Development of a Sustainable Multi-Objective Approach to Poultry Management System with IoT-Based Environmental Monitoring

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Abstract: - Poultry farming has greatly contributed to the global economy and food security by providing highly demanded products that offer unique nutrients to various demographics. With an ever-increasing population, the demand for poultry products will continue to rise. Therefore, an automated approach is necessary to ensure uninterrupted and increased production of these yields. This paper proposes a collaborative approach that integrates internet of things (IoT) and wireless sensor technologies to remotely monitor and control environmental parameters within the poultry farm. The system employs autonomous devices, wireless sensors, and internet-enabled smartphones to measure and benchmark parameters such as humidity, temperature, food availability, water level, illumination level, and presence of ammonia waste against required thresholds. The central mote and cloud receive the results and initiate control actions on the monitored factors. The system provides real-time monitoring and control, and the parameters and corresponding actions can be recorded and viewed over the central hub and web. The evaluation results indicate an accuracy of 93.7% and a delay time of 2s in real-time. The developed model system is robust and intuitive, providing a management solution for poultry farming. Results further show that the quality of eggs produced were not affected by varying environmental conditions as a result of the real-time monitoring and control system.

Key-Words: - Real-time monitoring, Multi-objective, IoT, Poultry management, Sustainable environment, Autonomous devices, Parameters, Wireless sensor technologies.

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1 Introduction

The enhancement of food quality and security is a crucial aspect of the sustainable development goals to eradicate global hunger (FAO, 2019). This is directly related to the population increase and its demand for sufficient food production. Therefore, there is a continuous need to improve food production methods to increase yields and quality. Poultry farming plays a significant role in the agro-food sector by producing meat and eggs, which affects food security and profitability for farmers, marketers, and governments. The awareness about the need for increased agricultural yields and food safety has increased in the recent past years. The contribution of poultry farming to the global economy through agriculture is immense [1, 2].

Poultry is defined to include a range of birds, especially the domestic varieties [3, 4]. Poultry farming is specifically an important contributory part of the agro-food sector for the production of meat and eggs. However, poultry farming directly affects food security due to the linkage of consumer issues with the availability of products to meet demands, accessibility, affordability, and consumption safety [5–7]. Personal income to the marketers and farmers, the revenues to the governments are mainly impacted by the good profitability and productivity in the sector [8]. The profitability of a poultry farm is a measure of the revenue, fewer costs, and dependent on the efficient economics of productivity [9], [10]. Industrial revolutions and human civilization have led synergistic technologies to helping the agri-food sector into growth and thriving [11]. Nations and economies are adopting new approaches and protocols to digitize food production and incorporate automation into agricultural practices. Food production has continued to present the necessity for innovative disruptions and automated systems beyond the imminent possibilities from outmoded traditions of handling poultries and others [1, 12]. The management of poultry systems typically contains three basic distinct functions to include monitoring or sensing, decryption and decision-making, and control action or necessary intervention [13].

The healthy growth of chicks and chickens within the poultry area are dependent on various environmental parameters such as temperature, humidity, air quality and light. Also, these birds required adequate water, food, and decreased toxicity [14–16]. Different types of gaseous pollutants are generated by chicken and their droppings in the poultry farm, which include carbon dioxide, ammonia, hydrogen sulfide, methane (CH4), and nitrous oxide gases [17].

The existing poultry management systems are credited with automated condition monitoring, but with manual control methods [18]. The unique limitations of the manual feeding process include delayed supply of feeds and harmful over-feeding. This paper aims at using a synergistic approach to combine internet-enabled autonomously designed devices in solving environmental monitoring, decision-making, and automated control action as an extension of the work in [14]. The objectives of this work are to develop an IoT-PMS model which will automatically monitor important environmental parameters; sends caution messages and take actionable decisions in remeding extreme conditions; after which the designed system will quantify and assess the environmental impact of poultry farming practices using some metrics to measure sustainability.

The developed poultry management system which is based on the IoT synergistic method was modeled and designed with resourcefully selected internet-enabled autonomous devices. It achieved continuous poultry farm health condition monitoring and regulating; which ensured the best possible condition necessary for the birds healthy growth. Overall, the work furthered researches on Poultry management System through the combination wireless communication, sensor technology, IoT and automation in providing a smart poultry. Improvement in the health and growth of the birds was achieved by preventing infectious diseases among them, reducing the gaseous pollutants, ensuring improved egg production, reducing human intervention, and hence maximizing the overall profit.

2 Related Works

In [1, 3, 17, 18], it was discussed that different gases such as ammonia, carbon dioxide, and methane (CH4) could accumulate to toxic levels inimical for a poultry house if adequate aeration is not sustained. Both the chickens and poultry workers are susceptible to the health hazard of the different air pollutants. Meanwhile, ammonia gas is usually discovered to be the most abundant air toxin in the poultry facilities. There is a variation in ammonia concentration depending on several factors which include humidity, temperature, animal concentration and ventilation rate within the facility. Hence, ventilation plays a major important control consideration for humidity, heat, and different gases. For instance, an optimal temperature of 15- 20oC is required for laying hens. In addition, environmental temperature and humidity are correlated with other performance metrics including feeds and water level [19 – 21]. The control of these factors requires a multi-objective approach for automation and real timeliness [22]. Hence, synergistic methods of the Internet of things technology.

Internet-enabled objects can cooperate with themselves, and with other autonomous devices to execute processes in food production and poultry management. Internet of things (IoT) has notably been defined as a revolutionary technology for integrating devices which include sensors and personal computers to the communication infrastructure and the internet through software solutions for independent and automated actions. Recently, researchers in the agri-food sector are giving major considerations to adapting the IoT capacity available to modern tools, machinery, information technologies, and emerging communication. The objective is to reinforce the food regimen with automation, digitalization, connectivity, and efficient use of resources [23, 24]. IoT is flagged to provide a far-reaching influence in the agri-food sector and consequently become an essential part of smart poultry farming. Employing the IoT technology in the smart poultry production will infuse the internet-based devices to separately act, while the human intervention will only be involved at any higher-level intelligence demand [18, 25–31]. Farm management can benefit enormously from the communication medium between sensors and various equipment used to ensure task automation and efficiency.

The communication architecture is as important as the incorporated systems. IoT networks adopt feasible communication approaches which include device-device, device-human, and human-device communications. The automation of the various procedures within the network of systems can be initiated by a simple communication command. At present, IoT networks mainly consist of homogenous nodes in the same fashion as it is obtainable in the wireless sensor network, thereby making the two synergistic technologies to share common communication architecture. However, the developing multi-device communications in the new complex IoT systems are billed for inherent challenges attributed to heterogeneous nodes such as limited power supply, processing units, storage, and network access inconsistency [32].

Meanwhile, the challenges associated with multi-device IoT systems can be approached by using instrumented algorithms that allows for higher capacity for farm automation through processes such as precise feeding instrumentation by which past weight determination is relied upon to administer the feeds to the broilers [30, 31]. Also, feeding frequency, health status listing, and rate of egg-laying in a poultry system can be monitored through application of radiofrequency tags. The data parameters on the birds can then be used to make decisions and initiate control measures. An IoT infrastructure can be applied in the poultry farms to ensure that processes and procedures for data protection, overseeing and governance for continuous data integrity and quality are moderated [20, 33]. After careful review of the similar works, it was noted that the majority of the PMS has efficiency less thn 90%. The poultry system must be monitored in real time for better efficiency. Therefore, there exists the need for a more reliable PMS not only in the quantity of eggs produced, but also in quality.

3 Methodology

The approach employed for the IoT-Based Poultry Management System (IoT-PMS) was incorporated using validated algorithms for the system model and resourcefully selecting the autonomous devices to develop it. First the system model was developed using equations as representation of the overall poultry house, then individual environmental conditions (such as temperature, humidity and illumination) are monitored, after which depending on the status determined per time, actionable control outputs are made as decisions. The details of the system representation as well as the hardware and software design methods are discussed below.

A) System Model

The multiple function decision-making model [34] is adopted in designing the IoT-PMS. The different independent factors are sensed, and compared with the respective references, to determine the required control action necessary. The intervention offered by the system at any instant is dependent upon the decision-making pitch enabled by the multiple sensed input parameters.

The IoT-PMS system is a definite large entity consisting of m subsystems with n major actions to be taken. Let b_ij^k represents the input environmental parameter i being observed in initiating a unit action j, and r_j^k is the overall output of action j in the sub-unit k. Consider p_i as the final weight of factor i in the overall system. Therefore, the characteristic equation of the overall system is as represented in equation (1). The first term of equation (1) represents the total response of environmental factors parameters to actionable outputs while the second term represents the system response to size.

$$\sum_{k=1}^{m} \sum_{j=1}^{n} b_{ij}^{k} r_j^{k} + p_i = \sum_{k=1}^{m} r_i^{k} \quad i = 1,2,\dots,n \tag{1}$$

Let d_j^kk characterises the representative output of action j in the unit k as determined by the decision-making of the unit. Therefore, if all $d_j^k(k = 1,2,m,j = 1,2,\dots.n)$ is the solution to equation (1), the decision-making of the overall system should correspond with the cooperative decision made by the subsystems that set the decision-making plan of the overall system as $r_j^k = d_j^k(k = 1,2,,m,j = 1,2,\dots.n)$. However, the observation is that this may not always be true as d_j^k may not often satisfy equation (1). Hence, a necessary further procedure is required.

Assuming one or more of the solutions for $d_j^k(k = 1,2,,m,j = 1,2,\dots.n)$ minimizes the entire differences among r_j^k and d_j^k an acceptable solution of the overall system can be established. A weighted measure multi-criterion decision-making method is herewith proposed as the mathematical model solution, being illustrated in equations (2) and (3).

$$min\left[\sum_{k=1}^{m} \sum_{j=1}^{n} \frac{1}{2} c_j^k (r_j^k - d_j^k)^2\right] \tag{2}$$

$$\sum_{k=1}^{m} \sum_{j=1}^{n} b_{ij}^{k} r_j^{k} + p_i = \sum_{k=1}^{m} r_i^{k} \tag{3}$$

where $c_j^k(k = 1,2,,m,j = 1,2,\dots.n)$ represents the weighting coefficients. $c_j^k \geq 0$ and$\sum_{k=1}^{m} \sum_{j=1}^{n} c_j^k = 1$.Therefore equations (2) and (3) are useful in deciding which parameters are to be controlled by taking into consideration all boundary conditions.

B) Hardware Design

The main objective of the IoT-PMS system is to monitor some environmental parameters and initiate interventionist control actions, while the real-time status of the system is documented and accessed via the internet. For instance, a sensed low-level feed in the feed bar would be an indication for an automated feed supply to be initiated from the food shelf, with an order placed to the feed suppliers. Likewise, an indicated high-level of sensed humidity and ammonia gas is an indicator for automated increased ventilation, as well as the need for chicken droppings/wastes evacuation. The system hardware is represented in the block diagram as shown in Figure 1.

The IoT-PMS hardware unit was designed mainly with autonomous sensor nodes to wirelessly monitor humidity, temperature, air quality, feed availability, and water level in the interested poultry space, and transfer the processed data through their transceiver to the central hub (access node). The data are being communicated to the cloud by the internet-enabled access node, where they can be retrieved in real-time. In addition, the access node initiates any necessary interventionist action, based on the conditioning data from the unit nodes, and relaying the status to the necessary stakeholders and administrator farm (system) in real-time.

A neutral zone for the thermal condition of the chicks/birds is required to accurately calibrate the humidity and temperature requirement. This condition defines the humiture or heat index of the birds at an instant time. The thermal data is a weekly required and recorded. The changes on the humiture data are continuous on an approximately daily basis because of the corresponding continuous growth of the chicks through the 'placing' to 'lifting', hence the importance of the daily record of the weight average. For instance, there is a significant difference in the body weight of chicks between day 7 and day 13. The weight of a 7-day old chick is approximately 190 – 200 grams and about 490 – 500 grams in 14 days. The IoT-PMS comprises two distinct heterogeneous sensor nodes, with the first node containing the air quality, humidity, and temperature sensors, while the other node contains the feed availability and water level sensors which measured their required parameters using a 1kg load cell.

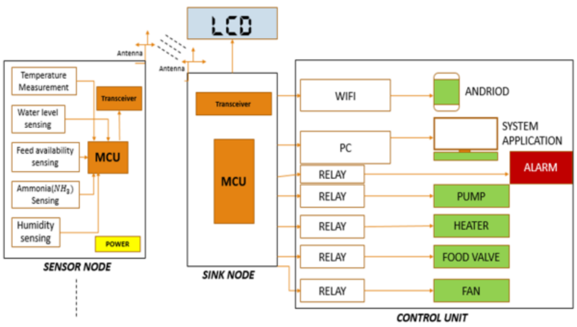


Figure 1. The Block Diagram of the Hardware Units of the IoT-PMS

The wireless devices were designed by selection, using comparative analysis and resourceful considerations among some alternatives. The humidity and temperature sensor selected was DHT21 AM2301, after the features were analysed against the TMP series, LM series, DHT variants and SHT series for temperature, and SENS-HYD2, HR202 series, and SHT series for humidity. This study selected the MQ137 for the air quality sensing. There was a consideration for the possibility of other gases in the air volume in the farm space such as CO2, H2S, CH4, NH3, but the focus was on the presence of the ammonia gas (NH3) present in the poultry waste and droppings. Chicken growth can be inherently stunted by the presence of ammonia gas, and can also cause several other diseases like bird flu, mouth disease, hand foot disease in the birds etc. The healthy threshold value for ammonia gas in the air is approximately 40% and used to determine the level of acceptable sensed condition regarding when the farm is to be treated for ammonia gas presence. A capacitive two-probe sensor was designated for water detection, and a weight sensor selected for sensing feed availability.

Arduino Nano was chosen as the microcontroller unit due to grove pins, voltage and current compatibility, and size. The board is designed based on the ATmega328, having 6 analogue inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. XBee RF module was selected for the transceiver unit after comparing the ZigBee, Bluetooth, and WIFI communication network standards. The modules are designed to meet IEEE 802.15.4/Zigbee standards. This standard defines a dual physical (PHY) layer and media access (MAC) layer, which is 2.4Ghz and 868/915Mhz. The Xbee has the capability of communicating these modules with the microcontroller unit (MCU) through a universal asynchronous receiver/transmitter. The General Packet Radio Service (GPRS) module was selected for mobile connectivity, having compared it with the Enhanced Data rate for GSM Evolution (EDGE) and High-Speed Packet Access (HSPA) technologies.

C) Software Design

The IoT-PMS algorithm was designed and developed in two parts. The first section is to report the variations in parameters (humidity, temperature, feed availability, water level, and ammonia gas level) in the poultry farm, while the second section is to initiate the suitable control action to normalize the deviations as designed in the overall system. The flowchart of the working model is as shown in Figure 2. The algorithm mainly highlights the specific working details of the system, and the configuration details for the microcontroller and transceivers modules adopted the generic format. The functional units integrated by the algorithm include the network coordinating node, monitoring sensor node, the control unit, the mobile device, and the internet.

4 Result and Discussion

The developed IoT-PMS validated the purported model, and incorporated the designed hardware and software units. The resulting networked nodes are as shown in Figure 3. The unit node monitoring the humidity, temperature, and ammonia gas is as shown in Fig 3(a), and the unit node gauging the food availability and water level is as shown in Fig 3(b). It was established that the critical temperature for healthy layers is between 20 – 25 °C [35, 36]. There is a requirement of an extra 1.5 g of daily feed for the birds for every 1°C lesser than 20 °C. From table, it can, the layers performed effectively between temperatures of 20 – 24 °C. Conversely whenever the temperatures rose above 24°C, the egg weight and the shell quality reduced. In like manner, the critical temperature for rearing birds and broilers is vastly dependent on their age. The system load cell measured the feed quantity in grams having been calibrated to determine the food weight in the percentage of the standard value. With the gradual consumption of the feed, the digital scale measured the weight reduction, and the moment the feed quantity reduced below 25% of the maximum possible value the load cell can accommodate, the servo motor was turned off and the grain nozzle was opened for grains to fill back the plate. Also, as water was being exhausted, the digital scale measured the decrease in the weight and when the water quantity reduced below 25% of the full water capacity, the tap was opened by the solenoid valve for the water cavity to be refilled.

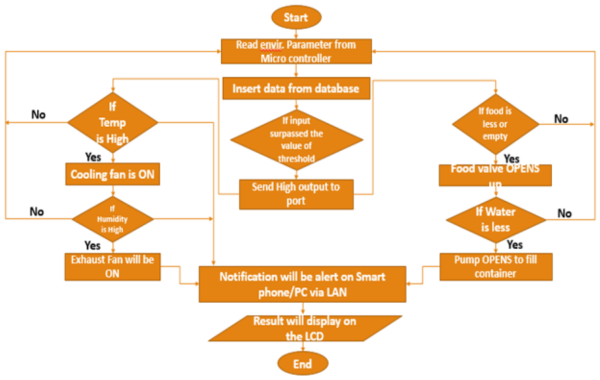


Figure 2. The flowchart of the system algorithm

In summary, the weight of the eggs remained averagely constant (between 56-59g), and this shows that with proper monitoring and control of key environmental factors using IOT, poultries can be effectively managed.

The coordinating access node with the internet gateway, the ventilation unit and result displaying Liquid Crystal Display (LCD) unit are shown in Figures 3(c) and 3(d) respectively. Also, the prototype unit under experimentation is as shown in Figure 3(e). The average daily parameters reading for temperature and humidity is as shown in Figure 4, while the corresponding control action taken by the IoT-PMS is as illustrated in Table 1. The user application interface routed with the internet cloud indicated its result as shown in Figure 5(a), while the corresponding result indicated on the LCD at about 16:20 hours on Wednesday 6th of January, 2021 is as shown in Figure 5 (b). The result showed that the temperature value was higher during the day but lower during the night, while the relative humidity value was higher during the night but lower during the day. The heating bulb was controlled depending upon the temperature. For a temperature below 24℃, the bulb automatically switched ON and remained ON until the temperature increased above 35℃ then it switched OFF and the fan came ON.

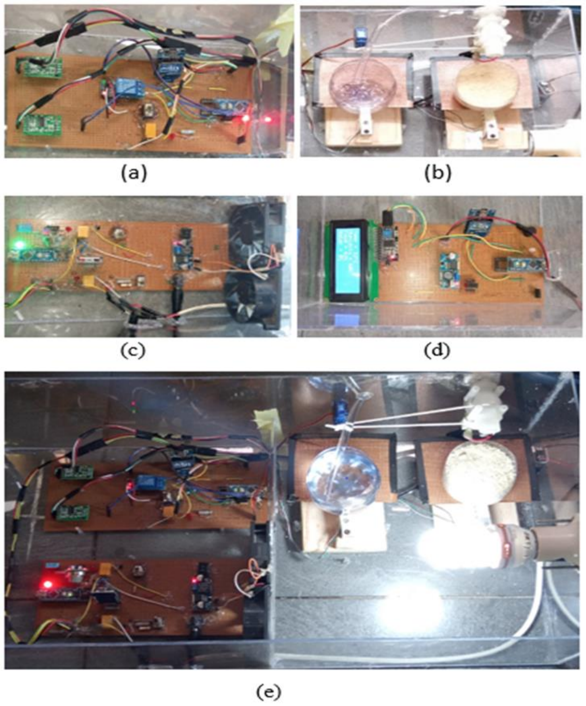


Figure 3. The system hardware (a) unit node 1, (b) unit node 2, (c) the fan unit, (d) coordinating access node, and (e) the prototype system experimentation

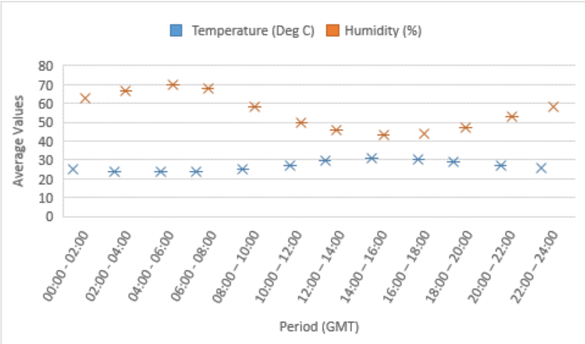


Figure 4. The average daily temperature and humidity reading

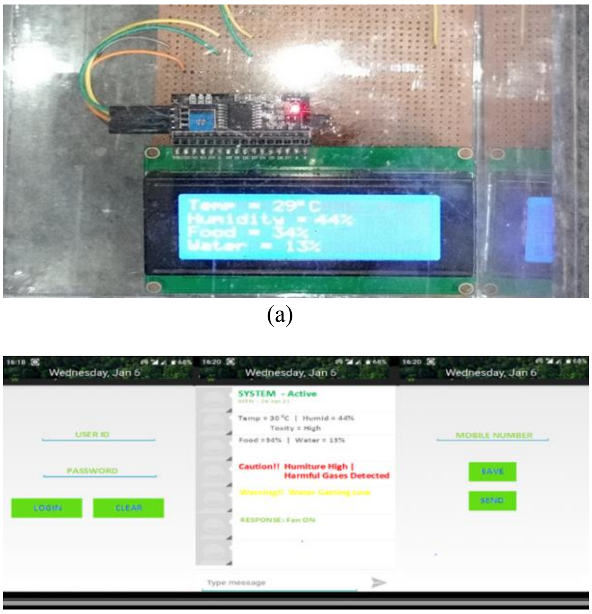
The integrated MQ2 sensor captured toxic gases and dust, especially ammonia gas. Whenever the gas concentration was below the recommended levels (the default) with an upper critical ammonia level of 20 ppm, there was no prompt for action. The alarm would then come ON whenever the threshold value had been surpassed, and prompted the farm manager to re-assess the nutrient and feed mixture administered to the chickens. The fan control was also connected to the operation of the MQ2 gas sensor to ensure optimization of the farm ventilation whenever the system faced certain anomalies of smoke, dust or increased ammonia level. Also, the indicated results on the system local LCD and that of the user application interface are almost the same, with about 2s delay response time.

Table 1.
The corresponding responses to the average temperature and humidity reading

(At the end of the table title, the authors should indicate its source or that it is the authors' design)

Period (GMT)	Average Temperature (^{0}C)	Average Relative Humidity (%)	Average Weight of Egg (kg)	System Response
00:00 - 02:00	25.0	63	58.2	No response
02:00 - 04:00	24.0	67	56.8	Bulb turns ON
04:00 - 06:00	23.7	70	56.2	Bulb stays ON
06:00 - 08:00	23.5	68	56.6	Bulb stays ON
08:00 – 10:00	25.0	58	58.5	Bulb turns OFF
10:00 – 12:00	27.3	50	59.0	No response
12:00 – 14:00	29.7	46	58.7	No response
14:00 – 16:00	31.0	43	55.6	Fan turns ON
16:00 – 18:00	30.0	44	56.2	Fan stays ON
18:00 – 20:00	28.8	47	57.0	Fan turns OFF
20:00 – 22:00	26.9	53	58.5	No response
22:00 – 24:00	26.0	58	56.8	No response

[a] developed by the authors



(a)

(b)

Figure 5: The output results (a) LCD display, (b) Application interface

5 Conclusion

A multi-objective poultry management system based on the IoT synergistic method has been developed. The developed poultry management system which is based on the IoT synergistic method was modeled and designed with resourcefully selected internet-enabled autonomous devices. It achieved continuous poultry farm health condition monitoring and regulating; which ensured the best possible condition necessary for the birds healthy growth. Overall, the work furthered researches on Poultry management System through the combination wireless communication, sensor technology, IoT and automation in providing a smart poultry. Improvement in the health and growth of the birds was achieved by preventing infectious diseases among them, reducing the gaseous pollutants, ensuring improved egg production, reducing human intervention, and hence maximizing the overall profit.

The IoT-PMS was modelled and designed with resourcefully selected internet-enabled autonomous devices. It monitored and regulated the condition within a poultry farm to ensure that the reared chickens are exposed to the best possible condition necessary for healthy growth. This study advanced the synergy among wireless communication, sensor technology, IoT and automation in providing a smart poultry. The aim achieved was in the health and growth improvement of the birds by preventing infectious diseases among them, reducing the gaseous pollutants, ensuring improved egg production, reducing human intervention, and maximizing the overall profit. The system involved resourcefully selected unit nodes, internet-enabled autonomous components, and networks. The modelled and developed management system enabled the poultry farm administrators to communicate or control the conditioning parameters open to the birds, based on the humidity, temperature, water availability, food dispensing, and ammonia gas coefficients in the space. The response time between the variation in the sense parameter and the initiated interventionist measure was evaluated at 87.3%, while the indicated results on the system local LCD and that of the user application interface are almost the same, with about 2s delay response time. This study established that temperature and humidity levels, animal concentration and ventilation rate within a poultry farm can affect the variation in the ammonia concentration. Also, the toxin level can be controlled in real time by adopting the distributed localization method of nodes and adaptive humiture control method. The previously adopted methods were discovered to be most likely limited in signal detection, this work advanced the synergy among wireless communication, sensor technology, IoT and automation in providing a smart poultry. The work has also contributed to advancing the field of knowledge in poultry system management through the overall health and growth improvement of poultry birds; by preventing infectious diseases among them, reducing the gaseous pollutants, ensuring improved egg production, reducing human intervention, and maximizing the overall profit.

In this work, the main constraint for implementation is that the condition for which the weighting coefficients are greater than zero (0) must always be met. For this system noise was limited by setting limits on adjustable parameters in PMS design, (such as water, humidity and temperature) and applying real-time algorithms to filter the noise using the microcontroller unit. Parameters are adjusted through the system algorithm using decision blocks to decide if measured inputs surpassed the desired threshold values or not. Depending on the status of the system, different relays operate to either open the food valve, operate pump, switch cooling/exhaust fan on, or even ring an alarm.

In further works, a more robust system would be achieved by integrating energy portability and rechargeability to the nodes. Also, a validated model would be evaluated for the real-time depiction of the developed system. Furthermore, the scalability potential of the system indicates a possibility for incorporating more poultry farms in the same neighbourhood for monitoring and control over the same internet infrastructure.

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References:

[1] *Rocchi L., Paolotti L., Rosati A., Boggia A., and Castellini C. (2019); "Assessing the sustainability of different poultry production systems: A multicriteria approach," J. Clean. Prod., vol. 211, pp. 103–114.*

[2] *Costantini M., Ferrante V., Guarino M., and Bacenetti J. (2021); "Environmental sustainability assessment of poultry productions through life cycle approaches: A critical review," Trends Food Sci. Technol.*

[3] *Iaksch J., Fernandes E., and Borsato M. (2021); "Digitalization and Big data in smart farming--a review," J. Manag. Anal., vol. 8, no. 2, pp. 333–349*

[4] *Onibonoje M. O. (2021); "IoT-Based Synergistic Approach for Poultry Management System," in 2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), pp. 1–5.*

[5] *Onibonoje M. O., Nwulu N. I., and Bokoro P. N. (2021); "A wireless sensor network system for monitoring environmental factors affecting bulk grains storability," J. Food Process Eng., vol. 42, no. 7, 2019, doi: 10.1111/jfpe.13256.*

[6] *Akinwumi A. and Folaranmi F. (2023), "Development of an Internet of Things Based Fire Detection and Automatic Extinguishing System for Smart Buildings," International Conference on Science, Engineering and Business for Sustainable Development Goals (SEB-SDG), Omu-Aran, Nigeria, 2023, pp. 1-6, doi: 10.1109/ SEB-SDG57117.2023. 10124381. https://ieeexplore.ieee.org/ document/10124381*

[7] *Onibonoje M. O., Ojo A. O., Ogundipe A. T., and Adeniji K. (2021); "A Multi-Objective Model Approach to an IoT-Based Granary Monitoring System," in 2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS), pp. 1–4.*

[8] *Kocaman B., Esenbuga N., Yildiz A., Laçin E., and Macit M. (2006); "Effect of environmental conditions in poultry houses on the performance of laying hens," Int. J. Poult. Sci., vol. 5, no. 1, pp. 26–30.*

[9] *Astill J., Dara R. A., Fraser E. D. G., Roberts B., and Sharif S. (2020); "Smart poultry management: Smart sensors, big data, and the*

internet of things," Comput. Electron. Agric., vol. 170, p. 105291.

[10] *Oso O. M., Metowogo K., Oke O. E., and Tona K. (2022); "Evaluation of light emitting diode characteristics on growth performance of different poultry species: a review," Worlds. Poult. Sci. J., pp. 1–15.*

[11] *Akinwumi A. O. (2022): "Improving System Reliability of Secondary Distribution Networks through Smart Monitoring," International Journal of Smart Security Technologies (IJSST), 9(1), 1-11.*

[12] *Sterling K. G., Bell D. D., Pesti G. M., and Aggrey S. E. (2003); "Relationships among strain, performance, and environmental temperature in commercial laying hens," J. Appl. Poult. Res., vol. 12, no. 1, pp. 85–91.*

[13] *Fabunmi, T. E., Onibonoje, M. O., Salau, A. O., and Akinwumi, A. O. (2023); "Development of an Extended Node-Life Internet-Enabled System for a Server Room Monitoring" Kongzhi yu Juece/Control and Decision, 38(1), 765-776.*

[14] *Shu-ning W. and Ting C. (1987); "The Multiple Criteria Decision-Making Concept Applied to Input-Output Analysis," IFAC Proc. Vol., vol. 20, no. 9, pp. 607–609.*

[15] *Kocaman, B., Yaganoglu A. V. and Yanar M. (2005); Combination of fan ventilation system and spraying of oil-water mixture on the levels of dust and gases in caged layer facilities in Eastern Turkey. J. Appl. Anim. Res., 27: 109-111.*

[16] *Del-Valle J. E., Pereira D. F. , Neto M. M., Gabriel-Filho L. R. A., and Salgado D. D. (2021); "Unrest index for estimating thermal comfort of poultry birds (Gallus gallus domesticus) using computer vision techniques," Biosyst. Eng., vol. 206, pp. 123–134.*

[17] *Guo Y., Chai L., Aggrey S. E., Oladeinde A., Johnson J., and Zock G. (2019); "A machine vision-based method for monitoring broiler chicken floor distribution," Sensors, vol. 20, no. 11, p. 3179.*

[18] *Bongaarts J. (2021); "Food and Agriculture Organization of the United Nations: the state of food and agriculture: agricultural trade and poverty: can trade work for the poor?," Popul. Dev. Rev., vol. 33, no. 1, pp. 197–198.*

[19] *Kademi H. I., Ulusoy B. H., and Hecer C. (2019); "Applications of miniaturized and portable near infrared spectroscopy (NIRS) for inspection and control of meat and meat products," Food Rev. Int., vol. 35, no. 3, pp. 201–220.*

[20] *Okinda C. (2020); "Egg volume estimation based on image processing and computer vision," J. Food Eng., vol. 283, p. 110041.*

[21] *Bilali H. E., Palmisano G. O., Bottalico F., Cardone G., and Capone R. (2021); "Food security and nutrition in agro-food sustainability transitions," Food Secur. Nutr., pp. 57–86.*

[22] *Akinwumi A. and Adeoye A. (2023); "Smart Computation and Interactive Communication for Infrastructure Monitoring and Control" Mathematical Statistician and Engineering Applications (MSEA), 72(1), 393–408.*

[23] *Abd Aziz N. S. N., Daud S. M., Dziyauddin R. A., Adam M. Z., and Azizan A. (2020); "A Review on Computer Vision Technology for Monitoring Poultry Farm--Application, Hardware, and Software," IEEE Access.*

[24] *Onibonoje M. O., Nwulu N., and Bokoro P. N. (2021); "Food 4.0: An Introduction," in Artificial Intelligence and IoT-Based Technologies for Sustainable Farming and Smart Agriculture, IGI Globa, pp. 83–100.*

[25] *Nižetić S., Šolić P., González-de D. L. I., and Patrono L., (2020); "Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future," J. Clean. Prod., vol. 274, p. 122877.*

[26] *Miranda J., Ponce P., Molina A., and Wright P. (2021); "Sensing, smart and sustainable technologies for Agri-Food 4.0," Comput. Ind., vol. 108, pp. 21–36.*

[27] *doje G., Dagiuklas T., and Iqbal M. (2021); "Survey for smart farming technologies: Challenges and issues," Comput. Electr. Eng., vol. 92, p. 107104.*

[28] *Bacco M., Barsocchi P., Ferro E., Gotta A., and Ruggeri M. (2019); "The digitisation of agriculture: a survey of research activities on smart farming," Array, vol. 3, p. 100009.*

[29] *Turkoglu M. (2016); "Defective egg detection based on deep features and Bidirectional Long-Short-Term-Memory," Comput. Electron. Agric., vol. 185, p. 106152, 2021.*

[30] *Onibonoje M. O. (2021) "Sensor Networks and Internet of Things in Agri-Food," in Internet of Things, CRC Press, 2021, pp. 177–194.*

[31] *Onibonoje M. O., Alli K. S., Olowu T. O., Ogunlade M. A., and Akinwumi A. O (2016); "Resourceful selection-based design of wireless units for granary monitoring systems," ARPN J. Eng. Appl. Sci., vol. 11, no. 23, pp. 13754–13759..*

[32] *Onibonoje M. O., Folorunso O., Ajibade A., and Adeniji K. A. (2016); "An integrated approach*

to automated control for air-conditioned home apartments using wireless sensor network," Indian J. Sci. Technol., vol. 9, no. 40, pp. 1–9, doi: 10.17485/ijst/2016/v9i40/98360.

[33] *Fang C., Zhang T., Zheng H., Huang J, and Cuan K. (2021); "Pose estimation and behavior classification of broiler chickens based on deep neural networks," Comput. Electron. Agric., vol. 180, p. 105863.*

[34] *Zhuang X. and Zhang T., (2019) "Detection of sick broilers by digital image processing and deep learning," Biosyst. Eng., vol. 179, pp. 106–116.*

[35] *Turkoglu, M., Arda M., Yetiþir R., Sarica M. and Ersayin C., (1997); Tavukçuluk bilimi. Samsung.*

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Aderonke Akinwumi carried out the circuit design, algorithm, simulation, design optimization and experimental report.

Stella Monye and Remilekun Elewa implemented the algorithm 2.1.

Imhade Okokpujie and Oluwatosin Banjoko organized the experimental setup of Figure 3.

Summarily all the authors contributed something in the present research, at different stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.