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Research Paper

Paraconsistent logic used for estimating the gait score of broiler chickens

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Visually estimating the gait score in a flock is not a precise task. The evaluation is done based on scores from 0 (sound bird) to 5 (lame bird). The extremes are easily identifiable; however, the intermediate scores are not evident. This study aimed to develop an algorithm and software to estimate broiler gait score. Video images were recorded from broilers walking on a special platform. The walkway was covered with bedding substrate. A blue panel provided a background to contrast with the birds. Selected broilers from the different gait scores were placed to walk on the runway, and a video was recorded. An algorithm was developed to analyse the video streams. The centroid of the chicken body was detected, through which the broiler's speed, and acceleration from gait score were calculated. The velocity and acceleration data were analysed using paraconsistent logic, and an algorithm was developed. The software was able to predict the intermediate values of broiler gait score with a low degree of uncertainty, given the broiler velocity and acceleration. For the estimation of GS 1, we obtained 50% accuracy. For GS 2 the estimation was 70% precise, and for GS 3, the results were 100% accurate. During the auditing of the flock welfare process, the intermediate results of broiler gait score are visually difficult to identify. Using the developed software it might be possible to detect lameness in broilers under commercial rearing since the velocity of displacement can be easily measured and used as input data by the growers.

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1. Introduction

The broiler chicken is the most highly genetically selected livestock as it has a short production cycle. Nowadays, broiler meat is the most popular healthy meat worldwide. The development of broilers has been primarily directed at economic traits which have reduced the costs of production (Emmans and Kyriazakis, 2000; Paxton, Daley, Corr, & Hutchinson, 2013). The body changes have included a significantly larger pectoral muscle mass (Corr, Gentle, McCorquodale, & Bennett, 2003; Schmidt, Persia, Feierstein, Kingham, & Saylor, 2009). Some associations have been studied relating the consequent skeletal abnormalities to these anatomical changes (Vestergaard & Sanotra, 1999; Kestin, Gordon, Su, & Sørensen, 2001; Alves et al., 2016), suggesting that their bodies did not evolve coherently with these traits, and perhaps predisposing them to lameness.

Broilers are reared worldwide using very similar and intensive systems of production, where birds are confined within a high flock-density housing during the growth (Knowles et al., 2008) and reared from hatch to slaughter within approximately 40 days. This advancement in meat production, at low cost, has led to reduced welfare (Bessei, 2006) with diminished walking ability. Broiler locomotion has been previously studied to find a proper and precise way of predicting any abnormality of their gait (Corr, McCorquodale, & Gentle, 1998; Bokkers & Koene, 2004; Dawkins, Lee, Waitt, & Roberts, 2009; Nääs et al., 2010). In the developed scale (Kestin, Knowles, Tinch, & Gregory, 1992) from 0 (sound bird) to 5 (lame bird), there are intermediate points in which even a trained observer might find it difficult to identify the appropriate gait score (GS).

Non-invasive methods have been developed to automatically assess the gait of several species including dairy cows (Song et al., 2008; Poursaberi, Bahr, Pluk, Van Nuffel, & Berckmans, 2010), and broilers (Aydin, 2017a; Dawkins, Cain, Merelie, & Roberts, 2013). Such models were able to predict lameness (Song et al., 2008), and to estimate animal traits and behaviour using pattern recognition techniques (Kashiha et al., 2013; Aydin, 2017). The use of the known models for estimating gait score in broilers face an issue as the extreme limits of GS are easily visually detectable while some difficulty arises to identify the intermediate scores.

The paraconsistent logic works with propositions p (μ, λ), where p is a proposition, and μ and λ indicate the degree of favourable and contrary evidence, respectively. The pair (μ, λ) is called the annotated constant, and the values of μ and λ are limited between 0 and 1 (Da Costa, Murolo, Leite, & Abe, 1999; Da Silva Filho et al., 2009). Input data processing is done by the application of connective equations defined by the degree of certainty and the level of uncertainty pA ($\mu 1$, $\lambda 1$) and pB ($\mu 2$, $\lambda 2$), respectively. Initially, the highest value of certainty is found ($\mu 1$ or $\mu 2$), proportional to (μR), followed by the minimisation of the degree of uncertainty ($\lambda 1$ or $\lambda 2$) proportional to (λR) (Da Costa et al., 1999; Da Silva Filho et al., 2009). The paraconsistent logic is applied to solve problems that present a high degree of uncertainty (Martins, 2003; Da Silva Filho et al., 2009; Da Silva Filho et al., 2016).

The gait score often found on commercial farms is in the in-between region, i.e. scores from 1 to 4, leading to a high level of uncertainty, as sound and lame birds are easily detected. The present study aimed to develop a paraconsistent algorithm to be used as the basis for software to predict the broiler gait score, given the recorded displacement velocity and acceleration of the bird.

2. Materials and methods

A total of 300 1-day old chicks (genetic strain Cobb®500) were reared in an experimental house at a flock density of 11 birds m^{-2}. Broilers were fed isonutrient feed ration and water *ad libitum*, as recommended for the genetic strain. When the broilers were 40 days old, 50 birds were randomly selected, and were each evaluated for gait using the six scores method. The scoring system is defined as follows: 0 = the gait is smooth, the foot curls when lifted, and the bird appears well-balanced; 1 = the gait is uneven, the foot may or may not bend when lifted; 2 = the gait is uneven, the foot remains flat when lifted, the bird's stride is shortened, and the bird may have poor balance and use the wings for support; 3 = similar to 2 but remains lying down unless gently nudged to move, and typically lies down after a series of steps; 4 = birds are reluctant to move and use wings like crutches to walk, the bird can only take a few steps before lying back down; 5 = is not able to take one step, and will shuffle if pushed to move (Kestin et al., 1992). Birds with a gait score of 4–5 were considered severely lame and were humanely culled. The field experiment took place at the Federal University of Grande Dourados, Brazil and the trial was approved by the Animal Ethics Committee (Protocol n. 030/2013).

2.1. Video recording

A video recording was made after visually assessing the GS of 25 birds. From the total of 25 scored birds, 18 males were carefully selected to represent the whole range of scores. The objective was to study birds which provide a clear description of the defined scores. The videos were taken in a specially built platform 1 m long and 0.30 m wide, with a flat surface covered with 8 cm of bedding substrate (rice hulls), the same material the broilers had in the rearing house of the background for the video recording was a blue wall, placed to provide proper contrast with the birds. The platform was closed with a transparent acrylic wall 50 cm high (Fig. 1a). The birds were stimulated to walk on the runway (Fig. 1b), and the video was recorded in AVI format with speed of 60 frames s^{-1} (FPS) using a video camera (Sony Handycam Memory Flash PJ200, Sony Corporation, Tokyo, Japan) equipped with special lenses (Lens Carl Zeiss® Vario-Tessar® Carl Zeiss, Oberkochen Germany). The video camera was fixed on a tripod at 1 m distance from the platform directly facing the runway.

The video signals of the broiler chicken movement (Fig. 2 a) were converted to image sequences and saved as a Jpeg files on the PC. The size of each captured image was 1080 × 1920 pixels. The centroid of the chicken body was detected using the 'regionprops' function in Matlab. The centroid detection process began with the selection of a region of interest (ROI)

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