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Evaluating novel methods to evaluate poultry housing, welfare and compliance of functional areas using modern, smart farming technology

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Key words
laying hen, rabbit, PLF, observation, animal welfare

Aim of the study
The project objective was to evaluate direct observations (DO) and video recordings (VR) against automated methods used in our group (Active low frequency tracking (ALF) system and Optic Flow (OF)). Each method was intended to be evaluated objectively (i.e., installation, removal, analysis) as well as the benefits with respect to animal welfare relevant questions in conditions deemed essential by the FSVO allowing integration of smart-farming technology

Material and methods
The project consisted of three parts: 1) Validation and 2) Application (investigation of bird movements with the ALF system) and 3) assessment of movement using OF.
Validation: The first step was to validate the ALF system under different barn settings. The investigation included qualitative (e.g. the feasibility of installating the system itself) and quantitative analysis of movement behavior. The ALF system was installed in a horizontally oriented barn set-up with broiler breeders (two housing systems) and in a semi-commercial laying hen system with stacked-tier aviaries (one housing system).
For the broiler breeders, 10 pens (4.3 m x 2.3 m) with 33 females and three males (Ross 308) each were set-up with four resource-related areas used as zones for the tracking system. In five pens the slatted area and nest boxes were raised (RAISED), while the remainder had nest boxes on the floor with a small ramp leading to the entrance (FLOOR). Within each pen, 10 female birds were selected as focal birds and equipped with a tracking device within a backpack labeled with unique color combinations for visual identification. Six pens (4.5 m x 7 m x 2.3 m) containing 225 laying hens (Dekalb White) per pen housed in an aviary (AVIARY) were set-up with five resource-related areas as tracking zones. Focal birds (18 per pen) were selected and equipped with the same tracking device and backpacks.
In both systems, wide-angled video cameras were installed in each pen. Each transition between zones logged by the tracking system was then verified on the video recordings. The video observations were conducted by two or three different observers for the horizontal and vertical set-up, respectively. To reduce false registrations while keeping true registrations, three different filtering methods were applied to the data sets. Additionally, direct observations were conducted by two persons per pen to estimate the time lapse between actual and ALF-logged transitions.
Application: All focal hens underwent health assessments at five time points which was then evaluated against movement data though analysis is continuing. To investigate underlying mechanisms for consistency in movement, fearfulness and exploration of 108 focal birds were tested in a novel object test. The birds were continously tracked for three weeks prior to the test, after which the test was conducted three times with different objects placed at night to minimize human impact and the object was accessible for the following day. In reference to the litter, the number of transitions, total duration within, and latency to visit the first time were extracted

for each novel object test and subsequent day (post-test day). As a baseline, the described variables were extracted for 3 weeks before the first test day and the average over all days was calculated per individual.
Optical Flow: For the broiler breeder and laying hens, videos recorded the day before, during and after vaccinations were intended for the OF algorithm as well as selected portions from a parallel project investigating rabbit housing. Unfortunately, our OF collaborators exited the project following numerous technical issues within their unit that could not be resolved (e.g., non-functioning operating systems, high staff turnover, etc.). Nonetheless, the change in resource-related zone usage was analysed by video observations based on the backpack identification of focal birds.
From the recordings, observable time in the nestbox, feeding, and drinking was quantified for all focal hens during daylight hours (15 hours/day) the day before, during and after vaccinations.

Results and significance
Validation: Duration spent per zone was reliable and stable across all three housing systems and all three cleaning methods. The values of the duration parameter producing stable results in total transitions were also reliable (based on Lin's Concordance Correlation Coefficient > 0.8) for AVIARY (Filtering CCC ≥ 0.847, Binning: CCC ≥ 0.839, Sliding Bin: CCC ≥ 0.840) and RAISED (Filtering: CCC = 0.825, Binning: CCC = 0.835) but not for FLOOR (Binning: CCC = 0.355). The initial performance of locations (duration of stay) was above the required minimum of 0.9 in all three housing systems and remained high in the post-cleaning performance. However, the initial performance of total transitions measured as Lin's CCC [95% confidence interval] was below the required 0.8 in all three housing systems (Aviary: 0.264 [0.143, 0.377]; Raised: 0.023 [-0.190, 0.234]; Floor: 0.064 [-0.229, 0.346]). The post-cleaning performance of total transitions exceeded the minimum of 0.8 for AVIARY and RAISED but not for FLOOR (Figure 1a). Moreover, the duration of stay after a transition was affected by the housing system ($p < 0.001$; $X2 = 18.176$; $df = 2$), as well as by true vs. false transitions (Figure 1b; $p < 0.001$; $X2 = 1231.9$; $df = 1$).

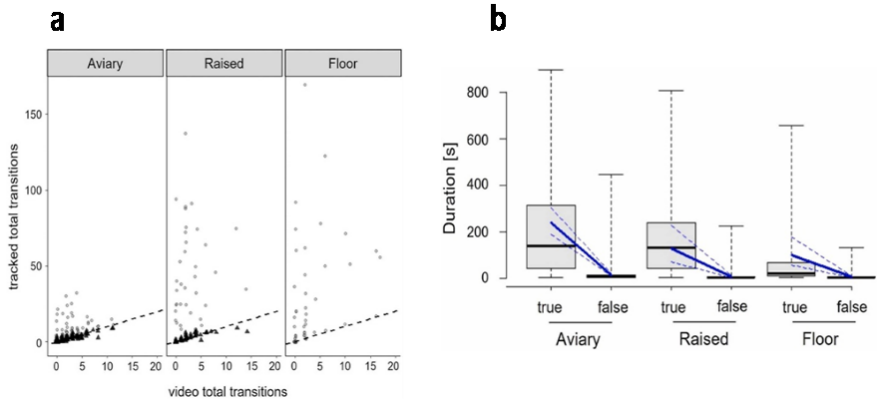

Figure 1 a. The number of transitions for the tracking System (y-axis) and for the video observations (x-axis). The initial performance is shown in light grey circles and the post-cleaning performance in dark grey triangles. The dashed black line represents a perfect match (CCC = 1) between the tracking system and the video observations. *Figure 1b. The duration of stay before moving on to a next zone after a true or false transition.* The boxplots represent the raw data with the blue lines showing the model estimates (solid line) and the 95%-confidence intervals (dashed lines).

Based on the results, after processing and cleaning, the tracking data was reliable and stable for vertically complex systems (e.g. as in layers) but also in horizontal set-ups with an elevated slatted zone (e.g. as in broiler breeders). These two systems were less prone to wrong transitions of similar duration than true transitions. Without an elevated slatted area the birds' moving speed made cleaning impossible.
Application: The presence of a novel object did not affect the number of transitions into the litter ($p > 0.05$) but led to a reduced estimated latency of 30.29 min compared to the baseline (61.91 min) and the post-test day (39.37 min) ($p < 0.001$). Furthermore, the estimated duration in the litter was highest on the test day (6.52 h) followed by the post-test day (5.98 h) and baseline (5.86 h) ($p < 0.001$). Our results indicate that focal hens adjusted their movement in favor of the litter area, potentially due to the presence of novel objects findings not possible with VR only.
Qualitative assessment of different methods: The qualitative assessment regarding advantages and disadvantages per method is given in table 1. For OF no qualitative assessment was possible.

Table 1. Qualitative assessment of novel tracking systems with respect to the gold standard of video observations.

	advantages	disadvantages
Direct observations	+ no expensive equipment needed + no time-consuming installations of devices + no technical skills needed	- time consuming - only two birds trackable per person - slow in generating enough data
Video observations	+ gold standard + retrospective analysis possible + repeatable	- Time consuming for recording behavior - Difficult to track birds in large flocks - Human error prone

UWB system	+ automatic continuous tracking + individual data of many birds in large flocks + data directly available for data processing	- Sorough, time consuming validation required for every new installation - regular checks of the system and fit of backpacks worn by hens - requires data processing and cleaning skills

Conclusion

Our results show the feasibility in applying continuous tracking on a large flock scale in birds. Furthermore, it provides many opportunities to identify health and welfare problems based on movement patterns established early in a hen's life. Moreover, tracking individual birds continuously over a long time allows the exploration of inter- and intra-individual variations in regard to housing systems at the group- and individual-level.

Publications, posters and presentations

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