Multi-Functional Poultry Farm Model with Remote Monitoring and Control Scheme

Kufre Esenowo Jack
Department of Mechatronics Engineering
School of Electrical Engineering &Technology
Federal University of Technology Minna
Minna, Niger State, Nigeria.
kufre@futminna.edu.ng

Abdulkabeer Abisola Amuda
Department of Mechatronics Engineering
School of Electrical Engineering &Technology
Federal University of Technology Minna
Minna, Niger State, Nigeria.
amudakb@gmail.com

Temitope Abimbola Johnson
Department of Mechatronics Engineering
School of Electrical Engineering &Technology
Federal University of Technology Minna,
Niger State, Nigeria.
temitopejohnson4ts@gmail.com

Aniekan Ben Inyang
Department of Electrical/Electronic Engineering
School of Engineering Technology
Akwa Ibom State Polytechnic Ikot Osurua
Ikot Ekpene, Akwa Ibom State, Nigeria.
linkonaniben@yahoo.com

***Abstract*—Application of Engineering practices in agricultural-businesses have aided high product yielding. But coordinating Poultry farming activities such as feed, water and drugs supply and regulating the temperature are difficult to achieve manually. Hence the development of this multi-functional poultry farm model with remote monitoring and control scheme for an improved poultry farm management. This model proposed an intelligent way of dispensing major poultry resources; water, feed, and drugs along with a temperature monitoring and control system. Simulation was carried out using Proteus and SolidWorks. Deploying mechanical, electrical and electronic components, the developed prototype remotely monitored and controlled the poultry farm while dispensing resources smartly. Ultrasonic, temperature and vibration sensors were used to collect data about activities in the prototype farm. At 35cm, the troughs were sensed as empty and relevant resources automatically dispensed. For birds 1-2 days, the temperature of the poultry house was constantly regulated above 29 ºC. Other ages selected on the mobile application ensured the temperature of the poultry house remained within optimum requirement. Also sounds produced when the birds' beaks beating the empty trough indicates feed availability. For every optimum deviation, notifications were sent and received on the cellphone. Prototype implementation will be the next research progression.**

Index Terms*—Multi-Functional Poultry Resources, Dispensary System, Temperature, Remote Monitoring, Control Scheme

I. INTRODUCTION

Every process seeks a better way to achieve its end product and with the advancement in technology and the introduction of microcontrollers and embedded systems, processes are becoming automated, safer and less labor intensive. With all these to be achieved at a cheaper cost, the poultry industry is not left out on this race of technological advancement. In poultry farming, domesticated birds such as chickens, ducks, turkeys, and geese are reared to produce meat or egg for final consumption or further processing [1].

Chickens are reared in great numbers since it became a major source of protein, as about 10 billion of chicken are produced annually to cater for the consumption of meats and egg, and still do not meet the average demand [2].Thus, monitoring and controlling the health status of the birds is of great importance as it enhances their meat, egg yield and the quality of shells. A favorable temperature condition contributes to the overall health status of the birds which in turns results in their improved nutritional value.

Just like temperature, feeding is very important in poultry farming. Feed supply in poultry production is a highly perfected process that ensures a maximum intake of energy for growth and fat production. Over time feed is supplied to the birds (chickens) manually in their battery cages or deep litter trough with less precision in the distribution of supplement as required for quality breeding. In addition, the ages of birds play a major role in influencing the temperature required for optimum performance, hence the need for the introduction of multi-functional poultry farm model with remote monitoring and control scheme for an improved poultry farm yield.

The design and implementation of a multi-facet poultry resources management model is presented. To achieve this, the following objectives are considered: design of an automatic means of dispensing feed, drugs and water to birds in the poultry; develop a smart temperature monitoring and control model and integrate a remote scheme for the system using Internet of Things (IoT). The multi-functional poultry resources catered for include: feeds, drugs and water dispensary, as well as temperature monitoring and control.

The proposed multi-functional poultry model uses sensors to collect its data, analyzes the data and enhances the state of poultry birds for improved yield. The design takes cognizance of interactive poultry farming techniques proposed by [3] to provide concise data for farmers to optimize the efficiency of their agricultural system, thus increasing the overall performance of the birds.

II. LITERATURE REVIEW

Giric and Juld reported that over 50 billion chickens are reared annually for production of egg and meat, making poultry farming a very major contributor to the world's economy [4]. Higher poultry production depends heavily on the breeding method, environmental and essential operations [5]. As a result, environmental parameters like temperature contribute a lot to the birds' performance [6]. Advancement in technology has brought about research on the development of automated practices that have since increased efficiency and yield in the poultry industry.

According to Corkery *et al.*, the automated farming system employs the use of sensors to collect data, followed by the analysis of data solely to optimize farming operations for increased productivity [7]. In validating the automated feeding system, Ghazal, Khatib and Chahine confirmed that with advancement in technology, farm and livestock are in top condition [1]. The proposed technique enables the user to automatically collect data about the environment in the livestock houses and deploy feed automatically, while also observing the birds' behavior. In furtherance of this technique, farmers can actively manage the needs of individual poultry birds using smart controlling methods and adjust their nutrition appropriately, thereby preventing illness and improving their health.

Fuzzy logic have been the used for the development of systems that dispense feed (solid) and liquid to the trough at intervals [8, 9, 10, 11, 12]. Fuzzy Logic based system replicates the human ability to make decisions and take actions when the need arises. Although the system did not consider the monitoring and control of temperature and can only be used in a deep litter poultry farming system.

Sinduja *et al.* studied automated poultry operations and the results of the study were presented on a graphical user interface programmed by LabView [13]. The system enables the user retrieve up-to-date information about the environmental factors in the poultry farm and also to activate commands through a short messaging service (SMS) gateway. The design has a distance limitation of 30 miles, this indicate a difficulty in the accessing of information from the controllers.

The development of an automated poultry farm using the Arduino microcontroller to monitor, control temperature and relative humidity are illustrated in [14, 15]. It employs the use of a dual sensing device (humidity and temperature) denoted as DHT11. The system doesn't include the automation of feed supply to the birds.

The Design and implementation of an automated poultry farm system which consists of Arduino UNO serving as the microcontroller are presented in [16, 17]. The system is such that a GSM module is interfaced to the controller together with temperature and humidity sensors, a buzzer, a door sensor, LED display, Wi-Fi module, other motors and relays which act according to the responses received from the farm's environment.

Mitkari *et al.* proposed the design and implementation of a smart mobile poultry farm robot that uses an Arduino microcontroller for its processing functions, a Bluetooth connectivity module for communication, DHT22 sensor for the temperature and humidity measurement and ammonia gas motoring module to mix soil when gas level is above set threshold [18]. Bluetooth being a close-range connectivity module limits the feature as it does not eliminate the human factor in execution.

The employment of the internet of things technology where different modules of the farm communicate and optimize themselves for better performance with the help of an Arduino UNO microcontroller are discussed in [19, 20, 21]. The system monitors and controls the temperature, humidity level, the feed and water supply to curtail wastage. Furthermore, the approach gives room for the generation of electricity from the waste of the poultry birds and sends all measured physical quantities to the farmer through a GSM module.

Ghazal, Khatib and Chahine also employed the use of a wireless sensor network based on zigbee technology to monitor physical environmental parameters like temperature, air quality and humidity in the poultry [1]. The poultry is equipped with sensors to give real time measurement of environmental parameters. In the research the sensors were integrated with a microcontroller which was placed on the zigbee network for effective communication amidst the control appliances.

The monitoring of natural gases within the poultry's internal environment is essential [22, 23, 24, 25]. The system uses the MQ series sensors to measure different natural gases such as, ammonia, benzene and carbon dioxide. Arduino microcontroller alongside Raspberry pi was used in controlling and monitoring the system. The raspberry pi sends all data received to an SQL database for storage and can be accessed with a mobile phone. This system makes no provision for the monitoring of feed and water level.

The aim of this work is to increase productivity in poultry farming using modern techniques. The researchers also provided information on how the use of sensors, record and analyze frequent data on the activities of birds for monitoring and control of physical parameters in the poultry. With this knowledge, this research selects sensor with suitable application considering the varying age of birds in the poultry. In the literatures reviewed, most of the researchers considered single poultry resource functionality thereby neglecting other essential resources required for optimal performance. However, this research looks to take into consideration all essential poultry resources functionality.

III. RESEARCH METHODOLOGY

Experimental approach was adopted for the implementation of the multi-functional poultry farm model. With these, components were assembled for the demonstration of the different features of the model: Temperature and Humidity Sensor, Wi-Fi Module, Heating device, Relay Module, Capacitors, Resistors, Diodes, Transformer, Power supply, Voltage regulator, Android Phone with developed application, Ultrasonic Sensor, Servo Motor, Solenoid Valve, Connecting Wires. Along with these hardware components, software materials were used in the execution of the model: Blynk, Proteus, Arduino IDE and SolidWorks. Fig. 1 shows the individual unit of the model combined to give the full multi-functional poultry farm model with remote monitoring and control scheme.

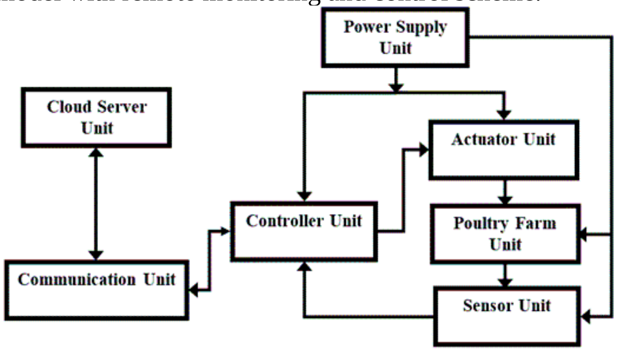


Fig. 1. Block Diagram of Multi-functional Poultry Resources System

A. *Design of Electrical Circuit Diagram*

Fig. 2 is the electrical circuit as simulated in Proteus software. The sensor unit is connected to the analog pins of the controller, while the actuator unit is connected to digital pin of the controller. The sensor, actuator and controller units receive power from the designed power supply unit.

The controller unit is the brain of the model; integrated with the sensing unit, actuating unit, and communication unit, it carries out the processing of every information received in the system. The sensing unit measures the temperature of the poultry, feed, water and drug availability for the poultry birds. The measured values are transmitted to the controller which in turn processes it and activates the actuating unit for the corresponding action of turning on/off the heating device or releasing feed, water and drug as the case may be. All the activities herein are all moved to the web service through the communication unit for remote access by the farm owner.

The sensing device comprises of two ultrasonic sensors, one vibration sensor and four temperature and humidity sensors. The ultrasonic sensors are responsible for measuring the availability of feed and water in the trough of the poultry birds, while the temperature and humidity sensors are to regularly measure the temperature of the poultry environment, and sends their individual temperature to the controller for aggregate temperature deployment to the actuating devices.

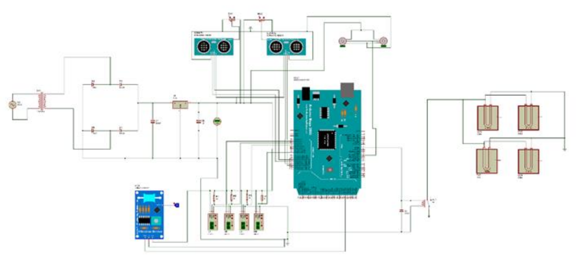


Fig. 1: Electrical Circuit Diagram of Multi-functional Poultry Resources System

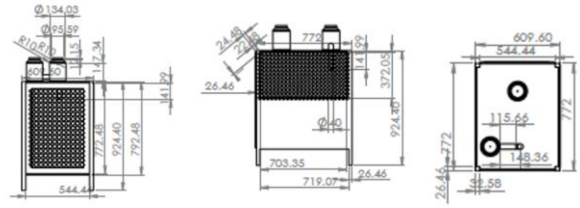
For the feed, the actuating device deploys the servo motors to dispense its resources whenever the troughs are empty. Apart from the ultrasonic sensors measuring the height of the available resources in the trough and sending feedback for control action, the birds on hitting the empty tough produces a continual sound which is received by the controller through the vibration sensor attached to the feeding trough. These actions prompt the deployment of feed by the actuating devices. In terms of temperature deployment, on stocking the poultry birds, the system takes record of the date and age of birds. The controller uses this information to supply the required regulated temperature according to the birds and updates the user on their ages and temperature status. The software program for the controller is presented as follows.

Pseudocode of the controller action

Start
Initialize Sensors
Take sensors readings
Set age of birds
Send sensors readings to IoT platform (Blynk)
Receive and display sensors reading on mobile application
Update the mobile application with current sensors reading every second
For every particular age limit, if resources go below optimum (the set limit), dispense the affected resource
Send notification of the affected resource to the mobile application via the IoT platform

B. *Mechanical System Design*

The mechanical aspect considered for the design of the poultry farm are, the housing of 2.5ft (0.7620m) by 2ft (0.6096m) structure as shown in Figure 4. The motor rating: Weight of motor 9g, rotation 0- 1800rpm, speed of 0.1s/60o, Torque of 2.5kg/cm and voltage of 5V required for actuation action. The mechanical system design of the multi-functional system was achieved using SolidWorks. The poultry farm houses the other constituents of the Multi-functional Poultry Resources system as in Fig. 3.



(a) front elevation (b) side elevation (c) top view

Fig. 3: Mechanical Design of the Multi-functional Poultry Resources System Cage

Fig. 3(a) is the front elevation of the poultry farm, Fig. 3(b) is the side elevation while Fig. 3(c) is the top view of the poultry farm. From Fig. 4, the containers on the poultry farm cage serve as storage for the feed, water and drug. These resources are passed down into the trough with pipes and regulated by the motors and valves.

Fig. 4: Complete Mechanical Design of the Poultry Farm Cage

C. *Cloud Services Design for the Multi-functional Poultry Resources System*

Cloud services were deployed to include remote monitoring features to the system. The design uses the Blynk Cloud Server to develop an Android Application for remote communication with the controller unit. Fig. 5 is the interface of the mobile application. Fig. 6 shows the flowchart of the network protocol for the multi-function poultry Resources system

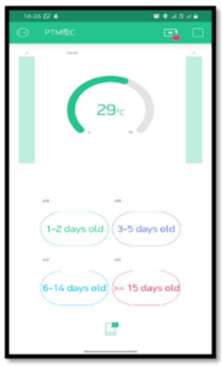


Fig. 5: Mobile Application Access Interface for the Multi-Functional Poultry Resources System

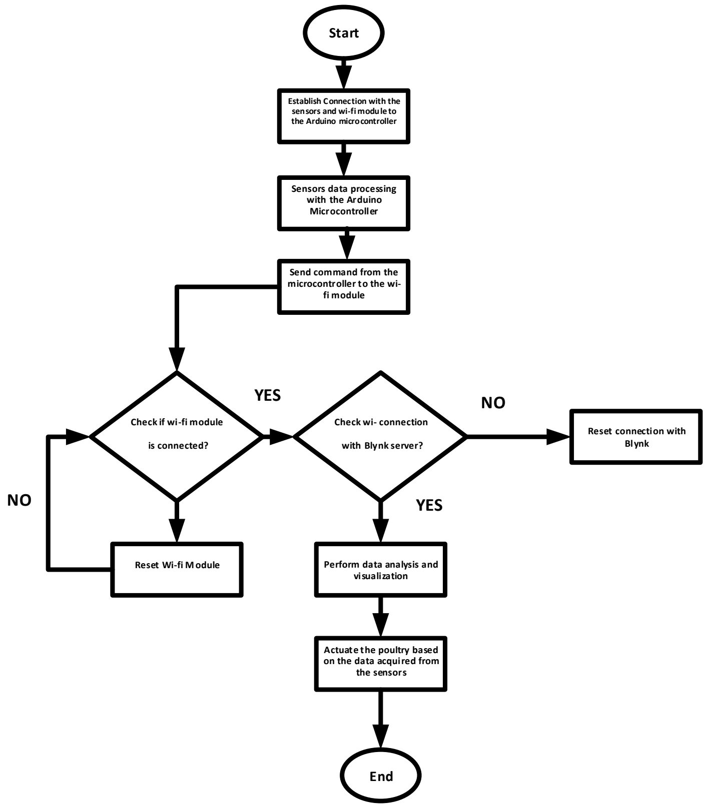


Fig. 6. Flow chart of the network protocol for the multi-function poultry Resources system

D. Complete design Assemblage of the Multi-functional Poultry Resources System

Fig. 7 shows the completely developed Multi-functional Poultry Resources System, ultrasonic sensors, temperature sensors and vibration sensors were mounted to communicate with the controller on the birds' activities and poultry resources dispensary as in Fig. 2.

Fig. 7: The Design Assemblage of the Multi-functional Poultry Resources System

E. Flow chart of Multi-Functional Poultry Resources System

In Fig. 8, the steps taken for the actualization of the multi-functional poultry resources dispensary system diagrammatically shown. The initial age of the birds is considered from the stocking date, the system then checks to ensure the temperature of the poultry house is suitable for the selected age, while also checking the level of feed and water in the troughs.

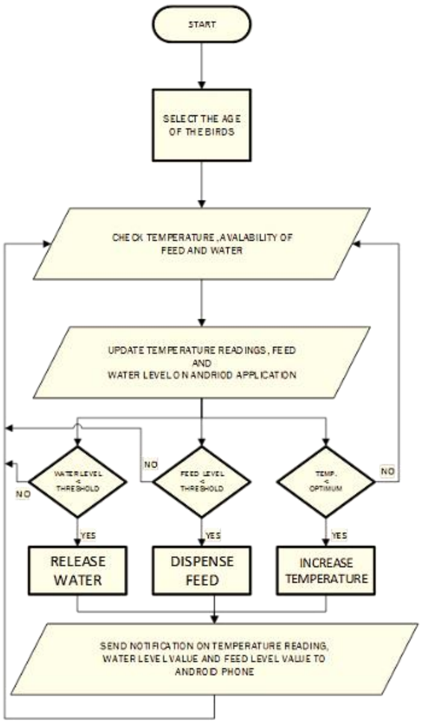


Fig. 8: Flow Chart of Multi-functional Poultry Resources System

IV. RESULTS AND DISCUSSIONS

A. Automatic Feed Dispensing

Table 1 and Fig. 9 shows the results obtained for the feed dispensing mechanism of the multi-functional poultry farm model. Ultrasonic sensors were mounted in proximity to the feeding trough to measure the level of feed in the trough in centimeter. When the ultrasonic sensor reads 30cm, this shows that the feeding trough is empty and triggers the motor to dispense feed into the trough.

Table 1: Sensor Reading of Feed Availability in Trough

Ultrasonic Reading (cm)	Actuator State	Notification
30	ON	Top up Feed Trough
28	OFF	Nil
25	OFF	Nil
27	OFF	Nil
32	ON	Top up Feed Trough
34	ON	Top up Feed Trough

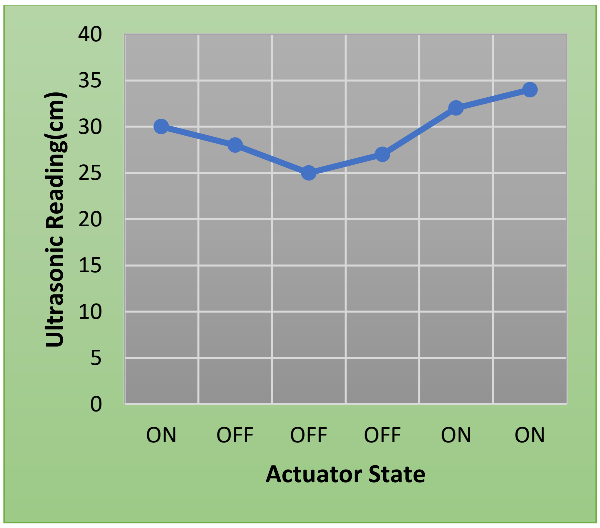


Fig. 9. Sensor Reading of Feed Availability in Trough with Actuator State

Fig. 9 interprets the actuator, servo motor turns clockwise when it receives signal from the controlling unit, thereby dispensing feed into the feeding trough for 10 seconds. The System was calibrated to accumulate feed level of up to 4.5cm. The threshold level for feed availability is set at 25cm. In context when the feed level was measured by the sensor and recorded 30cm, the actuator turned clockwise and released feed to the trough.

B. Automatic Water and Drug Dispensing System

Table 2 and Fig. 9 show the results obtained for the water and drug dispensing mechanism of the multi-functional poultry farm model. Ultrasonic sensors were mounted in proximity to the water trough to measure the level of water in the trough in centimeter. When the ultrasonic sensor reads 30cm, this shows that the water trough is empty and triggers the motor to dispense water into the trough.

In Fig. 10, the actuator, solenoid valve opens for free flow of water when it receives signal from the controller unit, thereby dispensing water into the drinker for 5 seconds. The threshold level for water availability was set at 25cm. In context when the water level was measured by the sensor and recorded 34cm, the solenoid valve opened and released water to the drinker.

Table 2: Sensor Reading for Water Availability in Drinker

Ultrasonic Reading (cm)	Actuator State	Notification
26	OFF	Nil
31	ON	Top up Water Drinker
35	ON	Top up Water Drinker
28	OFF	Nil
27	OFF	Nil
34	ON	Top up Water Drinker

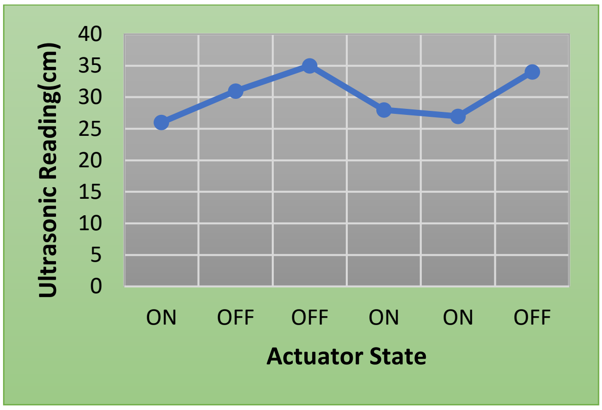


Fig. 10: Sensor Reading of Water & Drug Availability in Trough with Actuator State

C. Automatic Temperature Monitoring and Supply System

Table 3 and Fig. 11 shows the result obtained from the system when age 1-2 days is selected on the mobile application for the multi-functional poultry farm model. Four temperature sensors were mounted equidistance to each other within the 2 feet by 2.5 feet poultry house to measure the temperature and these temperature values were aggregated. When the aggregate temperature reading was below 29 ºC, it actuates the heater to dispense heat to the poultry house. For birds ages 3-5 days, the system was able to ensure a minimum temperature of 28ºC vice versa. The system was calibrated to provide the birds with thermo neutral conditions that corresponds with their ages.

D. Remote Monitoring System

With the mobile application in Fig. 5, the farmer has access to the information of the feed, water and drug availability as well as temperature condition in the poultry. When the feed, water and drug content were reduced, push notifications were received on the mobile device. Equally, when the temperature was below the optimum for the selected age range, a push notification is received on the mobile phone. However, in the case of the inability of the heaters to restore the temperature to thermo neutral or when the contents in the feed, water and drug storage are exhausted, the push notifications were repeated. This repetitive notification translates to a fault with the heaters or exhaustion of feed, water and drugs in storage.

Table 3: Aggregate Temperature Reading of the Poultry Farm

Aggregate Temperature Reading (°C)	Age of Poultry Birds (days)	Actuator State	Notification
30	1-2	OFF	NIL
29	1-2	OFF	NIL
28	1-2	ON	ON
29	1-2	OFF	NIL
30	1-2	OFF	NIL
31	1-2	OFF	NIL

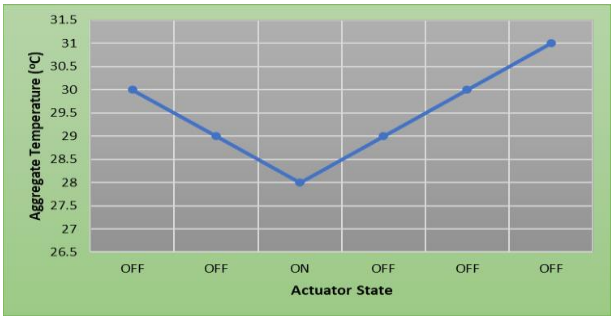


Fig. 11: Aggregate Temperature Reading with Actuator State

V. CONCLUSION

The Multi-functional Poultry Resources System was modeled, which gives rise to a smart feed, water, drug with temperature regulating functionality. The automatic feed and water dispensing system were developed and it addressed the problem of unavailability of a poultry attendant at every required time for the supply of feed to the poultry birds. The developed automatic temperature monitoring and control part of the multi-functional poultry resources system was able to ensure the poultry birds at different ages were provided the varying minimum temperature required per age as it addresses the challenge of proper heat supply to chicks. The result obtained showed that multi-functional poultry resources system was able to attend to the feed, water, drug and temperature needs of the poultry birds, simultaneously updating the farmer on activities in the poultry house. Further work should be tailored towards the inclusion of a data base system for data collection and analytic purposes.

REFERENCES

[1] B. Ghazal, K. Khatib, and K. Chahine, "A Poultry Farming Control System Using a ZigBee-based Wireless Sensor Network A Poultry Farming Control System Using a ZigBee-based Wireless Sensor Network Faculty of Sciences IV , Lebanese University (UL), Zahle , Lebanon Faculty of Engineering , Beiru," no. April 2018, 2017.

[2] K. Sinduja, S. S. Jenifer, M. S. Abishek, and B. Sivasankari, "Automated Control System for Poultry Farm Based On Embedded System," 2016.

[3] G. Corkery, W. Sh, C. Kenny, and H. Ph, "Incorporating Smart Sensing Technologies into the Poultry Industry," vol. 3, no. 4, pp. 106–128, 2013.

[4] S. Giric and J. Juld, "Poultry Farm Monitoring and Controlling using PLC Abstract :," vol. 1, no. 1, pp. 339–346, 2019.

[5] M. H. Lashari, A. A. Memon, S. A. A. Shah, K. Nenwani, and F. Shafqat, "IoT Based poultry environment monitoring system," in Proceedings - 2018 IEEE International Conference on Internet of Things and Intelligence System, IOTAIS 2018, 2019, pp. 1–5.

[6] E. Chuka, W. I. Okonkwo, and A. Mbachu, "Impact of Solar and kerosene stove Brooding Methods on Growth Rate and Haematological Parameters of broiler chicken," J. Vet. Appl. Sci., vol. 6, no. 1, pp. 7–11, 2016.

[7] G. Corkery, S. Ward, C. Kenny, and P. Hemmingway, "Incorporating Smart Sensing Technologies into the Poultry Industry," J. World's Poult. Res., vol. 3, no. 4, pp. 106–128, 2013.

[8] O. O. Mikail, S. A. F., A. O. O., and A. O. S., "Design of an Intelligent Poultry Feed and Water Dispensing System Using Fuzzy Logic Control Technique," Control Theory Informatics, vol. 4, no. 9, pp. 61–72, 2014.

[9] C. A. Ameh, O. M. Olaniyi, E. M. Dogo, A. Usman, S. Aliyu, and B. Alkali, "Mathematical Modeling of an Intelligent Poultry Feed Dispensing System," J. Digit. Innov. Contemp. Res. Sci. Eng. Technol., vol. 5, no. 2, pp. 219–238, 2017.

[10] A. A. Olaniyi, O. M., Folorunso, T.A, Akogbe A. M, "Design of a Mobile Poultry Liquid Feed Dispensing System Using Pid Control Technique," 2015, no. 1993, pp. 107–114.

[11] O. M. Olaniyi, T. A. Folorunso, J. G. Kolo, and J. . Bala, "Towards The Development of a Mobile Intelligent Poultry Feed Dispensing System Using Particle Swarm Optimized PID Control Technique," African J. Comput. ICT, vol. 8, no. 3, pp. 93–106, 2015.

[12] A. F. Salami and O. O. Mikail, "Design of an Intelligent Poultry Feed and Water Dispensing System Using Design of an Intelligent Poultry Feed and Water Dispensing System Using Fuzzy Logic Control Technique," no. October 2016, 2014.

[13] K. Sinduja, S. S. Jenifer, M. Sri Abishek, and B. Sivasankari, "Automated Control System for Poultry Farm Based On Embedded System," Int. Res. J. Eng. Technol., pp. 2395–56, 2016.

[14] L. S. Ezema, M. C. Nnabuko, C. Ben-Opara, and H. O. Orah, "Design and Implementation of an Embedded Poultry Farm," in 2019 IEEE 1st International Conference on Mechatronics, Automation and Cyber-Physical Computer System Design, 2014, pp. 187–192.

[15] L. S. Ezema, M. C. Nnabuko, and C. Ben-opara, "Design and Implementation of an Embedded Poultry Farm," no. July, 2019.

[16] M. Islam, S. S. Tonmoy, S. Quayum, A. R. Sarker, S. U. Hani, and M. A. Mannan, "Smart Poultry Farm Incorporating GSM and IoT," 2019 Int. Conf. Robot. Signal Process. Tech., pp. 277–280, 2019.

[17] M. Hassanuzzaman, M. U. Ahammad, S. M. Bulbul, A. M. M. Nurul Alam, and M. A. Islam, "A comparative study on the efficiency of locally made low cost brooders for brooding chicks," Asian-Australasian J. Anim. Sci., vol. 17, no. 11, pp. 1586–1590, 2004.

[18] S. Mitkari, A. Pingle, Y. Sonawane, S. Walunj, and A. Shirsath, "IOT Based Smart Poultry Farm," Int. Res. J. Eng. Technol., vol. 6, no. 3, pp. 2380–2384, 2019.

[19] K. A. Sitaram, K. R. Ankush, K. N. Anant, and B. R. Raghunath, "IoT based Smart Management of Poultry Farm and Electricity Generation," in 2018 IEEE International Conference on Computational Intelligence and Computing Research, ICCIC 2018, 2018, pp. 1–4.

[20] K. A. Sitaram, "IoT based Smart Management of Poultry Farm and Electricity Generation," 2018 IEEE Int. Conf. Comput. Intell. Comput. Res., pp. 1–4.

[21] K. A. Sitaram, K. R. Ankush, K. N. Anant, and B. R. Raghunath, "IoT based Smart Management of Poultry Farm and Electricity Generation," 2018 IEEE Int. Conf. Comput. Intell. Comput. Res. ICCIC 2018, pp. 1–4, 2018.

[22] R. B. Mahale and S. S. Sonavane, "Smart Poultry Farm Monitoring Using IOT and Wireless Sensor Networks," Int. J. Adv. Res. Comput. Sci., vol. 7, no. 3, pp. 187–190, 2016.

[23] R. B. Mahale and S. S. Sonavane, "Smart Poultry Farm : An Integrated Solution Using WSN and GPRS Based Network," Int. J. Adv. Res. Comput. Eng. Technol., vol. 5, no. 6, pp. 1984–1988, 2017.

[24] R. B. Mahale, "Smart Poultry Farm : An Integrated Solution Using WSN and GPRS Based Network," vol. 5, no. 6, pp. 1984–1988, 2016.

[25] R. B. Mahale and S. S. Sonavane, "Smart Poultry Farm : An Integrated Solution Using WSN and GPRS Based Network," Int. J. Adv. Res. Comput. Eng. Technol., vol. 5, no. 6, pp. 1984–1988, 2016.