122. Automated individual walking distance of group-housed broilers: a comparison between ground-truth, RFID, and video

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Abstract

Individual broiler behaviour could serve as a proxy for an individual's health, welfare and performance. However, large-scale individual behaviour recording is difficult. Wearable and remote sensors have both been investigated to record individual broiler behaviour. In this study, we validated the use of automated tracking using video or radio frequency identification (RFID) by comparing the total estimated walking distance to ground-truth annotated from video. By using colour-marked birds we simplified the computer vision task of YOLOv5. The estimated walking distances by video pixel-based closely matched ground-truth pixel-based (≤2 cm difference). Overall, the RFID-system also closely matched ground-truth pixel-based, except for one movement event (75 cm underestimation). Over the entire duration of the trial, RFID and video gave similar animal rankings, but RFID seems more error prone due to missing reads. RFID is suitable to track broilers over time, but video could be more accurate and practical for on-farm application.

Introduction

There is a growing interest in the individual behaviour of broilers (Van der Sluis *et al.*, 2019), as behaviour could serve as a proxy for the individual's health (Hart, 1988), welfare (Van Hertem *et al.*, 2018), and performance (Reiter and Bessei, 2001). However, broilers are often kept in large groups (i.e. thousands of birds), which makes recording individual broiler behaviour difficult, but breeding programs require automated large-scale individual behaviour records.

Several sensors have been investigated to record individual broiler behaviour. Wearable sensors, such as ultra-wideband tracking (UWB; Van der Sluis *et al.*, 2019), radio frequency identification (RFID; Van der Sluis *et al.*, 2020), and accelerometers (Yang *et al.*, 2021) can record individual broiler behaviour. However, these wearable sensors are impractical and expensive, as these sensors either need batteries (UWB, accelerometer) or an extensive network of antennas (RFID). Alternatively, a remote sensor, such as a video camera, could be used. A video camera can observe multiple animals in a group, but it is challenging to automatically identify individual birds. Hence these cameras have been mainly used for flock level observations (Dawkins *et al.*, 2021; Li *et al.*, 2020; Van Hertem *et al.*, 2018). Nevertheless, individual broiler behaviour could be recorded with video cameras with the use of external markers such as colour-marks or RFID.

The aim of this study was to validate the use of automated tracking using video or RFID by comparing the total estimated walking distance to the ground-truth walking distance acquired from manual annotation on the video data. Furthermore, video and RFID were compared over the entire duration of the trial to assess tracking performance over a longer duration. By using colour-marked birds we simplified the computer vision task.

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Materials & methods

Animals and housing. The data used in this study were collected in the research of Van der Sluis *et al.* (2020) in collaboration with Cobb Europe. Van der Sluis *et al.* (2020) followed broilers from hatch until 34 days of age. Forty male broilers from two genetic crosses were housed in one pen (1.8×.6 m). At hatch, all birds were fitted with a RFID-tag. Four birds, two from each cross, were marked in four different colours. From 15 days of age, 34 out of 40 birds were equipped with an UWB-tag, because the number of available UWB-tags was limited. In the present study, only data at 18 days of age were used. The birds were kept under standard lighting conditions. Feed and water were provided *ad libitum* (Van der Sluis *et al.*, 2020).

Radio frequency identification system. A passive RFID-system from Dorset Identification (Dorset Identification B.V., Aalten, the Netherlands) was used to track individual broilers. Each broiler was fitted with a high-frequency RFID-tag (13.56 MHz, 15×3.7 mm, <1.0 gram) around its leg. In total, 30 sub-floor high-frequency RFID-antennas (32×41 cm each) covered the entire surface area of the pen. The RFID-system continuously recorded time, RFID-tag, and the antenna that registered the tag (Van der Sluis *et al.*, 2020).

Video. An RGB-camera placed above the pen recorded the birds from 10:44 AM until 12:59 PM at 18 days of age. The two-hour period was recorded in multiple videos of approximately 7 minutes. The video recordings were made with a Zavio B6210 2MP camera (Zavio Inc., Hsinchu City, Taiwan) at 25 frames per second in full-HD.

Frame extraction and annotation. Five-hundred frames were randomly selected from all extracted frames for annotation. The selected frames were randomly divided between two annotators (Annotator A and B). The Computer Vision Annotation Tool (CVAT) (Sekachev *et al.*, 2019) was used for annotation. Three out of the four colour-marked birds were annotated, since the colour of one bird was inconsistent over days. The birds were labelled by bounding boxes, each bird having its own colour-based class (black, lightblue, pink). Inter- and intra-annotator reliability were calculated based on 25 randomly selected frames from the 500 frames, which were annotated twice by both annotators. Reliability was assessed with the intersection over union (IoU), calculated by dividing the area of overlap with the area of the union of the respective bounding boxes. Expressed in median IoU, the inter-annotator reliability was 0.92 (interquartile range [IQR] = 0.08), and the intra-annotator reliability was 0.95 (IQR=0.04) and 0.95 (IQR=0.07) for Annotator A and B, respectively.

Ground-truth. Five one-minute-long snippets were randomly sampled from 5 different seven-minute-long videos at 3 randomly sampled frames per second. The frames were randomly sampled to increase frame differences. From the five one-minute-long snippets, three movement events (5 to 10 seconds), one for each annotated bird, were annotated with bounding boxes for ground-truth.

You Only Look Once (YOLO). YOLOv5 was used to automatically detect the colour-marked birds in the videos (Jocher *et al.*, 2021). A pre-trained YOLOv5s model was trained on 350 randomly selected frames and tested on the remaining 150 frames, with mostly default hyperparameters, except for batch size (lowered to 6). Model performance, reported as mean average precision (mAP@[.5:.95]; value between 0 and 1 in which 1 is perfect), was 0.798 on the train set and 0.812 on test set.

Distance calculations. Animal walking distance was calculated for RFID, video, and ground-truth. The distance moved by the animal was based on the Euclidean distance between the centre points of the recorded antennas in the grid (RFID; Van der Sluis *et al.*, 2020), the centre points coordinates of the detected bounding boxes of YOLOv5s (video) or the centre points coordinates of the annotated bounding boxes (ground-truth). The Euclidean distance was calibrated using one side of the pen. The animal was assumed to have remained at the last recorded RFID-antenna if no new read was received. The centre point coordinates of the detected and annotated bounding boxes were also translated to RFID-antennas and distances were calculated with the same method as described for the RFID-system (i.e. as RFID).

Results

Walking distance validation. In all movement events, the walking distance recorded by ground-truth pixel-based and video pixel-based agreed within 2 cm (Table 1). Overall, the RFID-system approximated the ground-truth pixel-based and video pixel-based, except for the black-marked broiler where it underestimated the movement with 75 cm. Ground-truth as RFID and video as RFID agreed, RFID reported an antenna switch for the pink-marked broiler and missed switches for the black-marked broiler.

Total walking distance. Overall, the recorded total walking distance substantially differed between RFID and video (Table 2). Compared to video, the RFID-system underreported the total walking distance of the animals. However, both RFID and video gave similar animal rankings, although not when the total walking distance on video was calculated as RFID.

Discussion

The aim of this study was to validate the automated tracking of broilers using video or RFID by comparing the total walking distance to ground-truth from video. Furthermore, video and RFID were compared to assess tracking performance over the entire duration of the trial. This study was the first time we were able to track broilers over time on video with computer vision, and in a setting that allowed us to visually confirm the location of individual broilers

Overall, the estimated walking distances by RFID and video pixel-based closely matched ground-truth pixel-based. However, for the black-marked broiler, RFID deviated with 75 cm compared to ground-truth pixel-based. The RFID-system seems to underestimate the total walking distance of the birds compared to video (Table 2). The RFID-system does not register movement within an antenna and can only register switches between antennas. However, not all antenna switches were registered, something that could be related to the hardware, the software or both. Similar observations were made in Van der Sluis *et al.* (2020).

Table 1. Walking distance (m) per movement event per broiler as recorded by ground-truth, RFID and video.

	Ground-truth		RFID	Video	
Broiler	as RFID	Pixel-based		as RFID	Pixel-based
Black	0.83	1.11	0.36	0.83	1.13
Light blue	0.36	0.34	0.36	0.36	0.35
Pink	0.0	0.48	0.45	0.0	0.48

Table 2. Total walking distance (m) per broiler as recorded by RFID and video.

	RFID	Video	
Broiler		as RFID	Pixel-based
Black	24.10	74.99	59.22
Light blue	24.79	63.68	68.68
Pink	27.85	94.42	80.58

Video pixel-based had a close-match with ground-truth pixel-based (≤2 cm difference, Table 1). Video could potentially overestimate the total walking distance over longer periods of time due to cumulative detection noise, but it could also be due to posture changes while lying and pecking behaviour (Table 2). This potential overestimation could be solved with a minimum movement threshold.

In conclusion, the estimated walking distances by video pixel-based closely matched ground-truth pixel-based (≤2 cm difference). Overall, the RFID-system also closely matched ground-truth pixel-based, except for one movement event (75 cm underestimation). Over the entire duration of the trial, both RFID and video gave similar animal rankings, but RFID seems more error prone due to missing reads. Nevertheless, RFID is suitable to track broilers over time, but video could be more accurate and practical for on-farm application. The study improved the understanding of both sensor systems and can help to develop a system for automated large-scale individual broiler behaviour recording.

Ethical statement

Data were collected under control of Cobb Europe. Cobb Europe complies with Dutch legislation on animal welfare. The Animal Welfare Body of Wageningen Research confirmed that this study was not an animal experiment under the Law on Animal Experiments.

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