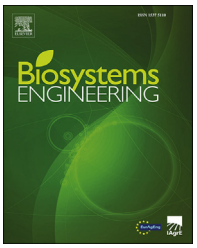
BIOSYSTEMS ENGINEERING XXX (2018) 1–10

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/issn/15375110



Special Issue: Engineering Advances in PLF

Research Paper

Predicting broiler gait scores from activity monitoring and flock data

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ARTICLE INFO

Article history:
Published online xxx

Kewyords:
Broilers
Computer vision
Flock activity
Flock distribution
Gait scoring
Linear regression model

Leg deformities and lameness are a major welfare concern in the European poultry industry. This study was focused on the development of a prediction model for gait score in broilers, based on automated measures for flock distribution, bird activity levels and body mass. Data were gathered in five different farms in Europe. Broiler gait was assessed on a discrete [0–5]-scale by trained local human experts. Bird activity was continuously monitored with a camera-based system that automatically calculated the activity and distribution of the birds in the flock from the recorded images. Data analysis showed a linear trend between activity level of the flock on the day of the assessment (ACT) and the average gait score of the flock (GS): $GS = -0.21*ACT + 2.85$ ($R^2 = 0.55$). Gait score and flock activity were negatively correlated ($r = -0.741$), whereas gait score and flock distribution was positively correlated ($r = 0.705$). Due to differences in management and broiler breeds, the absolute values in activity level and gait score vary between farms. The linear trend is however clear in all farms ($R^2 = [0.53–0.74]$). Flock gait score could be predicted from continuous farm data by means of a linear regression model with a root mean squared error (RMSE) = 0.181 ± 0.003. This study shows that a camera-based monitoring tool for flock behaviour analysis has potential to warn the poultry farmer of possible gait problems in commercial farm settings.

1. Introduction

The interest in animal welfare is growing in Europe and in the rest of the world (Turner, Garcés, & Smith, 2005). Intensive livestock production is under constant development to improve the animal rearing conditions towards more welfare friendly systems. Some organisations and retailers in the Netherlands have developed their own welfare standards or concepts (Dierenbescherming Nederland, 2017; Mulder, Zomer, Benning, & Leenheer, 2014). An EU-funded research project developed a manual animal welfare scoring protocol, and gait scoring was one of the welfare criteria (Blokhuis, Veissier, Miele, & Jones, 2010; Botreau, Veissier, & Pern, 2009). Trained experts make on-farm observations of all criteria, and based on these observations and scores, the

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https://doi.org/10.1016/j.biosystemseng.2018.07.002

Please cite this article in press as: Van Hertem, T., et al., Predicting broiler gait scores from activity monitoring and flock data, *Biosystems Engineering* (2018), https://doi.org/10.1016/j.biosystemseng.2018.07.002

welfare level of the animals can be assessed. These traditional methods of scoring animal-based information by human experts remain however difficult, subjective, time-consuming and expensive when implemented in commercial farms (De Vries et al., 2013). On top of that, the visit of a human assessor in a broiler house poses an infection risk to the farm.

Rather than constructing lists of various welfare indicators and giving each of them the same weight, the UK Farm Animal Welfare Council suggested to look for "iceberg indicators" in animal behaviour (FAWC, 1979). In that scope, Dawkins (2004) argues to use animal behaviour monitoring for on-farm assessment of animal welfare. Studies have shown the potential welfare benefits when monitoring broiler activity level on the farm: a decrease or increase in the level of activity in the flock may indicate an emerging disease (Colles et al., 2016); or a change in behaviour towards aggression due to lack of feed or water (De Montis, Pinna, Barra, & Vranken, 2013; Kashiha, Bahr, Vranken, Hong, & Berckmans, 2014).

The increasing availability of low cost sensor technology makes automated monitoring of animal welfare feasible (Rushen, Chapinal, & De Passillé, 2012). Camera technology is one such low cost sensor technology. 2D camera technology has been used in other species for gait analysis (Nasirahmadi, Edwards, & Sturm, 2017). Lameness detection in dairy cows is a hot topic in research (Pluk et al., 2012; Van Hertem et al., 2014; Viazzi et al., 2013). Also the problem of lameness in sows is being tackled (Stavrakakis, Guy, Warlow, Johnson, & Edwards, 2014). For horses there are technologies based on camera images that work for lameness detection (Colborne, Lanovaz, Sprigings, Schamhardt, & Clayton, 1998; Linford, 1994). This research is focused on the gait analysis of the individual animal, whereas for broilers most camera-based technologies are focused on flock behaviour. Cameras offer the possibility to monitor a big part of a flock in a non-invasive manner. A previous small-scale study under laboratory conditions has shown the potential of an automatic camera monitoring system for bird activity as an automatic tool for gait scoring in broilers (Aydin, Cangar, Ozcan, Bahr, & Berckmans, 2010). The chickens were grouped by gait score level. Broilers with Gait Score 4 and 5 had significantly lower activity levels. Broilers with Gait Score 3 showed significantly higher activity levels than the other gait score groups, possibly due to their higher need for feed. Severely lame broilers showed a reduced activity level. In a more recent study, Aydin (2017) found a strong correlation ($r > 0.8$) between feature variables measured by computer vision technology and gait scores ≥ 3. The experimental setup was however fixed and required chickens to walk through a specific measurement corridor.

In commercial farms however, lame and non-lame are mixed together in the flock. A previous study showed the potential of optical flow analysis as a substitute for gait scoring in commercial farms (Dawkins, Lee, Waitt, & Roberts, 2009). Their research was limited to flock behaviour analysis between the age of 32 and 35 days. They also mentioned four benefits of automated gait scoring: continuous measurements throughout the lifecycle of the flock, fully automated technology, completely non-invasive and non-intrusive, and no biosecurity risk of human assessors visiting different farms (Dawkins et al., 2009).

Our literature study has shown the relevance of leg disorders in broiler production and the steps that have been taken in research to find automated detection tools for this problem. To our knowledge, there is however not a single commercial system on the market that is able to warn the poultry farmer for potential leg disorders in his flock. In our belief, leg disorders will affect flock behaviours, and the best way to identify varying flock behaviour is to monitor animal behaviour from above with a 2D computer vision system.

The aim of this study was to evaluate the possibility of using automated measures of flock distribution, bird activity levels and body mass for the assessment of gait during the rearing period of the flock. In this study, key variables will be identified that are strongly related with broiler flock gait score levels.

2. Material and methods

2.1. Animals and housing

Data were collected from five commercial broiler farms spread across Europe (Netherlands, UK, Spain, and Italy) as part of the EU-PLF project. The characteristics of each farm and the number of assessed flocks in each farm are presented in Table 1.

2.2. List of variables

In order to give the reader an overview of the abbreviations in this manuscript, all used abbreviations are listed in Table 2.

2.3. Welfare assessments

Because the farms were spread over four different countries, four different trained local human assessors made the Welfare Quality assessments. All trained observers received the same training protocol in order to eliminate inter-observer variability in the assessment data. Litter quality (LQ) was evaluated to define the housing conditions. It was manually assessed and scored as good (completely dry and flaky,

Table 1 – Farm characteristics in this study.

Farm	Country	House area	Max number of birds	Number of flocks assessed	Number of welfare assessments
A	Netherlands	1298	28,000	9	31
B	United Kingdom	2530	45,000	9	30
C	Spain	2260	42,000	4	10
D	United Kingdom	2200	51,750	9	31
E	Italy	1560	30,000	6	18

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