Behaviours classification using leg-mounted accelerometers in dairy barns

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Abstract: Analysing behavioural changes (e.g., lying, feeding) has widely been considered as an interesting approach to monitor the reproduction status, health, and overall well-being of dairy cows. However, measuring these changes can be time consuming, especially in large sized farms. In response to these time constraints, using data loggers to automate behavioural recording has become increasingly important to continuously and accurately quantify cows' behaviours (Martiskainen et al., 2009; Müller and Schrader, 2003; Robert et al., 2009; Vázquez Diosdado et al., 2015). In the present study, we propose methods to classify three behaviours (i.e., lying, standing, and feeding) with a leg-mounted accelerometer using a relatively low sampling rate (1 Hz). This can reduce the energy consumption of the sensors and lower the maintenance requirements associated with recharging the batteries, therefore, extend the lifetime of the monitoring system.

Measurements were performed between March and July 2016 in a state-of-the-art dairy cattle research barn of the Institute for Agricultural, Fisheries and Food Research (ILVO) in Melle, Belgium. The cows (n=31) were housed in an area of 30 m long and 13 m wide with individual cubicles and concrete slatted floor. The cubicles (n = 32) were bedded with a lime-straw-water mixture. A total of 16 different second parity Holstein cows (parity 2.7 ± 1.4, milk yield 33.6 ± 5.6 kg/d; mean ± SD) were used for this study. Two cows were monitored simultaneously using an accelerometer attached to each cow from 10 AM to 4 PM. The accelerometer was attached to the right hind leg. The acceleration data were logged with a sampling rate of 1 Hz using HOBO loggers (Onset Computer Corporation, Pocasset, MA).

From the accelerations along X, Y, and Z axes, the acceleration sum vector (A_{sum}) was used. This vector was segmented into equal time intervals of 1 min (60 samples. Feature extraction was then performed for each data segment. Three supervised machine learning algorithms were used for the classification (i.e., K-nearest neighbours, naïve Bayes, and support vector machine) (Martiskainen et al., 2009; Vázquez Diosdado et al., 2015). K-nearest neighbours and the naive Bayes classifiers are possible options because they are fast, simple and well understood. Support vector machine (SVM) is better at handling complex classification tasks, but requires more computational costs, especially in the training phase.

Lying was the best classified behaviour with a sensitivity between 93% and 98% and a precision between 97% and 99%, followed by feeding (precision 73-81%, sensitivity 73-86%). Standing was the most difficult behaviour to classify with a sensitivity lower than 76% for all classifiers. This could be explained as follows.

When a cow is lying, the legs usually have small amount of movement. Therefore, this behaviour could be classified more accurately with the leg-mounted accelerometer (sensitivity around 100%). However, the legs have similar patterns most of the time during standing and feeding behaviours, which results in a misclassification of these behaviours. For the overall accuracy, SVM was the best classifier followed (89%) by K-NN (85%) and Naïve Bayes (84%). SVM algorithm is more suitable for complex classification tasks but it requires more computation capabilities than Naïve Bays and K-NN (Douglas et al., 2011), especially in the training phase. However, after the classification model is developed, SVM classifies the new data without looking to the training set, which would save the memory of the monitoring system, in contrast to Naïve Bays and K-NN, where the training set is always required to classify the new instances. Therefore, the selection of the best classification algorithms is a trade-off between performance and computation/memory capabilities.

The results from this research suggest that accelerometers are promising tools to automatically monitor cows' behaviours. Such a behaviour monitoring system would enable determination of relevant information about the cows' behaviour patterns (e.g., feeding time, lying time, lying bouts), which offers new potential technologies for the automated detection of health and welfare problems in dairy cows. More data would be needed especially from other herds to validate the findings of this research. Furthermore, other positions (e.g., neck, ear) should be addressed in order to investigate the best position for the behaviours' classification. Also a combination of the data from different positions could enhance the classification performances. Finally, the data logging time per cow (i.e., 6 hours) was not sufficient to collect enough data for some behaviours such as walking.

REFERENCES

Douglas, P.K., Harris, S., Yuille, A., Cohen, M.S., 2011. Performance comparison of machine learning algorithms and number of independent components used in fMRI decoding of belief vs. disbelief. Neuroimage 56, 544–553. doi:10.1016/j.neuroimage.2010.11.002

Martiskainen, P., Järvinen, M., Skön, J.-P., Tiirikainen, J., Kolehmainen, M., Mononen, J., 2009. Cow behaviour pattern recognition using a three-dimensional accelerometer and support vector machines. Appl. Anim. Behav. Sci. 119, 32–38. doi:10.1016/j.applanim.2009.03.005

Müller, R., Schrader, L., 2003. A new method to measure behavioural activity levels in dairy cows. Appl. Anim. Behav. Sci. 83, 247–258. doi:10.1016/S0168-1591(03)00141-2

Robert, B., White, B.J., Renter, D.G., Larson, R.L., 2009. Evaluation of three-dimensional accelerometers to monitor and classify behavior patterns in cattle. Comput. Electron. Agric. 67, 80–84. doi:10.1016/j.compag.2009.03.002

Vázquez Diosdado, J.A., Barker, Z.E., Hodges, H.R., Amory, J.R., Croft, D.P., Bell, N.J., Codling, E.A., 2015. Classification of behaviour in housed dairy cows using an accelerometer-based activity monitoring system. Anim. Biotelemetry 3, 15. doi:10.1186/s40317-015-0045-8