**Evaluation of a fully automated video surveillance system for cattle lameness detection using machine learning**

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**Application**

An automated system that could reliably identify lame cows would be a valuable tool for lameness management in modern dairy herds.

**Introduction**

CattleEye Ltd (Belfast, UK), has recently developed and commercialized an automated lameness detection system using a 2D security camera placed over an exit race. The system generates mobility scores via a machine learning algorithm on a scale 0-100, with each 25-points increments representing one grade on the 4-grade (0-3) AHDB mobility scoring method. Our aim was to evaluate the performance of this system using manual mobility scores and foot lesion records as reference.

**Materials and methods**

The study was conducted in 8 dairy farms located in west England and Wales. Herd size ranged from 600 to 2,300 lactating Holstein cows. Four experienced veterinarians (VETs) performed a total of 29 whole-herd mobility scoring sessions using the AHDB scoring method. On each session, individual daily scores of the last week recorded by the system (CE) were stored and analysed at the end of the study. The weekly average score was calculated and converted to represent a binary score of lame versus non-lame cows. Agreement between the binary converted manual mobility scores (MAN) and CE scores was assessed using simple percentage agreement (PA), Cohen’s kappa (κ) and Gwet’s agreement coefficient (AC). Moreover, the same VET was present during 17 professional foot trimming sessions in 3 of the participating farms. These sessions included both routine and therapeutic trims and the VET was blind to which cows were presented. The VET recorded the presence and graded the severity of any sole haemorrhage (SH), sole ulcer (SU), white line disease (WL), toe ulcer (TU), digital dermatitis (DD), interdigital phlegmon (IP) and interdigital hyperplasia (IH) cases in all four feet. Cows were binary classified as bearing potentially painful lesions that would impair their mobility or not, in two different ways. Cows with at least one case of SU grade ≥ 2, WL grade 3, TU, stage M2 of DD and IP grade 2, were considered as having lesions of HIGH severity, while cows with at least one case of SU, WL grade ≥ 2, TU, stage M1 or M2 of DD, IP and IH grade 2 were considered as having lesions of MODERATE & HIGH severity. Lesion records were then matched with the weekly average CE scores, resulting in a dataset of 991 cows. The same VET also mobility scored a subset of 340 cows in 2 farms 1-3 days prior to foot trimming. Accuracy (ACC), sensitivity (SE) and specificity (SP) were calculated for both CE and the VET in predicting the presence of lesions of HIGH or MODERATE & HIGH severity. Finally, individual daily CE scores covering a period of 90 days prior to the trimming sessions were retrieved. Two linear mixed models were fitted to assess retrospectively the association of the lesions status (HIGH or MODERATE & HIGH severity) with the daily CE scores on a continuous scale (0-100). Lesions status, farm, time, time × lesions status interaction were fitted as fixed effects and the random effect of each cow was considered for the repeated scores.

**Results**

A total of 27,082 mobility scores were available, after merging the weekly average CE and MAN scores using the cow ID. The agreement between binary CE and MAN scores produced overall PA, κ and AC ranging from 81.5% to 86.3%, from 0.23 to 0.41, and from 0.76 to 0.83, respectively. Prevalence of HIGH and of MODERATE & HIGH severity lesions was 9.6% and 43.6%, respectively. ACC, SE and SP of CE and MAN in predicting presence of HIGH severity, yielding a combination of 0.83, 0.40 and 0.88, and 0.80, 0.53 and 0.83, respectively. Accordingly, ACC, SE and SP of CE and MAN in predicting presence of MODERATE & HIGH severity, were 0.60, 0.23 and 0.92, and 0.60, 0.29 and 0.87, respectively. Finally, continuous CE scores were historically increased in cows with lesions of HIGH and of MODERATE & HIGH severity by an overall difference in estimated marginal means of 9.4 points (95% CI: 7.0-11.7, P< 0.001) and of 3.9 points (95% CI: 2.6-5.3, P< 0.001) compared to the non-affected ones, respectively.

**Conclusions**

The agreement between MAN and CE scores was in concordance with that previously reported between experienced human scorers assessing mobility of cows live (Linardopoulou et al., 2022; Anagnostopoulos et al., 2023). Further investigation of farm and cow-level factors that potentially influence the predictive ability of CE in identifying cows bearing potentially painful foot lesions is needed. The association of historical CE scores with foot lesions even of moderate severity creates an opportunity for early intervention before the development of severe pathologies.

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**References**

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