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PIONEERING POULTRY ROBOTICS: EXPLORING THE LATEST INNOVATIONS IN THE MARKET AND RESEARCH LABS

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Robotics has been deemed an effective solution for prevalent problems in agricultural industries. Be it human resource shortage or performing daily inspection more efficiently, robots can help mitigate management and production hurdles (Morris, 2018). Although the development and adoption of robots has been slow, the advent of artificial intelligence (AI) technologies has accelerated this automation process (Part et al., 2022). Specifically, the poultry robotics area is slowly emerging and has gained promising momentum recently. Integrating robotics into poultry management and production holds significant promise for addressing the aforementioned challenges.

In this context, various robots have been developed and implemented in both commercial markets and research laboratories. These robots are designed to assist producers in various areas including welfare management, monitoring greenhouse gases emissions, assisting and even replacing humans in some daily tedious tasks such as dead chicken identification and collection, and collecting floor eggs (Ren et al., 2020). Although promising, these advancements are still in a preliminary phase. A large area of concern is the gap between the perception, practice, and priorities of the commercial markets using technology and the research groups creating technologies. Furthermore, robots are considered impractical partly due to high initial costs and extended research and development (R&D) processes by both sides.

Welfare concerns in poultry

Ensuring the welfare of poultry is not a straightforward task. Several key factors such as diseases, poor physical conditions, genetic issues, rapid growth, and environmental stressors may adversely affect birds and, by extension, the overall success of poultry farming. For instance, the gait level (presence of lameness) of chickens generally deteriorates due to some or a combination of the mentioned reasons during their rearing period (Okinda et al., 2020). Hence, welfare issues, such as lameness, can be painful for the birds and have a significant impact on their performance and meat quality.

Poultry production is traditionally labor-intensive. Tasks such as feeding, monitoring, and managing flock health require a considerable amount of human effort. For instance, in a broiler house with 30,000 birds, daily mortalities will occur. Farm managers are required to identify dead birds' locations and remove them as fast as possible to increase biosafety in the farm. These processes are time-consuming, and poultry farmers must invest substantial hours to remove dead birds (Abd Aziz et al.,2020).

One other major challenge in poultry farming is the subjective nature of human judgment. Assessing the welfare of birds often relies on visual and manual checks, leading to errors and inconsistencies. The use of advanced technologies, particularly a robot equipped with various sensors and computers, can mitigate these concerns by providing consistent, objective, data-driven insights into the welfare assessment of poultry.

Robots: A solution

The introduction of robotics together with advanced AI capabilities in poultry production offers a promising solution to the challenges outlined above. Robots can be programmed to detect signs of diseases and health issues early in the flock, as early disease detection is crucial for fast intervention and preventing viral or pathogenic outbreaks and hence prevent economic losses and further compromised bird welfare (Li et al., 2022).

Furthermore, robots equipped with AI, sensors and cameras can continuously monitor, analyze, and make decisions autonomously to improve the welfare level of birds. They can also recognize and analyze poultry behavior patterns. This can help identify stressors, assess parameters such as brooding, socializing, eating, and drinking, and provide valuable insights into the overall health of the birds and improve flock management.

Finally, robots which can perform specific or general tasks in poultry farms, pose a viable solution to mitigate, to some degree, the scarcity of skilled workers in large markets such as the U.S. Robots are not limited to cultural barriers and can be used for many roles on the farms; furthermore, they are dispensable utilities that can be employed in hazardous tasks well.

Current Commercial Robots

The current market features several cutting-edge robotic solutions that can have a substantial impact on poultry welfare, operational efficiency, and sustainability in poultry production.

Figure 1. *Octopus Poultry Robot*

Figure 2. *Metabolic Robot*

1. **Octopus Poultry Robot**

   - The Octopus autonomous robot is designed for various tasks in broiler breeder farms, as shown in Figure 1 (Octopus Robots, 2023). It efficiently sanitizes the poultry environment, reducing the risk of viral or pathogenic disease transmission. Litter scarification is another vital ability of the robot which helps in breaking caked litter and reducing ammonia gas production. It can also monitor the animals for vital signs and collect data. However, the robot requires high initial investment which makes it unattractive for most farmers. Furthermore, it is a ground robot making it difficult to move around and through chickens.

2. **Metabolic Robot**

   - While still in the development phase, this ground robot is similar to the Octopus robot, making it a promising addition to poultry farming automation, as shown in Figure 2 (Chai, 2022). The robot is equipped with a computer that governs its functions on the spot. One of its differentiating specialties is in controlling the feed motors through which the feed efficiency is regulated by attracting birds to the empty feeders and drinkers through sound and light beams. Henceforth, the robot can help in decreasing feeding costs by increasing feed access to the general flock (The poultry site, 2018).

3. **Scout Robot**

- As shown in Figure 3, the Scout Robot focuses on bird welfare, offering real-time behavior analysis, environmental data, and mortality rates. As it is hanging from the ceilings, its high mobility allows it to cover extensive areas quicker than the previous ground robot examples. On the other hand, infrastructural modifications are required to hang this robot from the ceiling, which along with higher initial investment and operational costs, incurs huge expenses on the farmers (Cumberland Poultry, 2023).

Figure 3. *Scout Robot*

4. **Spoutnic and T-Moove Robots**

- The Spoutnic and T-Moov robots, shown in Figures 5a-b respectively, controls floor egg rates which is a major economic loss for poultry farmers (Octopus Robots, 2023; Chai, 2022). These plug and play robots have simpler designs which enable them to only move around a farm and reduce floor egg instances as well as encourage bird movement. Their initial price for acquisition is lower than the previously mentioned robots, as there are fewer added features, such as sensors, built on them.

Figure 4a. *Spoutnic and T-Moov Robots*

Figure 4b. *Spoutnic and T-Moov Robots*

Robots in the Labs

Research laboratories are at the forefront of developing highly advanced robotics solutions for poultry production. Test models for robotic hands for egg and dead bird collection, mobile low-cost robots with robotic hands, shown in Figures 5a-d have been tested under theoretical conditions (Li et al., 2021; Dennis et al., 2020; Usher et al., 2017). However, these robots are yet to be used in commercial settings.

The challenges of implementing lab-developed robots in commercial settings are multifaceted. High costs incurred by long required R&D processes can be a significant barrier to companies creating these technologies. Furthermore, innovative applications of technologies, such as robotic hands and drones, needs to be developed for practical use in farm conditions such as floors covered with thick and wet manure crusts, dusty environments with dimmed lighting or going through congested areas. Additionally, the complexity of integrating robotics into existing farming operations can pose significant challenges for farmers. Challenges like educating farmers for efficient utilization of the new technology or bringing infrastructural changes in the farms in order to accommodate robots can be tedious and may incur additional costs.

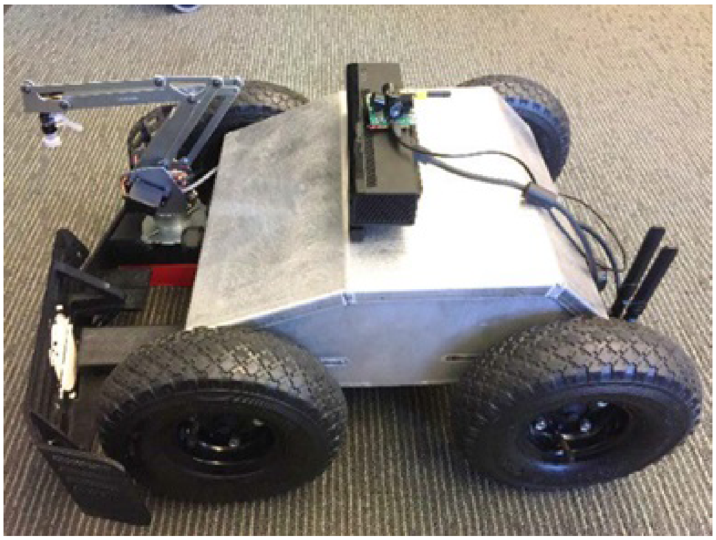

Figure 5a. *Robots in the Labs*

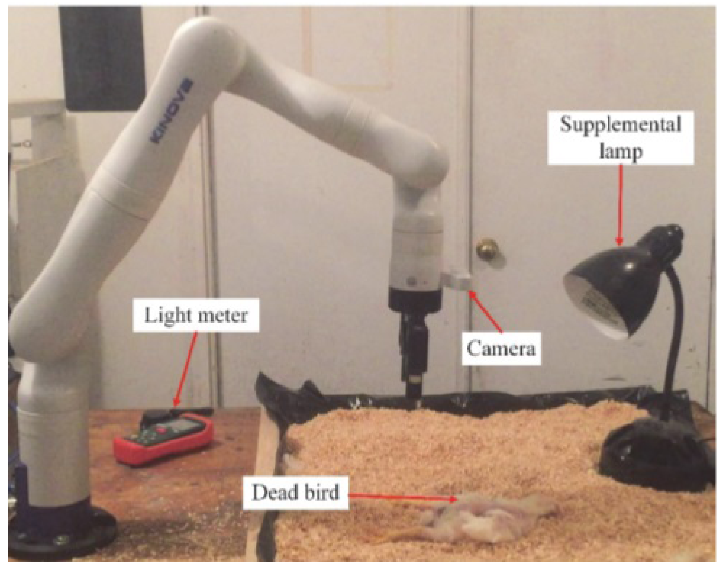

Figure 5b. *Robots in the Labs*

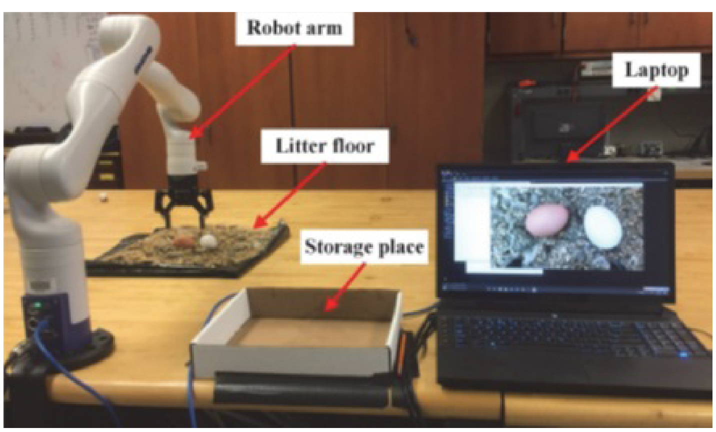

Figure 5c. *Robots in the Labs*

Figure 5d. *Robots in the Labs*

Challenges ahead

The adoption of robotics in poultry production is accompanied by a set of challenges that require attention and innovative solutions. The initial investment in acquiring robots can be overwhelming for most small to mid-sized poultry companies and poultry farmers. On the other hand, the payback time for these robots is still to be studied as for some existing robots the investments may be paid back in three to five years (Lely, 2016). Hence, it is crucial to find cost-effective solutions and to think long term when it comes to adopting such a vital technology.

Some robotic systems are limited in their mobility, such as less autonomous maneuverability, and adaptability to varying farm sizes and environmental conditions. This restricts their practical utility as frequent human interventions are needed for their smooth operations. Additionally, in the context of integrating robots into farms which are basically infrastructures built only for human-animal needs becomes very complex and challenging. What sort of infrastructural overhaul or innovation does the poultry ecosystem need to transform it into a human-animal-robot friendly infrastructure? In the long run, finding suitable answers for such questions becomes vital.

Furthermore, there is a need for more robust and innovative solutions integrated with robots such as robotic hands and drones which can expand their range of applications in poultry farming. These innovative adaptations are essential for success. It is also challenging to transform the human centered culture of the established farm operations while integrating robotics. End users, such as farmers, need support and training to make the most of these technologies for effective adoption and implementation. Without effective training to ensure use, any technology becomes a very expensive paperweight.

Bridging the gap between lab-based research and practical farm applications is a key challenge. A more streamlined and collaborative approach is needed between farmers and researchers. Research labs can play a critical role in developing and fine-tuning robotics solutions for poultry farming only if they have open channels of continuous communications with the poultry farmers. These channels of communication are vital in driving innovation and practical advancements in the industry.

Summary

In summary, the integration of robotics in poultry production offers substantial potential in addressing welfare concerns and enhancing production efficiency. The development and implementation of these technologies, however, requires a concerted effort to overcome existing technological, financial, cultural, and infrastructural challenges and ensure seamless integration into practical farm settings. Close collaboration between research labs in the universities, governmental agencies such as USDA, and poultry farmers is essential to bridge the gap between technological advancements and the real-world needs of the poultry industry. By addressing challenges and fostering collaborative innovation, the poultry sector can harness the full potential of robotics to ensure sustainable and welfare-focused poultry production.

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