Bringing artificial intelligence into the barn

Experimental set-up of the study boxes with individually coloured hens (Photograph by MSc José Antônio Delfino Barbosa Filho)

A pioneer research effort in Brazil is exploring an innovative method in the study of animal behaviour and welfare: the use of automated image analysis and interpretation systems. They have potential for evaluating differences in hen behaviour under different thermal stress conditions, offering a vast array of promising possibilities.

By Rogério G T da Cunha

How can we assess animal behaviour and stress under different conditions in a simple and fast way? Answering such a question is probably the dream of every producer (and even of any animal behaviour scientist for that matter), and one of the research focuses of NUPEA (Nucleus of Research on Ambience), a research group at ESALQ/USP (Superior School of Agriculture 'Luiz de Queiroz' at University of São Paulo, Brazil). The group is searching for alternative, efficient and cost-effective methods for assessing animal behaviour and welfare. The reasons are multiple. Through real-time monitoring, a producer can quickly detect changes in animal behaviour that may indicate problems, such as stress, and can thus take corrective measures as quickly as possible, with obvious implications for productivity.

Valéria Cristina Rodrigues, a researcher from the group, is exploring a new possibility: the use of an automated system of image processing and analysis. "Direct behavioural observation is time-consuming, demands specialised personnel both for data collection and also for its analysis, and the researcher's presence might interfere with the behaviour of the animals. The mere use of cameras solves only the interference problem. One would still need somebody with a strong scientific background to extract the relevant information from the images," Valéria explains. With her background as a physicist, she had the idea to explore the possibility of a system for automatic interpretation of the images, the so-called computational vision, which would solve both problems at once, speed up the process, and also had the potential to reduce subjectivity in the interpretation.

Seeing hens' thermal stress

So far, so good, but how can we teach a machine to analyse and correctly interpret images? That's the trick, and this is how a physicist comes into the story. Valéria explains that in her research the main idea was to apply techniques of computational vision to study the thermal stress of hens through the spatial distribution of the birds along time and their frequency at certain locations, such as drinkers. The reason for her choice is that animal thermal welfare is one of NUPEA's research flags, and the group has a large image database from a previous research project on the response of hens to different conditions (especially those related to thermal comfort) in terms of their behaviour, productivity, and so forth. In particular, she used the images from the MSc dissertation of José Antônio Delfino Barbosa Filho entitled 'Evaluation of the welfare of hens under different production systems and environmental conditions, using image analysis'.

Given the prevailing climactic conditions in Brazil, she concentrated on heat stress. Valéria explains the basic methodology: "I studied hens in 1m^2 boxes inside climactic chambers, which allowed me to simulate situations of thermal comfort (26°C, 60% humidity) and stress (35°C, 70% humidity)." According to Valéria, the project applies computational vision to images taken from the ceiling in terms of the spatial distribution of the hens along time, such as frequency at the drinkers, inactivity periods, motor activity levels, and so on. She dyes the back of the animals with different colours using non-toxic inks, something that allows the computer to follow each one's movements individually. Such methodology allows two approaches of study. In the group study, she follows the tendency of the whole group, in order to detect overall movement patterns, something that might have applicability in large commercial aviaries (see below). However, she is also able to follow the movements of individual birds, something that gives statistical reliability for the group study, through repeated confirmation of results.

Valéria describes the preliminary results: "Under heat stress, the behaviour of the birds change through time. In comfort situations, there are not many patterns, apart from a general randomness in the movements. At the beginning of a stress period, the hens show greater excitement, moving the wings to dissipate heat, go to the drinkers more often, search for cooler locations, and tend to disperse. With the progress of the heat stress, there is a decrease in motor activity levels, and most of these aspects can be identified automatically by the programme. But we expect even more information of this kind to pop up with the advance of the research."

Valéria studied many factors that might interfere with correct interpretation, proposing some recommendations with respect to the time interval to record the images, type of video equipment for recording and lamps in the environment, type of bedding to allow the best image contrast possible, and the ink used to colour and differentiate the animals, among others.

Artificial neural networks

This area of research offers still more promising surprises: artificial probabilistic neural networks. Valéria explains the technology: "With the advent of artificial neural networks, it became possible to 'teach' computers to perform tasks which involve interpretation of patterns, not the mere automated repetition of pre-defined routines. Although their computational and mathematical details are quite complex, their rough concept is fairly straightforward. It is pretty much like our

own neural networks in the brain. They recognise and differentiate patterns like sounds, images or signals. With time, and guided by the researcher, the network 'learns' through its own mistakes and correct judgements until it achieves a desired discernment level."

She adds that the approach she is following focuses on the interpretation of patterns of body shapes or postures related to certain behaviours, something that complements, expands and refines the movement analysis: "The importance here lies in the fact that the birds might be at certain places, but not performing the expected behaviour. For example, they might be at the feeders or drinkers, but doing other things apart from feeding or drinking. With interpretation of the body postures, we might know not only the location of the animal, but also its exact behaviour there."

She states that a Belgian group was able to automatically recognise with good confidence many different behaviours of individual birds based on the body shapes, but using another technique of robust programming, not neural networks. She explains the particularities of her own research: "Based on face recognition algorithms, we are investigating if the neural networks can detect with good accuracy some body shape patterns, such as the ones related to drinking, eating, sitting down, sand bathing, among others, of all the birds in a given image, after it has been processed for the spatial patterns. The study is still under way, and there are many problems yet to be solved, but some behaviours can be detected with high confidence, which can be a powerful tool to develop in the future an automated system for analysis of body postures of animals in general." Literally speaking, this amounts to automatically interpreting a species' body language without the need for a human brain.

However, Valéria says that a preliminary conventional behavioural study is needed: "The study will provide the link between the patterns that the computers are able to identify automatically, such as body postures or distribution of animals in space along time, with the information we want to extract from them, such as the behaviour actually being performed or the environmental condition. Only then, the computer can translate the pattern it interprets into useful information for the user."

Looking to the future

Valeria's initial intent was to show the potential of the methodology and to introduce to researchers a new a way to investigate patterns of behaviour and spatial distribution of birds (or any other animal for that matter) in a given environment. Stressing the importance of converting the theory from the well-known techniques of computational vision and neural networks into the practice of an automated system of image interpretation, and exploring how far we can go in its use, Valeria says they are also thinking far ahead. "Nupea and I intend to expand this methodology towards real-time monitoring in commercial aviaries, allowing quick detection of problems and decision-taking in critical periods of the year, when the environment does not offer adequate comfort to the animals, decreasing productivity. The information generated with the automated analysis could even input into software for automatic control of fans, exhausters or heaters or to help in the detection of problems in specific areas of the barn/aviary, and thus on its maintenance. In some situations, for example, the birds tend to concentrate in more comfortable regions and avoid some areas, which could be an indication of problems there, such as lack of proper ventilation, deficient water distribution, and the like."

The possibilities are endless. Right now the concept may sound like sci-fi, but the idea is highly promising. We may be witnessing the advent of a new cornerstone in industrial poultry production, bringing cutting-edge technology to the barn and taking production to another age. ■