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Early detection of abnormal weight patterns in dairy cows based on AMS weighing data

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Introduction

With increasing herd sizes, more farmers in Danish dairy herds install an automatic milking system (AMS) to ease the milking routines. During the daily management, farmers check the well-being of the cows and observes if some are lame, ill, or in other ways in need of extra attention. It can, however, be difficult to recognize early signs of lameness and diseases like post-calving metabolic disorder or fat cow syndrome timely enough to make preventive interventions. Preventive interventions could reduce both economic and productivity costs as well as the impact on health and welfare. In many AMSs a scale is installed, whereby the cow is weighted multiple times a day as it gets milked. This paper presents the first steps to develop an automatic monitoring system based on weighing data from the AMS to make an early identification of individual cows who need extra managerial focus.

Materials

Data concerning reproduction, medical treatments, breed, parity, days in milk (DIM), status of the cow (dried off or lactating), herd ID and cow ID were obtained from the Danish Central Cattle Database, whereas weight observations were obtained from the AMS. Weight observations were aggregated to a daily mean for each cow. For herds where a cow has access to more than one AMS per day, a correction was made to minimize differences in calibration across scales in different AMSs. In addition, the accumulated weight of the foetus was subtracted from the daily aggregated weight of the cow.
For each herd, the data set was split into training data and test data. The training data sets consisted of all unique cow-parity combinations where the cow had had no registered medical treatment and where weight observations were registered for minimum 250 days in the lactation. The test data sets consisted of all the cow-parity combinations which were not included in the training data set.

Methods

A dynamic linear model (DLM) was developed per herd for each cow-parity combination. The overall aim of a DLM is to predict the next observation of the monitored variable by estimating the parameter vectors, $\boldsymbol{\theta}_1 \ldots \boldsymbol{\theta}_t$ from the observations, $Y_1 \ldots Y_t$. Every observation is added to the model's prior knowledge of the modeled system, and this dynamic updating enables the model to predict the next observation with increased certainty over time as described by West & Harrison (1999). The expected daily change in weight was estimated by fitting a spline function to all observations from all cows in the herd, and the observation variance, $\boldsymbol{V}$, was assumed to increase linearly over time. Linear functions describing $\boldsymbol{V}_t$ given DIM was made separately for each parity group. A two-sided moving average was applied to the daily weight data of each cow, and the residuals between the observed values and the moving average were aggregated to daily variances. The system variance, $\boldsymbol{W}_t$, was estimated using a discount factor.

Forecast errors, generated by the DLM, were monitored by a two-sided tabular Cusum (Montgomery, 2013). If the summed forecast errors exceeded a threshold, an alarm was generated.

Results and conclusion

30 cows from the test data set from each herd were randomly selected to visually qualify if abnormal weight patterns were identified by the DLM based only on weight observations from the AMS. Thresholds for small alarms (small limit) and for large alarms (large limit) were arbitrarily defined to illustrate how alarms can be of different severity. A sudden change in weight was expected to be the indirect consequence of a disease. An example is shown in

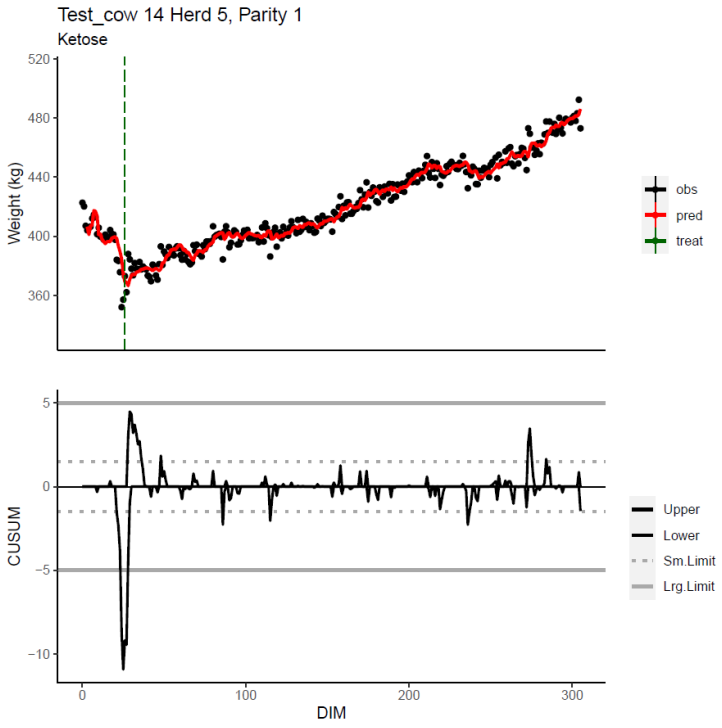

Figure 1: An example of the relationship between Cusum alarms and abnormal changes in weight pattern. The upper plot shows the observed weight (black dots) and the weight curve predicted by the DLM (red line). Day of treatment is shown (dashed green line).

The lower plot shows the twosided Cusum. The Lower Cusum exceeds the large lower limit around the time of the treatment. Both upper and lower small limits are exceeded multiple times during the lactation, indicating that the cow has an unstable weight curve and should get extra managerial focus

In conclusion it was possible to detect abnormal weight patterns in dairy cows based on AMS weighing data, although adequate thresholds must be defined, and more variables must be included to reduce false alarms.

Acknowledgements

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References

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