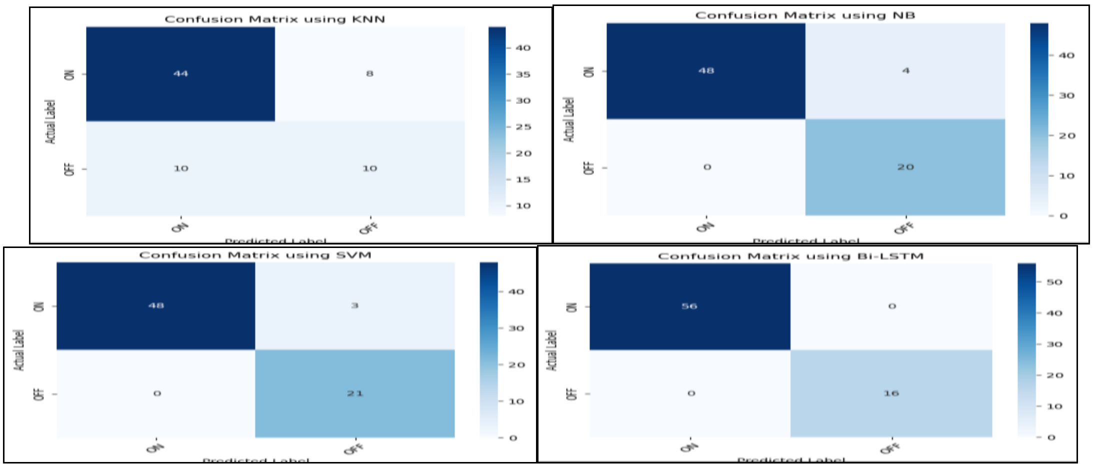


Fig 7: Confusion matrix results for humidifier actuator control

Table 3, 4 and 5 provide a detailed evaluation summary of the proposed framework in terms of average testing accuracy, precision, recall, and F1-score using KNN, NB, SVM, and Bi-LSTM classifier, respectively. From figure we can stated that the wrong category is also detected, the sensor data that is still classified as another category is greater than the class that is classified. The overall testing classification score using Bi-LSTM is much better as compared to other machine learning models. Our proposed deep learning framework, Bi-LSTM outperforms other machine learning model, KNN, NB and SVM classifier in terms of Accuracy, Precision, Recall, and F1-score with average accuracy rate of 99.57%, average precision rate of 99.97%, average recall rate of 99.47% and average f-score rate of 99.12%.

Table 3: Performance measures results for lighting actuators

Parameters /Algorithms	Average Testing Score (%)			
	Accuracy	Precision	Recall	F-score
KNN	66.66	67.78	66.66	67.17

NB	97.22	97.22	97.22	97.22
SVM	95.83	96.07	95.83	95.75
Bi-LSTM	99.57	99.97	99.47	99.12

Table 4: Performance measures results for ventilation actuators

Parameters /Algorithms	Average Testing Score (%)			
	Accuracy	Precision	Recall	F-score
KNN	98.52	98.75	98.52	98.12
NB	97.22	97.22	97.32	97.16
SVM	94.44	94.81	94.44	94.14
Bi-LSTM	99.67	99.77	99.67	99.37

Table 5: Performance measures results for humidifier actuators

Parameters /Algorithms	Average Testing Score (%)			
	Accuracy	Precision	Recall	F-score
KNN	75.0	74.27	75.0	74.57
NB	94.44	95.37	94.44	94.58
SVM	95.83	96.35	95.83	95.90
Bi-LSTM	99.18	99.95	99.18	99.22

D. Comparative Analysis

We also validated the superiority of our model by comparing its performance with the classification approaches used in relevant literature [4][5][6][10] based on smart poultry farm system dataset. Tables 6 presents a comparison of the proposed intelligent framework with feature attributes of sensors and technology used in their framework, with related work and some traditional methods mentioned in their paper. Despite the complexity of making direct comparisons to similar work, the suggested study shows good performance despite the use of a tiny model for categorization.

Table 6: Comparative analysis

Parameters		References				
		W F Pereira et.al. [4]	O Debauche et al. [5]	K A Sitaram et.al. [6]	A. S. Gbadamosi et.al. [10]	Proposed System
Used Sensors	Temperature	✓		✓	✓	✓
	Humidity	✓	✓	✓	✓	✓
	Light Intensity	✓	✓	✓		✓
	CO2		✓	✓		✓
	NH3	✓	✓			✓
Used Technology	IoT	✓		✓	✓	✓
	ML					✓

	DL		✓			✓
	Intelligent Management System		✓	✓	✓	✓

5 Conclusion

Poultry farming has a long history, not just in India but all throughout the world. In India and worldwide, commercial poultry farming has evolved from the humble beginnings of home chicken keeping to become a lucrative and respectable business. For efficient operation of a smart poultry farm, the suggested system is broken down into four distinct layers of infrastructure. Using the Internet of Things, a conventional chicken farm may be transformed into a state-of-the-art, fully automated facility. The purpose of this mechanised henhouse is to raise the standard of living for the chickens inside the flock. As a result, those who raise chickens for a living might expect to reap considerable financial rewards. By facilitating real-time data collecting, automated operations and enhanced decision-making, IoT-based sensor systems have substantial benefits in chicken farm management. A data analytics model deployed at the data processing layer allows for further optimisation of growth and health when these systems are integrated with actuators for precise control of environmental factors. This research shows that the integration of IoT and AI has the potential to improve animal welfare, poultry farm management, and overall efficiency. Farmers can provide a better, more sustainable, and safer environment for their chickens by utilising sensors.

In the future, we hope to simplify the user interface, increase the sensors' range, and integrate emergency shutdown in the event of any danger. We will also work to improve feeding approaches and alternate efficient ways. Additional features, such as automatic fire extinguisher design with a fire alarm system, as well as reminders to vaccinate the chickens and details on the employees, might be implemented in the near future. The proposed effort is expected to pave the way for more study into climate change adaptation strategies. Future developments may potentially include the use of image processing for early diagnosis of poultry diseases.

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