Identifying and tracking group housed hens using ArUco marker backpacks

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Introduction

The demand for improving animal welfare in livestock production has increased the need for novel approaches to monitor and evaluate welfare in large commercial flocks of laying hens. Current measurements of (mostly negative) health indicators focus on only one aspect of the concept of animal welfare and do not capture sufficient variation over time and between animals. Novel approaches are required to track individuals in group housing over time. Technology for measuring welfare-related indicators has been developed within the field of Precision Livestock Farming (PLF). Advancements in animal tracking technologies have primarily focused on indicators of negative health such as plumage damage or drops in production. A more broad array of welfare indicators could however be measured using such techniques. Automatic tracking of hens has been proposed as a method to monitor individual behavior and activity, as well as social interactions between animals [1]. Initial tracking using computer vision has been promising [2]. Identification of animals is still required, especially in applications for research and animal breeding. Since cameras are already installed to use computer vision, the use of computer readable markers enables data collection from one location [3]. These computer readable markers allow for both identification of animals and the tracking of location and orientation. When recognized, the positions of every ArUco marker are returned for every frame, allowing for precise tracking of location, activity and orientation for each individual. The use of ArUco markers thus allows for identification and position tracking of animals.

Method

The experiment was carried out with the same pullets as described by Kliphuis et al., (2023) and Manet et al., (2023), with the same annotation method as described by Guo et al. (2022). The research project was approved by the central authority for scientific procedures on animals (Centrale Commissie Dierproeven (CCD), the Hague, the Netherlands) under the number AVD1080020198685. Two commercial hybrids, ISA Brown and Dekalb White, were equipped with the backpacks during the 9th week and we collected data at the 13th week of age. We used ArUco markers printed on a previously tested laminated paper backpack design [6]. These were fitted on commercial layer hybrids in an experimental farm with 20 pens housing around 10 animals each. We examined 65 videos of 2 minutes each by running a basic ArUco recognition python script using OpenCV, as well as by doing manual bounding box annotations using the program CVAT. These double checked manual annotations provided our golden standard for examining the ArUco tracking results. Distances in pixel coordinates from the middle of the ArUco markers were used to calculate two novel individual phenotypes: The sum of distance moved and the average distance from one hen to all other hens.

Results and discussion

For the purpose of identification, only one read of the ArUco in a tracked video has to be recorded. For the Dekalb White hens we found 94.0% of the identities of hens which were visible on the video and for the ISA Brown hens we found 61.5%. The suboptimal fit of the backpacks on the larger ISA Brown hens resulted in blocking of the view on the markers compared to the Dekalb White hens. The longer feathers of the ISA Brown hens could be seen blocking the marker from the view of the camera. This did not occur in the Dekalb White hens. Therefore, ArUco is a feasible method for identification if animals are tracked for a minimum of 2 minutes and the design of the ArUco backpack matches the size of the birds.

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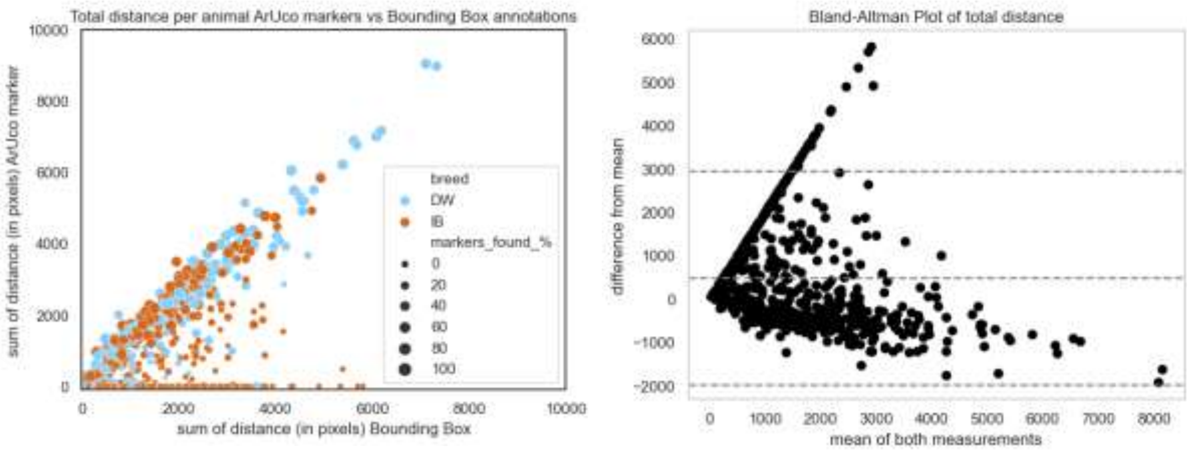
The use of ArUco marker positions was tested for tracking individual phenotypes of movement and positions. With the annotated positions, we could calculate the percentage collected of tracks compared to the theoretical maximum possible. By multiplying the number of frames with the number of animals present in the pen, we calculated the fraction of markers measured against the maximum possible number of markers. With the annotated data available, we were also able to find the correctly tracked fraction based on the animals which were visible. These results can be found in table 1 with the calculation method included.

Table 1. Tracking percentage of ArUco marker backpacks for identification and position tracking for two layer hybrids.

description	Calculation method	ISA Brown %	Dekalb White %	Total %
Expected markers found	$\frac{ArUco\ markers\ on\ visible\ animal}{(nr\ visible\ annotations \times fps)} \times 100\%$	36.3%	76.0%	52.6%
ArUco found compared to maximum	$\frac{ArUco\ markers\ on\ visible\ animal}{(nr\ animals \times nr\ frames)} \times 100\%$	30.1%	62.4%	43.5%
Identification rate	$\frac{nr\ linked\ ArUco\ markers}{(nr\ observed\ animals)} \times 100\%$	61.5%	94.0%	75.2%

When we compare the phenotype of distance moved to the corresponding bounding box annotations, we see a clear correlation (pearson 0.77, $p<0.0001$) for the available 52.6% marker tracks to the corresponding bounding boxes. This correlation is visible in the correlation plot in Figure 1a.

In order to understand the difference between the tracked data and our golden standard, we plotted the difference from the mean against the mean values in the Bland-Altman plot in Figure 1b. This type of mean-difference plot allows us to spot the agreement between the two methods. . A clear increase can be seen in deviation at higher distances moved in the Bland-Altman plot. Therefore distance moved should be corrected for. The animals without ArUco tracks are now included through manual linking to bounding box information, which will not be possible in future research. Now these points show the amount of missing data to be expected as well as the similar distribution of data compared to the points with ArUco marker tracks.



1a.

1b.

Figure 1. The sum of distance moved per animal as measured by manual annotation and through marker tracking in a correlation plot (1a) and Bland-Altman plot (1b).

Conclusion

ArUco markers on printed backpacks could provide a standalone solution for collecting novel phenotypes in the laying hen production sector. We do however suggest a smaller research setting with group housed animals as the optimal use case. Missing data is one of the greatest challenges that needs to be overcome through backpack design improvements. Even in a situation with a good design of the backpacks, for instance in the Dekalb White hens, 76.0% of the ArUco markers were detected compared to the maximum possible number of marker detections. We need to consider correcting these measurements, for which we could improve design, data filtering, data extraction and measurement type. When combined with computer vision technology, ArUco markers provide a convenient method of identifying animals and providing additional information on location and orientation.

References

1. Ellen, E.D., van der Sluis, M., Siegford, J., Guzhva, O., Toscano, M.J., Bennewitz, J., Van Der Zande, L.E., Van Der Eijk, J.A.J., De Haas, E.N., Norton, T., Piette, D., Tetens, J., de Klerk, B., Visser, B., and Bas Rodenburg, T. (2019). Review of sensor technologies in animal breeding: Phenotyping behaviors of laying hens to select against feather pecking. *Animals*, **9** (3).
2. Guo, Q., Sun, Y., Min, L., van Putten, A., Knol, E., Visser, B., Rodenburg, T., Bolhuis, J., Bijma, P., and N. de With, P. (2022). Video-based Detection and Tracking with Improved Re-Identification Association for Pigs and Laying Hens in Farms. *Proceedings of the 17th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*. 69–78.
3. Alarcón-Nieto, G., Graving, J.M., Klarevas-Irby, J.A., Maldonado-Chaparro, A.A., Mueller, I., and Farine, D.R. (2018) An automated barcode tracking system for behavioural studies in birds. *Methods in Ecology and Evolution*, **9** (6), 1536–1547.
4. Manet, M.W.E., Kliphuis, S., Nordquist, R.E., Goerlich, V.C., Tuyttens, F.A.M., and Rodenburg, T.B. (2023) Brown and white layer pullet hybrids show different fear responses towards humans, but what role does light during incubation play in that? *Applied Animal Behaviour Science*, **267**.
5. Kliphuis, S., Manet, M.W.E., Goerlich, V.C., Nordquist, R.E., Vernooij, H., Brand, H. van den, Tuyttens, F.A.M., and Rodenburg, T.B. (2023) Early-life interventions to prevent feather pecking and reduce fearfulness in laying hens. *Poultry Science*, **102** (8).
6. van der Eijk, J.A.J., Verwoolde, M.B., de Vries Reilingh, G., Jansen, C.A., Rodenburg, T.B., and Lammers, A. (2019) Chicken lines divergently selected on feather pecking differ in immune characteristics. *Physiology and Behaviour*, **212**.