Taxonomy, Open Challenges, Motivations, and Recommendations in Smart Poultry: Systematic Review

Ahmed Y. Mohammed,	Department of computer sciences, Collage of computer sciences and Math, Tikrit University, Iraq Ahmed.y.mohammed35526@st.tu.edu.iq
Mocehab L. Shuwandy,	Department of computer sciences, Collage of computer sciences and Math, Tikrit University, Iraq Moceheb@tu.edu.iq
Harith A. Hussein	Department of computer sciences, Collage of computer sciences and Math, Tikrit University, Iraq Harith_abd1981@tu.edu.iq

ABSTRACT

This work presents a systematic review of the latest studies on the promotion of smart poultry based on modern and smart technologies in line with the development of the agricultural sector, such as artificial intelligence, and the Internet of Things that are used to cover issues in poultry. Then, the classification was created to group the articles according to their motivations, goals, and challenges. The search was performed in three major databases: IEEE Xplore, Science Direct, and Scopus. A total of 995 research papers were collected from 2016 to 2022. The retrieved articles were filtered and 52 articles were selected and categorized into three categories. System monitoring falls under the first category (n=39/52; 75%) and may be used to monitor the environment to maintain ideal environmental conditions, monitor chickens to find illnesses and determine chicken mortality, or monitor chicken weight. Monitoring based on the dataset, which keeps data in the cloud and analyzes it to detect illnesses and take necessary action, is included in the second category (n=2/52; 3.85%). Other is the third group (n=11/52; 21.15%). On the other hand, it must take some limitations in such applications more seriously, for example: the establishment of a system adapting to the appropriate conditions of the chicken according to the age of the chicken and attention to factors that reduce thermal stress that increase productivity. Our study attempts to provide a comprehensive overview of intelligent poultry in the literature. We hope that other researchers will use this study as a starting point to expand the research further based on the challenges we have discussed.

Keywords: Internet of Things, Monitoring Systems, Sensors, Smart Poultry.

1. Introduction

People have been more aware of the nutritional advantages of chicken meat in recent years, and it is now beginning to have a bigger demand in the market[1]. Poultry farming is a popular agricultural industry that involves raising a variety of domestic birds to produce eggs and meat for use and sale[2]. Chickens are grown in a controlled environment with a certain temperature and humidity[3]. Poultry chickens are divided into two parts, broiler chickens and layer chickens. In layer chicken, the most efficient temperature range is between 20° and 24° C[4]. For broilers, the perfect temperature is according to age, as shown in Table 1 [5]. For chickens in general, relative humidity of 50-70 percent is ideal[6], and the recommended amount for ammonia is less than ten (10) ppm[7]. Heat and cold stress, insufficient or excessive ventilation, and poor air quality can all lead to the chicken's life being cut short[8]. In addition, poultry illness, particularly broiler chicken disease, is characterized by high mortality, many forms of the disease, and frequent epidemic disease. Broiler chicken sickness not only causes farmers to lose a lot of money, but it also puts their health and the health of people around them in jeopardy[9]. The voice, video, and temperature of hens can be used to assess and identify the majority of these diseases[10]. One of the responsibilities of the caregiver is to make sure that the chicken has enough food and water[1].

Temperature	
Levels	Weeks
32 ∘ C - 34 ∘ C	1-2
26 ∘ C - 30 ∘ C	3-4
18 ∘ C - 24 ∘ C	5-7

Table 1. The optimum temperature for broiler chicken

The Internet of Things (IoT) is a network of connected objects that communicate with one another through online services[11]. We may simply operate a system with the assistance of these little network-connected sensors or gadgets[12]. IoT allows an appliance to be managed in the cloud, making it available from anywhere, whether it's data, information, transportation, or equipment[13]. The information gathered by the gadgets is utilized for two objectives. The first goal is to automate the process, and the second goal is to use data analytics to evaluate the obtained data and forecast any future events[14].

As the globe moves toward new technologies and the adoption of IoT, agricultural research is adopting IoT benefits in order to produce the greatest cattle[15]. IoT aids in the storage of data in one location so that farmers can readily access, evaluate, and use it to make the best choice possible[16].

This systematic review seeks to give deep insights into IOT-based smart poultry methodologies and implementation, as well as to aid researchers in comprehending current strategies to fill in the gaps of the field, present a unified taxonomy for the literature. Furthermore, the topic's motives and challenges are determined. The following is a breakdown of the paper's structure. The first section discusses IoT-based smart poultry. The study approach, scope, literature sources, and filtering stages are all described in Section 2. Section 3 summarizes the findings of this paper's final group of articles and offers a taxonomy for relevant literature and statistical data. The motives, challenges, and suggestions taken from the final collection of articles from 2016 to 2021 are classified and discussed in Section 4. The conclusion is presented in Section 5.

2. Method

To achieve a comprehensive understanding of smart poultry by relying on the Internet of Things has been applied **Systematic literature review (SLR).** Systematic literature reviews try to find as much relevant research on a specific research subject as feasible and to utilize specified procedures to determine what can be asserted with confidence based on these studies.

2.1 Information sources

To search for targeted articles, we selected three digital databases :

1- IEEE Xplore provides the most reliable and wide-ranging articles in the fields of engineering and technology.

2- ScienceDirect is a large database that contains reliable scientific, technical, and medical articles.

3- Scopus is a massive abstract and citation database of scientific journals, conference proceedings, and books.

These three databases adequately cover IoT and its applications in smart poultry, as well as provide a thorough overview of current literature in a variety of disciplines.

2.2 Study Selection

The study period was from 2016 to 2022. A literature search was conducted first, followed by two stages of screening and filtering. By scanning the titles and abstracts, the first stage removed duplicates and irrelevant articles. In the second stage, the literature was filtered through a full reading of the articles that were filtered in the first stage , as shown in Figure 1.

2.3 Search

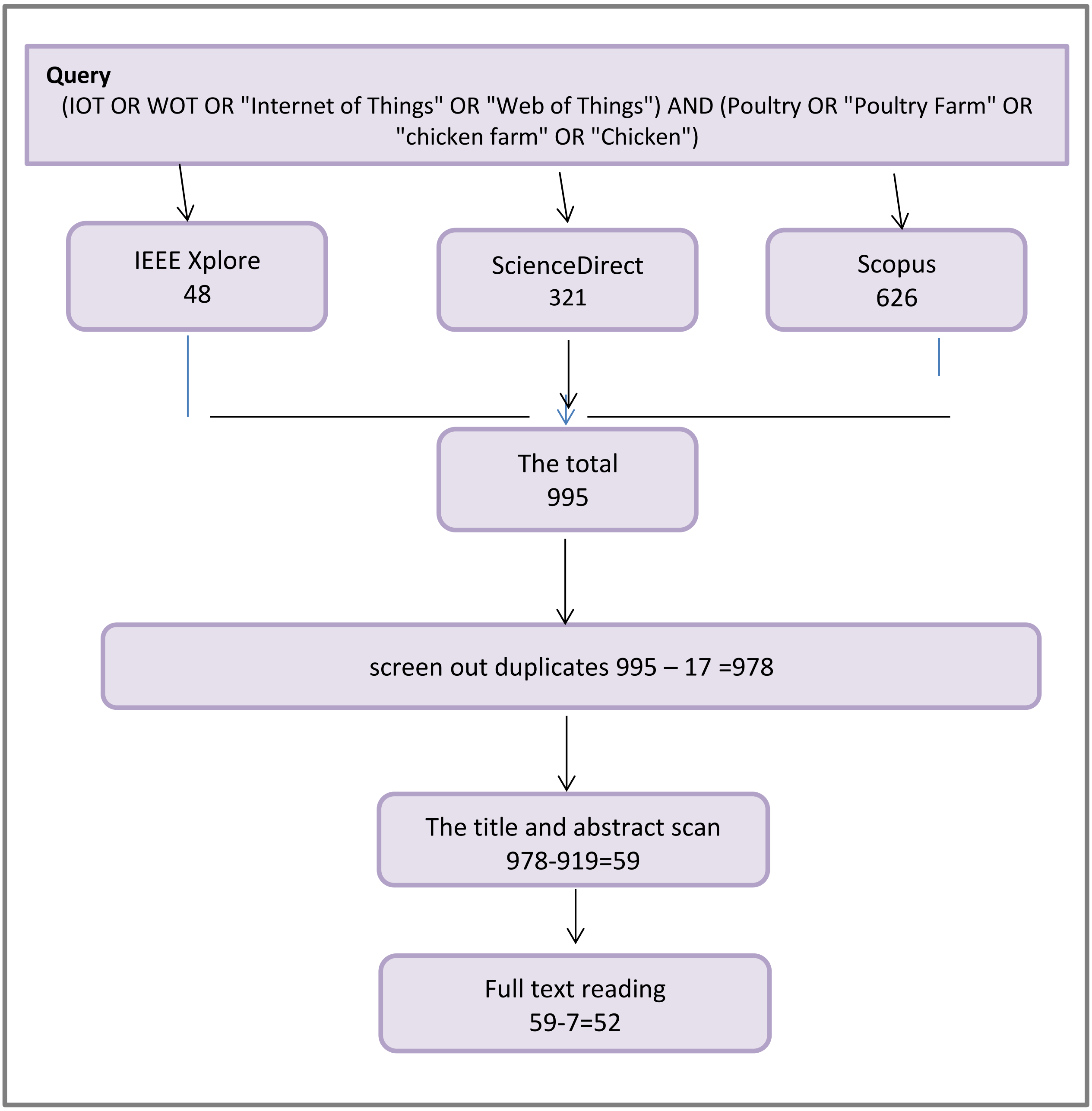
The search was conducted on September 10, 2021, using the ‘advanced search’ in Scopus, ScienceDirect, and IEEE Xplore. We use two groups of keywords, the first group included 'IOT', 'WOT', 'Internet of Things', 'Web of Things', the 'OR' operator was used to combine these keywords. The second group included 'Poultry', 'Poultry Farm', 'chicken farm', 'Chicken', The 'OR' operator was used to merge them. The 'AND' operator was used to combine the two groups.

2.4 Eligibility criteria

Each database's choices were taken into account. Books, reports, and other content found in the search results were not included. However, we used the most recent journal publications and conferences, and only the most relevant were considered. The exclusion criteria included the following.

1-The article is non-English.

2- The subject is limited to a specific aspect of poultry and does not include the smart poultry.



3. Taxonomy and Statistical information of articles

Only 995 items remain after scanning the databases given above and selecting the period from 2016 to 2022. following the removal of duplicates and a screening of titles and abstracts, Only 59 articles passed the preliminary screening.

Seven of the articles were eliminated after reading the full text, leaving 52 articles, The final review, which was broken into three categories, contained them. The first category (n=39/52; 75%) includes System monitoring either environmental monitoring to maintain optimal environmental conditions or monitoring of chickens to identify diseases and mortality of chickens or knowledge of chicken weight. The second category (n=2/52; 3.85%) includes monitoring based on the dataset Which stores data in the cloud and analyzes it to detect diseases and take appropriate action. The third category (n= 11/52; 21.15%) is other. As shown in **Error! Reference source not found.**, our systematic review categorized all linked publications under the stated category into a literature taxonomy. In the next sections, the observed categories are given, with basic statistics shown throughout the discussion.

3.1 Monitoring system

This section contains 39 articles out of 52, the equivalent of 75% of the total, and aims to produce healthy chickens by monitoring environmental parameters, reducing number chicken mortality, as well as predicting and diagnosing disease. This category is divided into three subcategories.

The first is Environmental Monitoring (n=31/39, 79.49%), this category is divided into three groups. The first group is multi-sensing for broiler and layer chickens and has (n=17/31, 54.84%), includes many studies, including the provision of proactive and preventive methods to avoid or reduce bird deaths through monitoring heat stress[17]. In[18], the Internet of Things and blockchain technology are applied in monitoring environment. In the following studies[5, 7, 11, 12, 15, 16, 19, 20], poultry houses are generally protected by environmental monitoring by relying on the Internet of Things. In [21] edge computing was applied to the Internet of Things to solve the problems of bandwidth and delay. This [22] article tests a low-cost IoT-based model for remote control of a poultry environment. [23]developed a smart poultry farm to monitor environmental parameters using RTOS on Arduino. In [24] environmental parameters are monitored and controlled, in addition to designing a system to regulate the flow of water and feed, as well as electricity, is generated through chicken manure. [6]uses an artificial intelligence algorithm to forecast and monitor air quality in poultry. In, it monitors the environmental parameters and also monitors the water and nutrition system. In addition, it uses a camera to allow the owner of the poultry house to monitor the poultry remotely. To maintain the optimum temperature, this study [8] describes a self-contained chicken coop cooling system that uses renewable energy and recycled water. Broiler chickens(n=9/31 , 29.03 %) are the second group, and environmental characteristics that impact their health, such as ammonia gas, temperature, and humidity, are monitored[3, 14, 25-31]. The third group is layer chickens (n=5/31, 16.13%), and includes providing healthy chickens by monitoring several factors such as temperature, humidity, lighting, air quality, and ventilation to increase egg production[4, 32-35] .

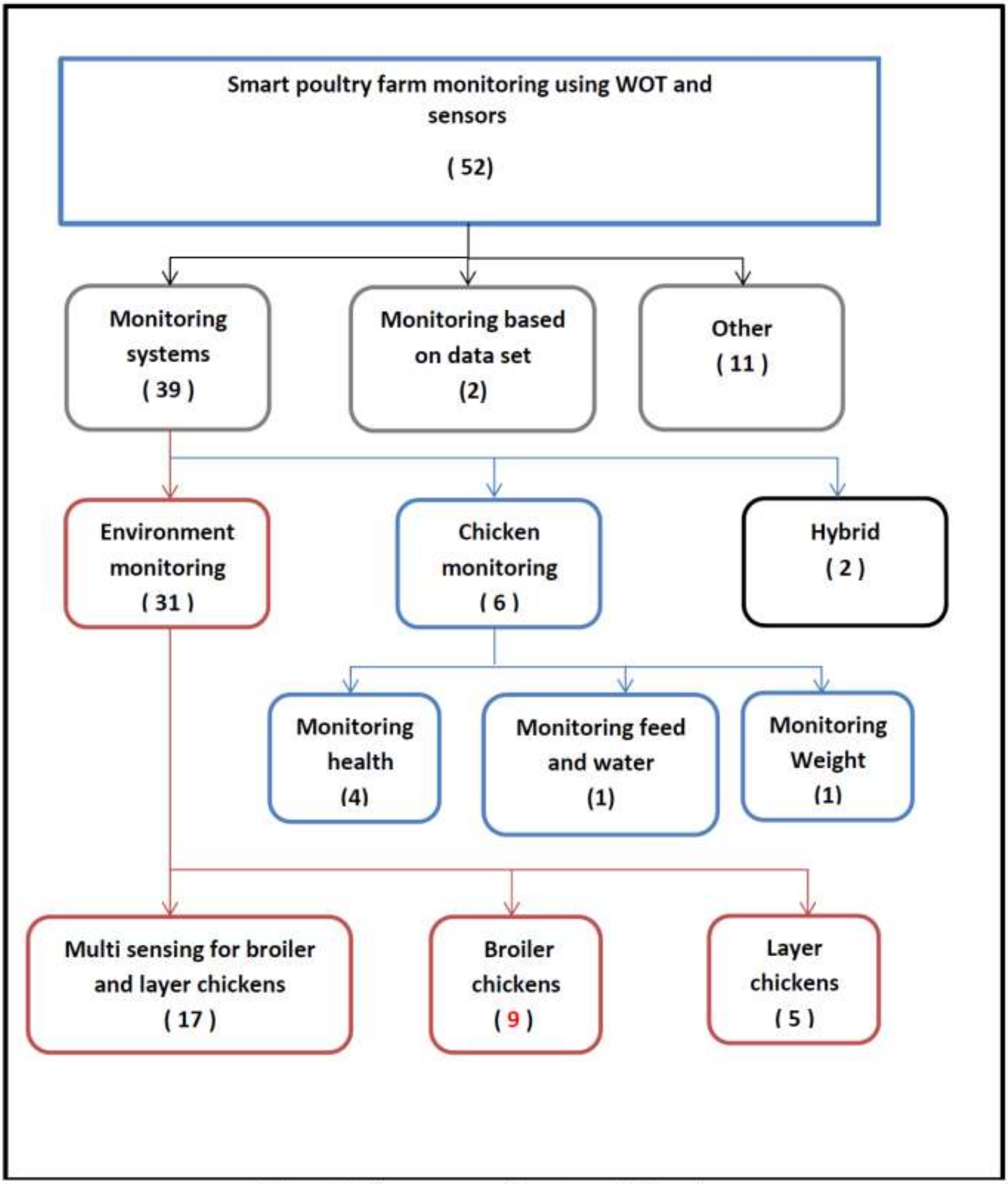


Figure 2. Taxonomy of research literature

The second is chicken monitoring (n=6/39, 15.38%), and this category alos divided into Three groups. The first group is monitoring health(n=4/6 ,66.66 %), it consists of identifying sick chickens and using an algorithm to anticipate the appropriate disease, as well as determining chicken mortality[9, 10, 36, 37]. The second croup is feed and water monitoring(n=1/6 ,16.67%), which keeps track of and supplies water and feed to poultry animals[13]. Monitoring Weight(n=1/6 ,16.67) is the third group, which keeps track of the chicken's weight in order to produce high-quality, safe meat[38].

The third is hybrid(n=2/39 , 5.13%), environmental parameters are monitored in this area, and a monitoring camera is utilized to keep an eye on the status of the poultry house in real-time. Furthermore, eggs are gathered[39, 40].

3.2 Monitoring based on data set

This section contains(n=2/52 , 3.85%). Sensor nodes installed within the chicken coop capture data in real-time. Customers are provided with manual data via a web page or a smartphone app. The data is moved to a cloud data center and analyzed[41, 42].

3.3 Other

This section includes studies related to developing an algorithm to know the weight of chickens, identifying sensors used in poultry, and a study to develop a mobile application that helps farmers in making decisions, in addition to reviews[1, 2, 43-50].

4. Discussion

This section aimed to discuss and highlight three significant components:(1) motivations related to the topic's benefits and significance as explained by researchers; (2) challenges and problems identified through previous and current research and academic studies; and (3) recommendations in which authors share their future ideas and aspirations for future studies.

4.1 Motivation

This section depicts the many components of motivations, which are categorized according to their distinct benefits. Figure 2 depicts the many motives for smart poultry based on IoT.

Figure 2. motivation categories for smart poultry based on IOT

4.1.1 Motivations related to the risks of changing environmental parameters

Most people have difficulty maintaining a regular watch on the chicken coop[51]. Therefore, Environmental characteristics, such as temperature, humidity, ammonia levels, and luminosity, must be monitored regularly to ensure the system runs smoothly since they directly influence chicken performance and welfare[15, 20, 23, 25, 28, 34, 40]. These environmental variables also have an influence on poultry food quality and health[16, 26] and it has an effect on the respiratory system and can lead to mortality[7]. One of the most important aspects of growing healthy chickens is temperature regulation in the poultry house[52]. Heat stress is an unpleasant experience for chickens. It's a situation in which living organisms absorb too much heat, causing stress, disease, and even death[8, 17]. Increased relative humidity leads to increased stress[35].

4.1.2 Motivations related to reducing time and cost

Agriculture's fast growth necessitates the use of more advanced technology[48]. The majority of poultry farms are inspected by hand. As a result, they face significant financial losses owing to their incapacity to fully automate the monitoring and management of environmental conditions, which prompted several academics to establish an intelligent farm[3, 19]. Furthermore, because the cost of human labor is increasing[11], smart farms can assist cut labor expenses[5], boosting productivity[38], minimize waste[39], and lower death rates. Physiological factors on the farm, including temperature, humidity, and light intensity, should be monitored and maintained with little human involvement to ensure the health of the poultry[14]. Proper nutrition is one of the other aspects that impact poultry productivity that motivates researchers[18, 29].

4.1.3 Motivation related to the economic situation

Demand for chicken products grows as the world's population grows[4, 12, 13]. Because poultry is one of the agriculture sector's most significant economic development sectors[24, 33], various things must be considered in order to increase production outcomes[45]. One of these factors is the temperature and humidity of the broiler farm[9, 30]. A clever and cost-effective approach of automating the greatest number of human tasks is necessary to improve the quality and dependability of this area[31]. Another motivator for the researcher [32] was to use the Internet of Things to boost egg production in order to avoid future shortages.

4.1.4 Motivations related to Health

Most poultry farms can accomplish automation with the continual enrichment of scientific and technical means. Still, there is no automatic monitoring step for dead and ill birds on the farm, just ongoing manual inspection and detection[36]. Many researchers were prompted by these factors to design and build removal devices for deceased chickens [37] and to use images to detect unwell birds[10]. Weight, on the other hand, is a crucial measure of broiler chick health during their raising period, which prompted the researcher [43] to develop an automated weighing device.

4.1.5 Motivations related to data management synchronization

Most poultry environmental management systems are currently developed to meet specific needs. Users with a large agricultural scale can manage each breeding location independently, resulting in issues such as complexity and difficulties in evaluating and interpreting data[49]. Poultry producers must carefully monitor all data connected to poultry management to manage their daily production operations[22]. IoT enables real-time poultry monitoring, analytics, and sophisticated automation if the data is of high quality[6]. As a result, numerous academics were inspired to create a management system capable of acquiring, transmitting, storing, managing, analyzing, and forecasting future events[41, 42]. Furthermore, some researchers have found that using mobile decision support technologies to aid farmers in making informed decisions is an excellent strategy to help them. [2] developed a mobile decision support system that would assist small farmers and rural poultry producers in obtaining trustworthy information needed to make informed decisions about their farming operations.

4.2 Challenges

Various smart poultry challenges were discovered when the academic literature was analyzed. Numerous issues have been raised by researchers about both the smart poultry procedure . The primary difficulties are categorized and described in the next subsections, along with citations. The main challenges identified in the academic literature are shown in Figure 3.

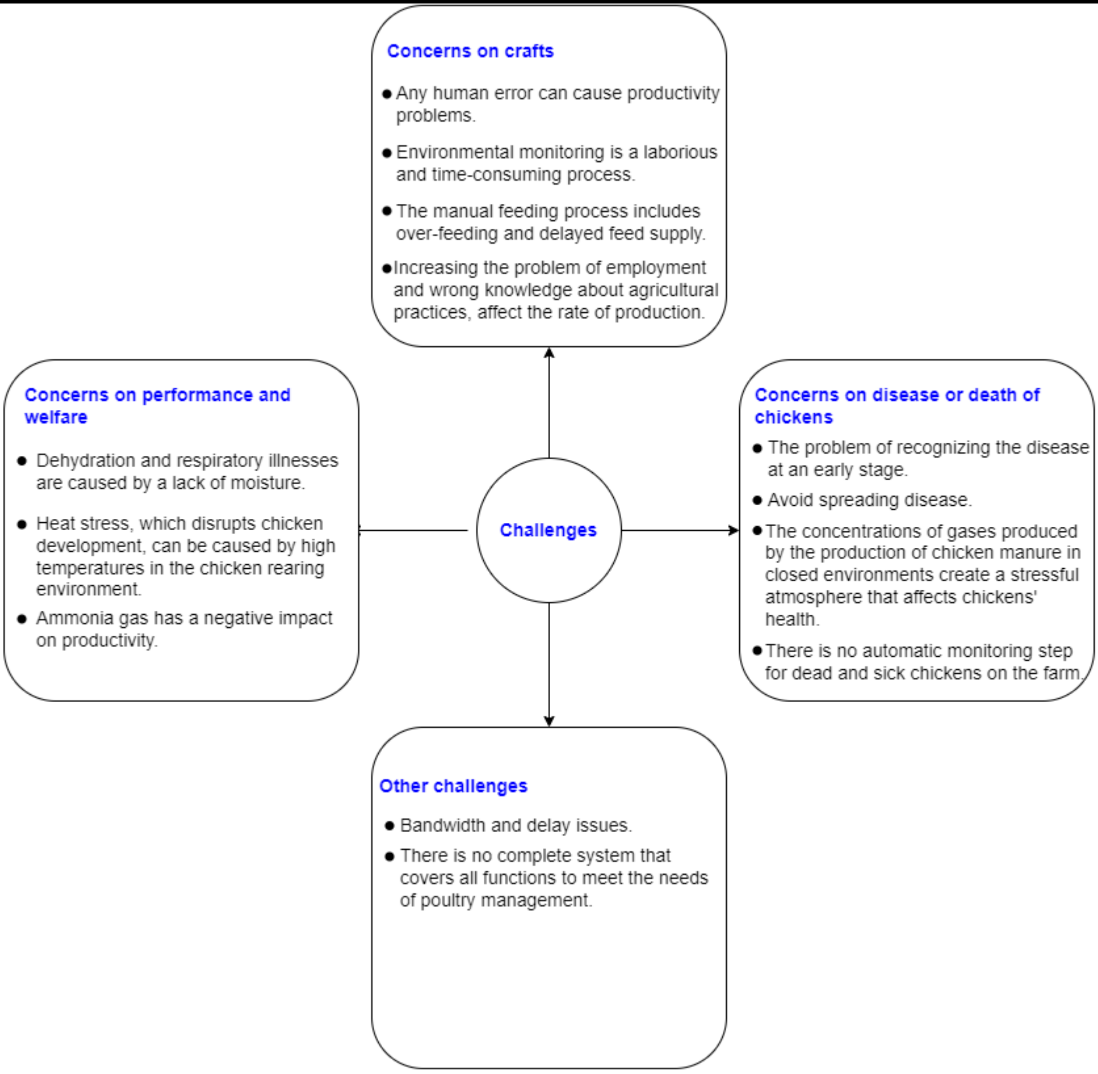


Figure 3. Challenges for smart poultry

4.2.1 Concerns on crafts

Large poultry farms, particularly, require much work because it is necessary to check all environmental conditions manually. This makes environmental monitoring a laborious and time-consuming process, and false knowledge about agricultural practices increases the problem of employment, and any human error is harmful to production [11, 18-20, 24, 30, 33, 38]. The majority of poultry farms still manually tend to the animals' needs for food and water. The issue with farms that have a lot of animals to care for is the amount of laborious work that must be done[13]. Hand feeding has certain drawbacks, such as dangerous overfeeding and delayed meal provision [4, 29]. As for water, an adequate water supply level must be maintained for poultry at all times[48]. The typical method of weighing broiler chicks is on a steel scale, which is laborious, time-consuming, and frequently results in stress-related behavior in the broilers [43]. The administration of poultry farms is largely labor-intensive. It is highly challenging to retrieve, process, and analyze the vast amount of vital data for the manufacturing process that is either preserved incompletely or only kept as paper documents[42]. Breeders are required to regularly check on the well-being of their broilers throughout the day. To stop the spread of infections inside the chicken house, the breeder manually removes sick birds from the house when they are discovered[37].

4.2.2 Concerns on performance and welfare

These days, problems impacting animal performance and welfare are significant. Environmental factors including temperature, humidity, ammonia levels, and glossiness must be continuously monitored since they directly affect the performance and welfare of chickens[7, 14, 15, 22, 23, 25, 34, 51]. As the high temperature causes heat stress which leads to disruption of chicken growth and affect productivity [8, 12, 17, 27, 35, 52], and lack of moisture leads to dehydration and respiratory diseases.[3, 28] , excess moisture can lead to the production of ammonia [16] . The animal waste produces harmful gases like ammonia (NH3), which hurts the well-being of hens and it can also cause respiratory problems in humans[6, 26, 31].

4.2.3 Concerns on disease or death of chickens

Farmers face many problems such as pollution and bird diseases[39]. The lack of veterinary staff is just one of numerous issues and shortcomings with poultry. As a result, chicken illness, particularly broiler disease, is characterized by a high mortality rate. The presence of broiler illness not only results in significant financial losses for farmers[5] but also poses a major threat to their health and the people around them[9]. Recognizing the illness at an early stage and preventing the illness from spreading to other illnesses is one of the issues faced by poultry [10], so there is no automatic monitoring stage to recognizing the illness; instead, detection is done manually continuously[36]. Some farmers look for various information on poultry health from multiple sources of information when they encounter numerous health-related issues on their farms. Still, most of these sources are untrustworthy, so they frequently make the wrong choices[2].

4.2.3 Other challenges

The proliferation of smart devices is only one of many additional issues that developers must deal with. Network bandwidth is strained by rapid data expansion, and cloud computing is not always practical. Therefore, problems with bandwidth and delays must be fixed[21]. The dependable transmission of wireless data has issues. The wireless data transmission of several sensors experienced a lot of interference, including redundant data and lost data[53]. Building an integrated system for poultry management presents another issue, as there is currently no comprehensive system that addresses all requirements for poultry management[40, 41]. On the other hand, only a few users with massive agricultural scales can manage each breeding location independently, which creates specific issues like complexity and difficulties in analyzing and using information[49].

4.3 Recommendations

Many parts of suggestions were found in the literature, whether they were connected to the need for more research, hardware upgrade, or system improvement. This section looks at suggestions that have come up in the literature. Figure 4 illustrates the IOT-based smart poultry suggestion categories.

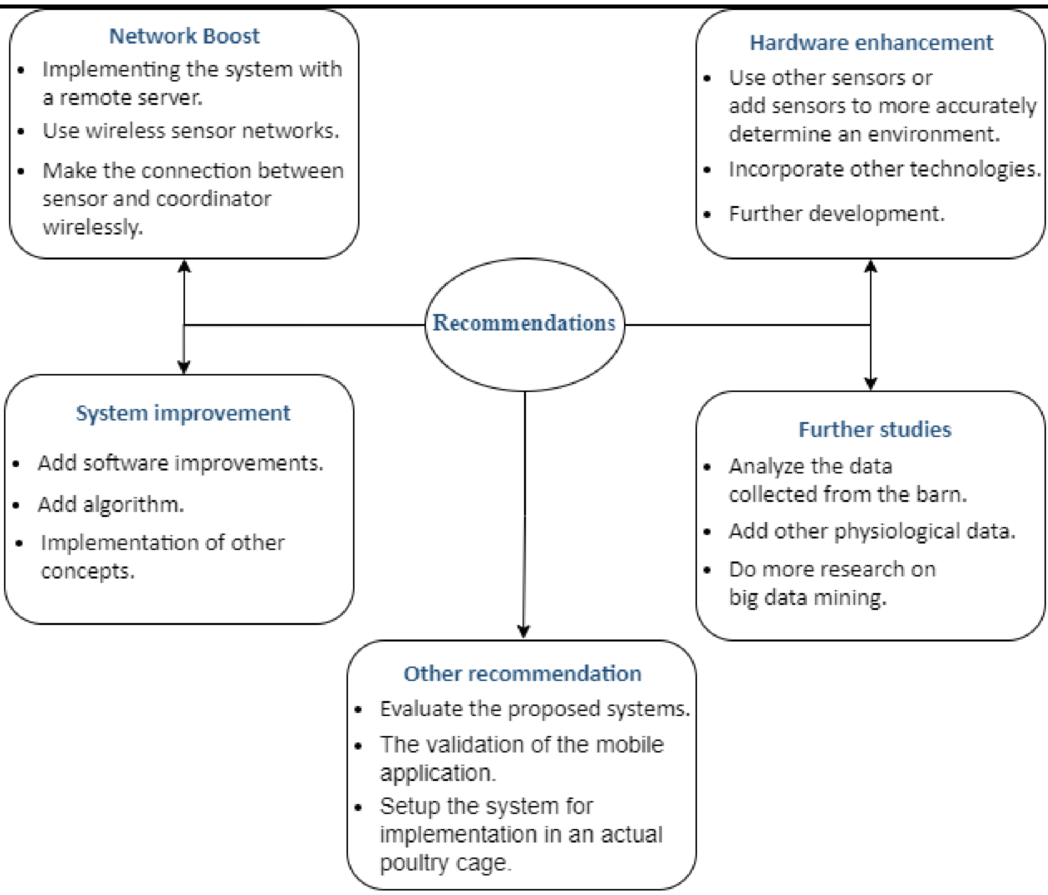


Figure 4. Recommendation categories for smart poultry based on IOT.

4.3.1 Network boost

From a variety of perspectives, many recommendations were made to network boost. [17] he is suggested that the system be implemented with a remote server in order to acquire empirical data on its performance and to conduct an analysis of the peak heat time in a year in Sub-Saharan Africa. Using wireless sensor networks and mobile communication technologies to complete poultry farms minimizes the amount of human labor necessary by automating the process[39]. According to the criteria, the researcher [11] provided various future works that can build a wireless connection between the sensor module and the coordinator using Bluetooth, XBee, or wifi modules. Because Raspberry Pi 3 storage is restricted, cloud data storage may be employed; the web interface can be designed to display the sensor's geographical position, and the interface can be tuned to give a rich user experience. For remote monitoring, data logging, and control, the researcher [23] proposed connecting the Arduino system to the Internet.

4.3.2 Hardware enhancement

Several studies have recommended the enhancement of hardware by adding more sensors. Utilizing other sensors to more correctly environment the surroundings of a chicken farm using blockchain technology is recommended by [18]. Other research has also proposed the inclusion of sensors that allow monitoring of other environmental factors important to preserving air quality[25, 41]. Other sensors, such as flood and fire detectors, are recommended in [8] to increase the system's safety. Other technologies that might be added (closed circuit television, infrared cameras, gas detectors, mobile Internet, GSM, etc.) to install it and expand the project's potential were recommended in a research [32]. According to research [33], all environmental output data may be obtained in a more trustworthy state by utilizing more modern sensors and technological concepts. Another study recommended adding a video recognition capability and utilizing it as an extension of the camera device to monitor the chicken coop in real time is a good idea[9]. Further development, according to the researcher at [27], should include a screen that can be used to monitor temperature and humidity as well as solar panels to produce power continually and effectively.

4.3.3 System improvement

Many researchers recommend improving the system. In [16] recommended executing all of the core functions of creating a true system. In [15] recommended that feasible to expand the work by giving forecasting functions for data analysis and obtaining a better outcome. Another research [24] suggested installing a fire alarm system and constructing an automatic fire extinguishing system, as well as adding more information about the poultry farm to the website, such as vaccination reminders, worker information, and so on. Approximately 3-5 hens may be tracked at a time using the sensors used in [10]. The researcher advised raising the higher RGB, increasing the RGB resolution, and increasing the higher thermal camera in this article to improve chicken count tracking. The researcher in [6] will conduct video treatment and analysis of animal hens in the future in order to discover problems in poultry such as aberrant mortality, stress, and meaning. The researcher [51] mentioned that the cleaning procedure could not be completed due to a lack of time and funds. Therefore, he offered a cleaning system to monitor and control the chicken coop's cleanliness. This cleaning procedure will help the hens and their owners feel more at ease. Another study recommended improving the system by adding a more reliable prediction algorithm[5]. Another research suggested automating various phases of the chicken production chain's data collecting procedure and better connecting it with the PCM platform[45].

4.3.4 Further studies

Various proposals for the conduct of additional research have been made in the literature from various perspectives. In[14], it was suggested that data collected from the barn be analyzed using data analytics to predict avian diseases such as avian influenza and other diseases that could have devastating effects on the productivity of the poultry farm ecosystem be predicted so that farmers can take appropriate measures before they occur. in [48] clear that future work should concentrate on preparing the technology in a real chicken cage, aside from assessing the implementation's start-up and running costs and determining the number of operating expenses saved by managing and monitoring the system's water supply level. There should be more study to add other physiological data like blood pressure, heart rate, etc[42]. Furthermore, further study on large data mining and analysis is required[36]. The prospect of doing additional studies aimed at enhancing software engineering was discussed by the researcher in [25].

4.3.5 Other recommendations

A study recommended the security features of this technology might be enhanced and lessen vulnerability to cyber assaults and data infiltration[18]. Incorporating energy recharging and mobility within the nodes will also make the system more resilient[4]. In research[34], he explained that it is possible to implement the concept of hydroponics. The creation of a smartphone application with additional capabilities such as scheduling vaccination reminders, according to the researcher [7], would be a great contribution to the effort. Future work in [2] focuses on testing mobile applications created to guarantee that this study helps farmers get crucial chicken raising information needed to make educated decisions.

5. Conclusion

A recent experimental trend has emerged in using the Internet of Things and smart poultry. It is important to get insights into this emerging trend. This article aims to contribute such ideas by scanning and categorizing related works. All recent and published work on smart farms based on IoT were scanned, and essential contributions were highlighted. The first contribution is to provide taxonomy in this paper based on the literature. In the second contribution, we covered the selected studies' main highlights, including motivations, challenges, and recommendations. We highlighted the benefits of stimulus related to the risks of changing environmental parameters, reducing time and cost, economic situation, health, and data management synchronization. Our analysis raised several concerns that the researchers reported. Therefore, we have highlighted these challenges related to the limitations of chicken disease or death, craftsmanship, performance, and welfare. In addition, we emphasized the recommendations regarding users' need for further studies, hardware enhancement, system improvement, network boost, and other recommendations. Our study attempts to provide a comprehensive overview of smart poultry using the Internet of Things in the literature. We hope that other researchers will use this study as a starting point to expand the research further based on the challenges we have discussed.

References

1. Bea, J.G. and J.S.D. Cruz. *Chicken farm monitoring system using sensors and Arduino microcontroller*. in *Proceedings of the 9th International Conference on Information Systems and Technologies*. 2019.
2. Shapa, M., L. Trojer, and D. Machuve, *Mobile-based Decision Support System for Poultry Farmers: A Case of Tanzania.* 2021.
3. Edwan, E., et al. *Design and Implementation of Monitoring and Control System for a Poultry Farm*. in *2020 International Conference on Promising Electronic Technologies (ICPET)*. 2020. IEEE.
4. Onibonoje, M.O. *IoT-Based Synergistic Approach for Poultry Management System*. in *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*. 2021. IEEE.
5. Chiluisa-Velasco, G., et al. *Intelligent Monitoring Systemof Environmental Biovariables in Poultry Farms*. in *Proceedings of SAI Intelligent Systems Conference*. 2020. Springer.
6. Debauche, O., et al., *Edge computing and artificial intelligence for real-time poultry monitoring.* Procedia computer science, 2020. **175**: p. 534-541.
7. Lufyagila, B., D. Machuve, and T. Clemen, *IoT-powered system for environmental conditions monitoring in poultry house: A case of Tanzania.* African Journal of Science, Technology, Innovation and Development, 2021: p. 1-12.
8. Khalid, S.K.A., et al., *Autonomous coop cooling system using renewable energy and water recycling.* Indonesian Journal of Electrical Engineering and Computer Science, 2019. **13**(3): p. 1303-1310.
9. Zhang, H. and C. Chen. *Design of sick chicken automatic detection system based on improved residual network*. in *2020 IEEE 4th Information Technology, Networking, Electronic and Automation Control Conference (ITNEC)*. 2020. IEEE.
10. Raj, A.A.G. and J.G. Jayanthi. *IoT-based real-time poultry monitoring and health status identification*. in *2018 11th International Symposium on Mechatronics and its Applications (ISMA)*. 2018. IEEE.
11. Raghudathesh, G., et al. *Iot based intelligent poultry management system using linux embedded system*. in *2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*. 2017. IEEE.

12. Lashari, M.H., et al. *IoT Based poultry environment monitoring system*. in *2018 IEEE International Conference on Internet of Things and Intelligence System (IOTAIS)*. 2018. IEEE.
13. Batuto, A., et al. *e-poultry: An IoT poultry management system for small farms*. in *2020 IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA)*. 2020. IEEE.
14. Hambali, M.F.H., R.K. Patchmuthu, and A.T. Wan. *IoT Based Smart Poultry Farm in Brunei*. in *2020 8th International Conference on Information and Communication Technology (ICoICT)*. 2020. IEEE.
15. Manshor, N., A.R.A. Rahiman, and M.K. Yazed. *IoT based poultry house monitoring*. in *2019 2nd International Conference on Communication Engineering and Technology (ICCET)*. 2019. IEEE.
16. Mondol, J.P., et al. *IoT based smart weather monitoring system for poultry farm*. in *2020 2nd International Conference on Advanced Information and Communication Technology (ICAICT)*. 2020. IEEE.
17. Afeez, N., et al. *A framework for Poultry weather control with IoT in sub-Saharan Africa*. in *2019 15th International Conference on Electronics, Computer and Computation (ICECCO)*. 2019. IEEE.
18. Elham, M.N., et al. *A preliminary study on poultry farm environmental monitoring using Internet of Things and blockchain technology*. in *2020 IEEE 10th Symposium on Computer Applications & Industrial Electronics (ISCAIE)*. 2020. IEEE.
19. Mansor, H., et al., *Development of smart chicken poultry farm.* Indonesian Journal of Electrical Engineering and Computer Science, 2018. **10**(2): p. 498-505.
20. Yan, Z., W. Xiu-li, and L. Bao-quan. *Intelligent poultry environment control system based on internet of things*. in *International Conference on Cloud Computing and Security*. 2018. Springer.
21. Yang, X., et al. *Environmental monitoring of chicken house based on edge computing in internet of things*. in *2019 IEEE 8th Joint International Information Technology and Artificial Intelligence Conference (ITAIC)*. 2019. IEEE.
22. Mumbelli, A., et al. *Low cost IoT-based system for monitoring and remote controlling aviaries*. in *2020 3rd International Conference on Information and Computer Technologies (ICICT)*. 2020. IEEE.
23. Gunawan, T.S., et al. *Development of smart chicken poultry farm using RTOS on Arduino*. in *2019 IEEE International Conference on Smart Instrumentation, Measurement and Application (ICSIMA)*. 2019. IEEE.
24. Sitaram, K.A., et al. *IoT based smart management of poultry farm and electricity generation*. in *2018 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC)*. 2018. IEEE.
25. Pereira, W.F., et al., *Environmental monitoring in a poultry farm using an instrument developed with the internet of things concept.* Computers and Electronics in Agriculture, 2020. **170**: p. 105257.
26. Syahrorini, S., et al. *Design smart chicken cage based on internet of things*. in *IOP Conference Series: Earth and Environmental Science*. 2020. IOP Publishing.
27. Ramadiani, R., et al., *Temperature and humidity control system for broiler chicken coops.* 2021.
28. Nalendra, A.K., et al. *Monitoring System IoT-Broiler Chicken Cage Effectiveness of Seeing Reactions from Chickens*. in *Journal of Physics: Conference Series*. 2021. IOP Publishing.
29. Wibowo, E.P., et al. *Prototype Of Feeding Devices, Temperatures And Humidity Monitoring At Broiler Chickens Breeders With The Internet Of Things Concept*. in *2018 Third International Conference on Informatics and Computing (ICIC)*. 2018. IEEE.
30. Wicaksono, D., D. Perdana, and R. Mayasari. *Design and analysis automatic temperature control in the broiler poultry farm based on wireless sensor network*. in *2017 2nd International conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE)*. 2017. IEEE.
31. Arunkumar, S. and N. Mohanasundaram, *Smart poultry farming.* International Journal of Innovative Technology and Exploring Engineering, 2018.
32. Nicolas, R.D.M., et al. *An IoT Monitoring Assistant for Chicken Layer Farms*. in *2019*

International Conference on Information and Communication Technology Convergence (ICTC). 2019. IEEE.

33. Islam, M.M., et al. *Smart poultry farm incorporating GSM and IoT*. in *2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*. 2019. IEEE.
34. Jayarajan, P., et al. *IOT Based Automated Poultry Farm for Layer Chicken*. in *2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)*. 2021. IEEE.
35. Deepika, Nagarathna, and Channegowda, *Monitoring and Detection of Heat Stress of Layers in Poultry Farm using Multiple Linear Regression.* 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), 2020: p. 1186-1191.
36. Bao, Y., et al., *Detection system of dead and sick chickens in large scale farms based on artificial intelligence.* Mathematical Biosciences and Engineering, 2021. **18**(5): p. 6117-6135.
37. Liu, H.-W., et al., *Identifying images of dead chickens with a chicken removal system integrated with a deep learning algorithm.* Sensors, 2021. **21**(11): p. 3579.
38. Ichiura, S., et al., *Exploring IoT based broiler chicken management technology.* Proceedings of the 7th TAE, 2019: p. 205-211.
39. Thomas, D.A., et al. *Automated Poultry Farm with Microcontroller based Parameter Monitoring System and Conveyor Mechanism*. in *2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS)*. 2020. IEEE.
40. Li, X., et al. *Key technology implementation of poultry breeding system for 5G intelligent IOT*. in *2020 IEEE Conference on Telecommunications, Optics and Computer Science (TOCS)*. 2020. IEEE.
41. Zheng, H., et al., *Design and implementation of poultry farming information management system based on cloud database.* Animals, 2021. **11**(3): p. 900.
42. Hongqian, C., et al., *Cloud-based data management system for automatic real-time data acquisition from large-scale laying-hen farms.* International Journal of Agricultural and Biological Engineering, 2016. **9**(4): p. 106-115.
43. Ma, W., et al., *A method for weighing broiler chickens using improved amplitude-limiting filtering algorithm and BP neural networks.* Information Processing in Agriculture, 2021. **8**(2): p. 299-309.
44. Abd Aziz, N.S.N., et al., *A Review on Computer Vision Technology for Monitoring Poultry Farm—Application, Hardware, and Software.* IEEE Access, 2020. **9**: p. 12431-12445.
45. Esnaola-Gonzalez, I., et al., *An IoT platform towards the enhancement of poultry production chains.* Sensors, 2020. **20**(6): p. 1549.
46. Singh, M., et al. *Artificial intelligence and iot based monitoring of poultry health: A review*. in *2020 IEEE International Conference on Communication, Networks and Satellite (Comnetsat)*. 2020. IEEE.
47. Pitesky, M., et al., *Data challenges and practical aspects of machine learning-based statistical methods for the analyses of poultry data to improve food safety and production efficiency.* CABI Reviews, 2020(2020).
48. Tjoa, G.W., A. Aribowo, and A.S. Putra. *Design of Automatic Drinking Water Supply System for Poultry Cage*. in *2019 5th International Conference on New Media Studies (CONMEDIA)*. 2019. IEEE.
49. Qun, Y., et al. *Research on master-slave distributed large-scale poultry farming measurement and control system*. in *2019 International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*. 2019. IEEE.
50. Astill, J., et al., *Smart poultry management: Smart sensors, big data, and the internet of things.* Computers and Electronics in Agriculture, 2020. **170**: p. 105291.
51. Karim, N.S.A., T.B. Mohamed, and U.A.B.M. Nordin, *Urbanized chicken coop monitoring system using IoT.* International Journal of Advanced Trends in Computer Science and Engineering, 2019.
52. Lau, K., et al. *Temperature Distribution Study for Malaysia Broiler House*. in *2018 2nd*

International Conference on Smart Sensors and Application (ICSSA). 2018. IEEE.

53. Li, H., et al., *Development of a remote monitoring system for henhouse environment based on IoT technology.* Future Internet, 2015.