

# Application of Imaging Systems for Monitoring Poultry Well-being

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**EXTENSION**

# Poultry Production Challenges

The global population is predicted to reach over 9.5 billion in 2050 and the demand for global animal protein (e.g., eggs, meat, and milk) is expected to increase by over 70% in 2050 as compared to 2005. Providing food for an increasing world population with limited natural resources is a grand challenge for animal agriculture. Broiler (meat chicken) production has undergone remarkable advancements over the past decades. A marketable broiler chicken (5-6 lb) rearing period in 1950 was 16 weeks, whereas it takes only 5 to 6 weeks to complete today. Innovations in breeding, nutrition, vaccinations, disease management, and house environmental management have allowed for this dramatic progress. Highly efficient poultry farming has allowed broiler chickens to dominate among global animal production. Currently, the United States is the world's largest broiler producer with an annual sales value of \$40 billion. However, global broiler production is facing emerging challenges in animal health, food safety, environmental impact, and increasing concern regarding animal welfare from the general public.

The rapid growth rate of broilers is associated with welfare concerns such as lameness, which potentially can restrict chickens' behavior, cause physical discomfort, and affect their fundamental freedoms. Those welfare concerns have triggered the attention of the general public and the food industry to improve broiler well-being and well-being assessments. Current assessments include audits of daily records from producers and independent third-party assessments. As these assessments have matured and the science of bird well-being assessment has been validated, subjective or qualitative scoring systems are being replaced with quantifiable measurements. The automation of well-being assessment has benefits beyond removing subjectivity and aids in customer guarantees of poultry well-being in products they purchase.

## Imaging Technologies for Poultry Well-being Monitoring

Sensing technologies—such as ultra-wideband radio frequency identification (RFID), accelerometers, and computer vision-based monitoring—have been and are being adapted and tested for livestock and poultry farming systems to aide well-being assessments. Monitoring methods requiring direct contact with birds (e.g., RFID and accelerometers) may affect animal activity or behavior and welfare, thus noncontact vision-based methods (i.e., cameras and automatic image processing) are considered the ideal approach. Monitoring the behaviors of large animals (e.g., cattle and pigs) is possible because of well-developed computer vision-based (phenotyping) technology. However, it is technically challenging to monitor smaller individual animals, such as broilers in commercial houses.

Most existing computer vision-based monitoring systems focus on a single bird's activity or behavior such as feeding and drinking, light preference, perching, pecking, dust bathing, and group activity or response to water sprinkling. Some early versions of imaging systems for automated assessment of broiler chickens' welfare have been tested, but none are ready for commercial farm use. Among previous studies, two groups have developed computer vision monitoring systems for poultry: the eYeNamic system and the optical flow method.

## The eYeNamic system

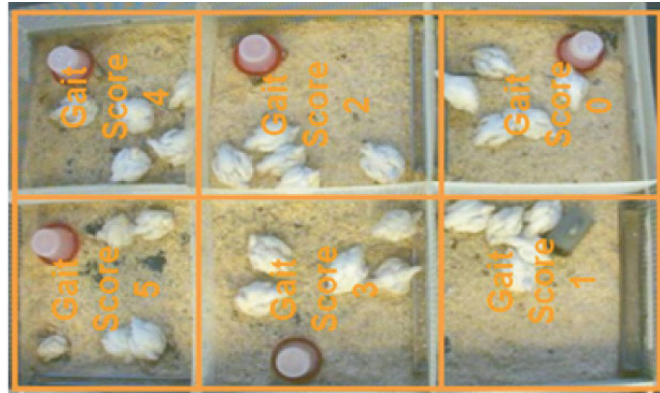
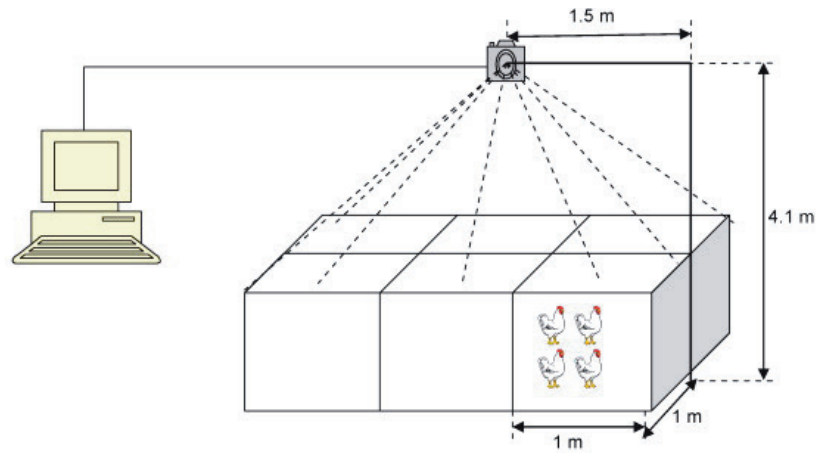
Daniel Berckmans's team in Belgium integrated a monitoring system called eYeNamic for gait-score monitoring in broiler houses (Figure 1). This system is based on the six-point Kestin scale suggested for evaluating gait score of broiler chickens. The current version of the eYeNamic system can detect the difference in activity index between groups with different gait scores. Activity index is quantified as pixel change of images over time. The method indicates that an automatic tool in determining activity in relation to gait score can be developed (i.e., a walking ability indicator). The European Union countries are using a six-point gait scoring system and the United States is using a three-point gait scoring system. Higher gait scores mean worse leg health. Broilers with gait scores of 4 and 5 had significantly lower activity levels. However, the eYeNamic system was sensitive in detecting birds with high gait scores of 4, 5 or 6, but not for intermediate scores (i.e., gait scores 2 and 3),

according to the lab test. There also are many interferences on the floor of commercial broiler houses (e.g., feeders, drinkers, and other equipment) that affect the monitoring of poultry images and activities. The tool needs more innovations or optimizations in individual tracking before commercialization.

## The “optical flow” method

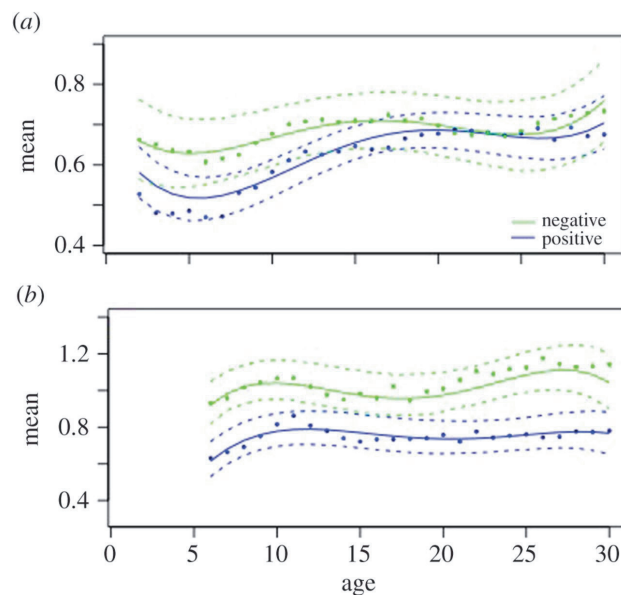
Marian Dawkins’ team in the United Kingdom developed an optical flow method for measuring broiler welfare and health based on optical flow statistics of flock movements recorded on video (Figure 2). The optical flow method can be used to detect the change of brightness in pixels of moving objects (e.g., chickens) and then generate statistical properties of moving objects (e.g., mean flow rate, variance, skew, and kurtosis) for analyzing the correlation between the statistical properties of chickens’ movement and health or welfare indicators such as gait score, pododermatitis, gastrointestinal infection, and hock burn. The latest study, based on 74 commercial broiler flocks, indicated that the correlation between hock burn/mortality and the statistical properties of movement can be detected automatically. However, the current method or system only can detect the correlations between some statistical properties and birds. It’s still unclear how the method can be used to track individual birds with welfare concerns.

Currently, no validated systems are available for automated assessment of broiler chicken welfare in commercial houses. Early studies with systems such as optical flow and eYeNamic show great promise that future poultry welfare evaluation can be conducted with computer or machine vision-based imaging systems.



**Figure 1. “eYeNamic” monitoring system developed by Berckmans’s team in Belgium.**

From “Application of a fully automatic analysis tool to assess the activity of broiler chickens with different gait scores,” by A. Aydin, O. Cangar, S. E. Ozcan, C. Bahr, and D. Berckmans, 2010, *Computers and Electronics in Agriculture*, 73(2), pp. 194–199 (<https://doi.org/10.1016/j.compag.2010.05.004>). Copyright 2010 by Elsevier B.V.



**Figure 2. The correlation between chickens’ health and flock movements.**  
 Note. Lines represent daily mean optical flow (flock movements) for *Campylobacter*-positive (blue) and *Campylobacter*-negative flocks (green). As early as the first 10 days of life, *Campylobacter*-positive flocks showed lower mean movements than flocks in which *Campylobacter* was not detected. The solid lines show response across ages, with dots representing the observed daily values. Dashed lines represent 95% confidence limits for responses across ages. The x-axis is the age in days. From “Monitoring chicken flock behaviour provides early warning of infection by human pathogen *Campylobacter*” by F. M. Colles, R. J. Cain, T. Nickson, A. L. Smith, S. J. Roberts, M. C. Maiden, D. Lunn, and M. S. Dawkins, 2016, *Proceedings of the Royal Society B: Biological Sciences*, 283(1822), Article 20152323 (<https://doi.org/10.1098/rspb.2015.2323>). Copyright 2016 Colles, et al.

# A Case Study of Poultry Floor Distribution Imaging at UGA

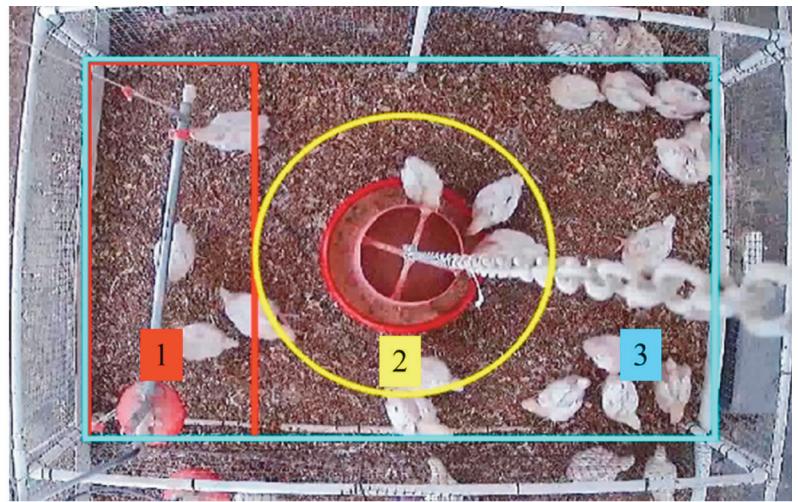
In commercial poultry houses, bird density and distribution in drinking, feeding, and resting zones are critical factors for evaluating flock productivity, bird health, and well-being. Proper distribution of chickens in the house greatly influences animal well-being and house environmental management (e.g., ventilation problems causing concerns with litter quality). Currently, routine daily inspection of broiler flock distribution in commercial grow-out houses is done manually, which is labor-intensive and time-consuming. UGA poultry science researchers currently are developing an automated imaging system for monitoring floor distribution of chickens.

**Methods:** This work was conducted at the Poultry Research Center at the University of Georgia in Athens, GA. Six identical pens measuring 6 by 3.6 ft were used to raise Cobb-500 commercial-type broiler chickens (21 broilers per pen) for 49 days (see Figure 3). Each pen was monitored with a high-definition camera mounted on the ceiling 8 ft above the pen floor, which captured videos of grouped chickens. For video-image analysis by computer, each pen floor was virtually divided into drinking, feeding, and rest/exercise zones.

Broilers were raised without antibiotics on reused litter (i.e., bedding material previously used in another trial) made of pine shavings, feed, and chicken manure. To determine the number of chickens in each drinking and feeding zone, a new artificial intelligence computer programming method was developed and applied.

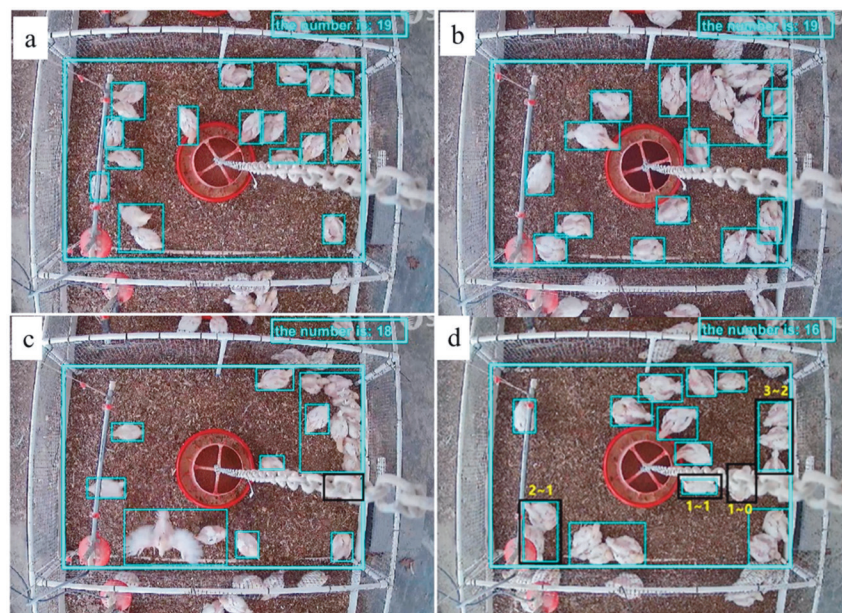
**Results:** The distribution of broiler chickens in feeding and drinking zones was identified automatically by the newly developed method (Figure 4). The method first analyzes the total number of chickens within the pen (Figure 3a) and then quantifies their distribution in each zone (Figure 3b). The computer programming method was tested with an accuracy of 94% for drinking and 95% for feeding (i.e., 95 out of 100 chickens in feeding zones were identified correctly with the method).

One of the issues with using any imaging technology is the visual angle—specifically anything from that angle that obstructs the camera’s view. Missed detections primarily were caused by facility interferences such as feeder-hanging chains and water lines that block the view of chickens in the image. These issues were solved



**Figure 3. Experimental setup for floor-distribution monitoring by zone in UGA research broiler houses.**

*Note.* Zones are labeled; 1 – drinking; 2 – feeding; and 3 – resting. From “A machine vision-based method for monitoring broiler chicken floor distribution,” by Y. Guo, L. Chai, S. E. Aggrey, A. Oladeinde, J. Johnson, and G. Zock, 2020a, *Sensors*, 20(11), 3179 (<https://doi.org/10.3390/s20113179>). Copyright 2020 by Guo et al.



**Figure 4. Broiler chicken distribution in feeding and drinking zones identified by a new UGA-developed computer vision method.**

*Source:* “A machine vision-based method for monitoring broiler chicken floor distribution,” by Y. Guo, L. Chai, S. E. Aggrey, A. Oladeinde, J. Johnson, and G. Zock, 2020a, *Sensors*, 20(11), 3179 (<https://doi.org/10.3390/s20113179>). Copyright 2020 by Guo et al.

partially by using a newly developed imaging-fixing technology (Figure 5). This image-analysis computer program was developed and tested to identify broiler chicken floor distribution in drinking and feeding zones.

We focused on the floor distribution pattern (i.e., counting real-time bird numbers in feeding and drinking zones) as it is technically quantifiable, and the information is correlated to bird well-being, as birds with underlying conditions such as lameness or high gait scores tend to have less activity and stay closer to feeders/drinkers because of restrictions in locomotion. The current methods provide the basis for developing an automated approach to monitor poultry floor distribution and behaviors in a commercial production system. Ongoing studies are focusing on detection of individual chickens with different gait scores in the research facility. It's challenging to track individual birds with early health or welfare concerns using a computer vision-based method, but it is necessary and critical for producers to identify birds with well-being concerns and address those issues quickly.

## Summary and Implications

Routine inspection of broiler chickens' well-being is done manually each day in commercial grow-out houses, which is both labor-intensive and time-consuming. Therefore, sensing technologies that can assist with well-being assessments, such as ultra-wideband radio frequency identification, accelerometers, and computer vision-based monitoring, are being tested for use in poultry farming systems. Two early versions of computer vision-based monitoring systems, eYeNamic and optical flow, were developed for poultry welfare monitoring and were tested in previous studies. Although these systems are not ready for commercial farm use to track individual animals with well-being concerns, they provide a blueprint for future poultry welfare evaluations to be conducted with computer or machine vision-based imaging systems.

An ongoing study led by UGA poultry science researchers is focusing on the correlation between chicken welfare indicators and floor distribution patterns (i.e., real-time counts of chickens in drinking, feeding, and resting zones) because proper distribution of chickens within the house can be an indication of a healthy flock. A computer program for image analyses was developed and tested. Around 7,000 chicken areas/profiles were extracted from 2,000 high-quality images (collected when birds were between 18–35 days old) to develop the method. Results showed that the identification accuracy of birds' distribution in the drinking and feeding zones was 94% and 95%, respectively. Most missing detections were caused by equipment interference (e.g., the feeder-hanging chain or water line). This study provides the basis for devising a real-time evaluation tool to detect broiler chicken floor distribution and behaviors in commercial facilities. However, there still are gaps in understanding animal behaviors. For example, determination has not been made of "good" or "bad" thresholds for the distribution of birds within the feeding, drinking, and resting zones. In addition, optimization of hardware and software is needed for producers to more easily implement and fully utilize a behavior-monitoring system as a component of an automated well-being monitoring system.



**Figure 5. Broiler images used to improve individual animal detection tested in UGA research broiler houses.**

Source: "A machine vision-based method optimized for restoring broiler chicken images occluded by feeding and drinking equipment," by Y. Guo, S. E. Aggrey, A. Oladeinde, J. Johnson, G. Zock, and L. Chai, 2021, *Animals*, 11(1), 123 (<https://doi.org/10.3390/ani11010123>). Copyright 2021 by Guo et al.

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