# Time Series Analysis of Live Weight as Health Indicator

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Of daily changes in live weight in dairy cattle is often claimed that they could serve as useful information for both the diagnosis of health problems and for feed management (Maltz et al., 1997). However the inter and intra individual differences in live weight data make straight-forward thresholds hard to use, as they are likely to cause high amounts of false attentions. Due to the noisy character of the data it is crucial to use adequate filter techniques to be able to apply management by exception. The Astronaut A3™ (Lely Industries, Maassluis, the Netherlands) is equipped with a weighing floor primarily used to guide the robot arm safely into the robot box, but live weight data can be used for other purposes too. The aim of this study is to show the accuracy and precision of the live weight data as a health indicator when using a Holt-Winters forecasting technique.

## Materials and Methods

On a farm in France the live weight data of 191 cows was captured with the Astronaut A3 in a period from April 3rd 2007 to August 17th 2009. In total 198,992 live weights were gathered resulting in 79,099 daily live weights. The health records of the farm were available to serve as a reference for the live weight health indications. The farmer's veterinarian reported 472 diseases; main groups were mastitis (186), metritis (38) and locomotion problems (76).

Daily live weight data was smoothed using Holt-Winters forecasting technique, subsequently the change between days was determined and smoothed again. Attentions were given when (a) live weight dropped more than the attention threshold in comparison to a previous reference period or (b) when daily weight loss was more than one tenth of the attention threshold. In comparison a straight-forward method using averages and standard deviations was used (Maltz, 1997) to evaluate sensitivity (%), specificity (%) and false alert rate (FAR; per 1000 observations) with respect health records of the farm. The performance of different thresholds (1-3% live weight) and sequential attentions (1-3 days) was tested.

## Results and Discussion

The high sensitivity of live weight as health indicator using the straight-forward method clearly coincided with a low specificity. In practice this will effect in a lot of attentions as shown in the high FAR that is unlikely to be accepted by farmers (Table 1). The dynamic method used aimed to be more of

**Table 1. Sensitivity, specificity and false alert rate of the models**

| | Method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Straight-forward | Dynamic filter | | | | | | | | |
| Number of Attentions | | One attention | | | Two sequent attentions | | | Three sequent attentions | | |
| Attention Threshold | | 1% | 2% | 3% | 1% | 2% | 3% | 1% | 2% | 3% |
| Sensitivity (%) | 84.6 | 74.5 | 60.0 | 50.5 | 73.1 | 59.6 | 50.1 | 67.5 | 54.6 | 45.7 |
| Specificity (%) | 77.2 | 93.8 | 97.1 | 98.4 | 94.7 | 97.5 | 98.6 | 95.6 | 97.9 | 98.7 |
| FAR (per 1000) | 136.5 | 38.1 | 22.0 | 13.3 | 32.5 | 19.1 | 11.9 | 30.3 | 17.6 | 11.0 |

practical use to the farmer. Hence a high specificity was needed. The dynamic method did not respond to sudden changes in weight, but a trend in weight loss was accurately shown (figure 1). Daily or weekly changes in weight, likely to occur in stochastic signals like live weight, will not end up in false attentions as easily as it does in straight-forward techniques. The use of lower thresholds will improve sensitivity and sequential attentions showed promise to increase specificity or FAR (Table 1).

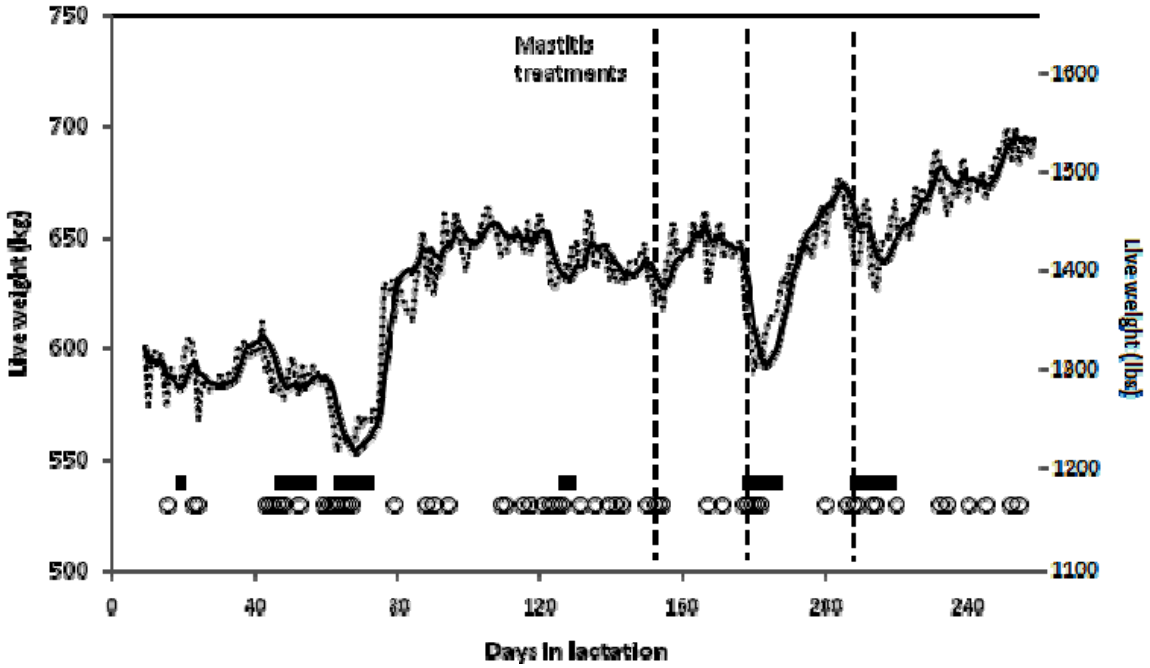


**Figure 1. Live weight changes in kg (left axis) and lbs (right axis) of a cow during lactation; day 40 until 80 the cow had ketosis, on day 152, 177 and 208 she was treated for mastitis. Dotted line - raw weight data; solid line – smoothed weight data; ○ – attentions from straight-forward method; ■ – attentions for dynamic method; dashed vertical line – mastitis treatment**

Though live weight is recognized as a health indicator (Maltz, 1997), in automated detection methods it is often neglected. Other health indicators respond faster, are more specific (*e.g.* milk conductivity for mastitis detection) or diseases will not cause a reduction in weight. Live weight might have added value when combined with other indicators and in terms of a safety net when all others are failing. Research needs to continue to explore its full potential in what thresholds and algorithms to use and how to combine live weight changes with other (disease specific) key health parameters.

## Conclusion

Applying a dynamic filter on live weight data increased specificity drastically at the cost of lower sensitivity. Although fewer cases were detected with a weight attention, the attention lists were a lot shorter resulting in a practical feasible attention method.

## References

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