



Hen health status by machine vision on free-range farms

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by C. McCarthy

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Foreword

This project was conducted to develop a proof-of-concept machine vision system with image analysis for early detection of abnormal flock appearance and behaviour. Automated monitoring with machine vision system potentially enables frequent observation of a flock for disease detection without disturbance or handling of the flock, enhancing business efficiency and layer welfare. Automated cameras were set up at pop-holes and used for proof-of-concept of detecting and categorising prevalence of chickens exhibiting abnormal health conditions, for the purpose of generating alerts for the farmer about flock appearance and behaviour that potentially warrant follow up veterinary inspection.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to Australian Eggs Limited's range of peer reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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About the Author

Associate Professor Cheryl McCarthy is a researcher in Mechatronic Engineering at the Centre for Agricultural Engineering, University of Southern Queensland. Her area of research specialisation is advanced robotic sensing technologies to enhance autonomy in crop production, biosecurity and animal welfare on-farm, with aims for on-farm adoption in the commercial farm conditions of today. Cheryl was awarded AgriFutures Australia Researcher of the Year 2023 for innovative machine vision technology for the Australian Chicken Meat industry to monitor flock growth and welfare. In addition to poultry monitoring, recent research highlights are the commercialisation of machine vision-based weed spot spray technology to international manufacturer John Deere, and the development of automated monitoring technologies for plants in space with the Australian Space Agency.

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Executive Summary

Free-range farms are an increasing proportion of the Australian egg industry. Chickens are free to roam about large expanses of land, with positive outcomes for flock welfare, but increased risk of disease and injury as chickens interact in the outdoor environment. A proof-of-concept machine vision system has been developed to automatically monitor behaviour and appearance of chickens, at single chicken and flock level, for the purpose of providing early indication of flock health. Cameras were placed at free-range sites and recorded video of chickens entering and leaving pop-holes. An oblique view angle enabled monitoring of the motion of large groups of chickens in the range area, whilst also providing visibility of facial features for signs of health condition. Novel proof-of-concept machine vision algorithms were developed that performed feature recognition for facial analysis, as well as individual behaviour classification (e.g. walking and running) and a novel indicator for smothering risk. Developed algorithms could process real-time video frame rates using a computer with modest specifications, indicating potential for algorithm deployment to a remote camera with onboard computer, for the purpose of real-time monitoring and alert generation. It was concluded that numerous flock behaviours can be successfully monitored from a single video stream in a commercial environment. Further work (e.g. in a follow-on project) should perform extended trials and algorithm refinement, including trials for image analysis-based alert generation, and development of the technology in collaboration with a commercial partner.

Overall Conclusions

Novel proof-of-concept machine vision algorithms have been developed that were successful in detecting multiple chicken flock metrics indicative of health in commercial conditions. Camera apparatus positioned beside the shed was suitable for real-time analysis of numerous chicken and flock behaviours. The algorithms were based on traditional machine vision techniques.

Machine vision analysis of group head lifting, face detection and beak open or closed status was achieved. Automated face detection provided an avenue for further machine vision research, e.g. for more detailed disease studies, as automatically-extracted facial imagery had visual clarity comparable to veterinarian image resources for identifying clinical signs of disease. There have been previous reported studies for automated facial landmark recognition for other animal species (e.g. cats, sheep and horses), however not for imagery of chickens in commercial conditions.

Tracking of chicken movement enabled behaviours of walking, running, or other, to be directly calculated. Classification of additional behaviours would be expected with further analysis. A novel metric for smothering risk was developed which distinguished close groups of chickens from groups at potential risk of smothering.

Developed algorithms operated for real-time video frame rates by post-processing. Further research should perform extended trials in a greater range of conditions, including evaluation with a higher camera vantage point so the camera has visibility of a large proportion of the range area beside the shed. Further research should also examine the correlates between the detected behaviours, and adverse flock health events recorded by farms, to establish baseline relationships between detected behaviours and health outcomes. Additionally, further research should examine commercial considerations for farmer adoption of the technology. This would include evaluation of camera hardware with on-board real-time video analysis capability and alert generation.

1 Camera equipment

1.1 Diagrams/photos of assembled camera system

Colour video cameras were mounted in a cordless waterproof enclosure for automated video recording at two free-range sheds. The camera box contained a 5 V power bank and 6 V solar panel, as such the camera did not require mains power. A memory card (256 GB Micro SD, Sandisk, USA) placed in the camera enabled two weeks of video storage. The cameras were pre-programmed to capture video at regular time intervals during daylight hours.

Initially, both colour and thermal camera apparatus were assembled for video capture. However, review of collected imagery revealed that colour imagery was far superior to thermal imagery in terms of image quality (i.e. clarity), as well as number of pixels, ability to automate image measurements with algorithms, and cost-effectiveness.

1.2 Details of recommended placement

The camera placement used in this research project was next to a pop-hole, approximately one metre above the ground, to enable visibility of individual chicken behaviours, as well as overall flock movement. Following video collection and analysis in this project, a higher vantage point is recommended in further work which is expected to enable the same discrimination ability at the single chicken and flock level, whilst also enabling visibility further along the whole length of the shed.

2 Image data collection and initial image analysis results

2.1 Collection and collation of images from commercial farms

Video data was collected at farm sites throughout February to April 2023, using the pre-programmed recording schedule in the assembled camera apparatus. The recording schedule was 5 minutes on, 8 minutes off, from approximately 10 am to 6 pm each day. As such, collected imagery contained a range of lighting conditions and chicken behaviours.

2.2 Initial image analysis results

The desire to monitor behaviours at the single chicken and flock level necessitated development of algorithms with feature detection for single chickens. Image analysis steps were developed which accounted for variations in natural outdoor lighting conditions. Detection of chicken faces and analysis of whether the beak was open or closed was achieved, as well as detection of group head lifting events, where a group of chickens simultaneously raised their heads, for example in response to a perceived change in environment. It is expected that with further work (e.g. follow-on project), specific disease studies would establish baselines between chicken behaviour and health outcomes.

3 Image analysis refinement and classification results including veterinarian assessment

3.1 Further image analysis refinement and collection of images as necessary

Following analysis of single frames to detect chickens, motion analysis was implemented which enabled: classification of the behaviours of walking, running, and other; and analysis of flock motion which provided a unique metric to detect smothering risk. With further work (e.g. follow-on project), additional behaviour categories are expected to be achievable, as well as on-farm trials of smothering risk detection for real-time alerts.

3.2 Summary of veterinarian assessment and image analysis classification results

A desktop review of clinical facial signs of chicken disease was conducted, to ascertain the level of detail required for automated facial image collection and analysis. An image summary of facial appearances of chickens of various health conditions was curated from online sources including veterinarian reference manuals. Critical facial features indicating disease symptoms were identified as the eyes and beak, with additional clinical signs indicated by the wattles, comb and nose. Facial features potentially provide specific disease recognition capability, however other body features mainly relating to weight and activity also inform health assessment.

The PI consulted with veterinarians at the farm site during regular meetings while video data was being collected, and at other industry events (e.g. Australian Eggs research forum, 24 May 2023), to confirm the importance of machine vision monitoring of facial features and overall flock motion (e.g. for smothering).

4 Recommendations

4.1 Specifications for reproducing proof-of-concept machine vision system

A video camera (F7N Dashcam, Redtiger, China) was used for recording at the farm sites, with video resolution 3840×2160 pixels and frame rate of 30 fps (frames per second). The camera specifications are not specialised, so other camera makes and models are also expected to be compatible with the developed algorithms, e.g. security cameras, trail cameras or Raspberry Pi cameras. The developed algorithms operated at real-time frame rates on a laptop computer with modest processing specifications, for recorded video files resampled to a resolution of 1152×648 pixels. All code was implemented with the Python programming language and using OpenCV libraries.

4.2 Library of typical and abnormal layer hen behaviour in a downloadable and storable format

Video files recorded in the project are stored securely at UniSQ, including image classification results separating behaviours into healthy and potentially adverse conditions.

4.3 Recommendations for adoption pathway

A follow-on project is recommended to conduct extended trials for further image analysis refinement including trials for health alert generation.

Plain English Summary

Project Title:	Hen health status by machine vision on free-range farms
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Objectives	1. A proof-of-concept machine vision system developed which can identify abnormal layer hen appearance. 2. Machine vision system developed and tested in 2-3 different commercial free range layer flocks. 3. Library of typical and abnormal layer hen behaviour built and verified by Industry Veterinarian.
Background	There is growing usage of free-range production systems for layer hens due to consumer demand. Chickens are free to roam about large expanses of land, with positive outcomes for flock welfare, but increased risk of disease and injury as chickens interact in the outdoor environment. Machine vision has potential to perform automated monitoring of free-range layer flocks to provide indicators of flock health complementary to human inspections.
Research	Proof-of-concept machine vision algorithms were developed to monitor multiple behavioural attributes of free-range flocks at the single chicken and group level. The algorithms operated at real-time frame rates for video imagery recorded in commercial farm conditions. The detection capability enabled inspection of chicken movement and facial features and proposed a novel metric to identify groups of chickens at risk of smothering.
Outcomes	The developed algorithms have been evaluated to proof-of-concept stage using off-the-shelf cameras at a commercial site. Further trials (e.g. follow-on project) are recommended to demonstrate the potential for real-time alerts based on machine vision analysis.
Implications	The technology demonstrated success in automated flock monitoring and is expected to enable early detection of emerging flock health issues with reduced labour and disturbance to the flock. Further development would be required for wider scale deployment.
Key Words	Video camera, image analysis, behaviour, health
Publications	