

Mastitis detection in dairy cows using Neural Networks

J. Krieter, D. Cavero, C. Henze

Institut für Tierzucht und Tierhaltung der Universität Kiel

Olshausenstr. 40

24098 Kiel

jkrieter@tierzucht.uni-kiel.de

dpintado@tierzucht.uni-kiel.de

chenze@tierzucht.uni-kiel.de

Abstract: The aim of the present research was to investigate the usefulness of neural networks (NN) in the early detection and control of mastitis in cows milked in an automatic milking system. A data set of 403,537 milkings involving 478 cows was used. Mastitis was determined according to udder treatment and/or somatic cell counts (2). Mastitis alerts were generated by a NN model using electrical conductivity, milk production rate, milk flow rate and days in milk as input data. The evaluation of the model was carried out according to block-sensitivity, specificity and error rate. When the block-sensitivity was set to be at least 80%, the specificities were 51.1% and 74.9% and the error rates were 51.3% and 80.5% for mastitis definitions 1 and 2, respectively. Additionally, the average number of true positive cows per day ranged from 1.2 to 6.4, and the average number of false negative positive cows per day ranged from 5.2 to 6.8 in an average herd size of 24 cows per day for the test data.

1 Introduction

Mastitis is the most costly disease in dairy farming today and remains one of the major problems concerning the dairy industry. [Ba98] found mean infection rates of clinical mastitis of 25-30%. Average economic losses due to mastitis are estimated to be around 150 Euro per cow and year ([Dv02]). In herds with an Automatic Milking System (AMS), identification of udder infections is no longer based on visual observation. In contrast, control programs managing the health status of the cows have been introduced, based on sensor measurements. The aim of the present paper is to describe a neural network (NN) for mastitis detection using serial data.

2 Material and Methods

Data were recorded at the University of Kiel's experimental farm Karkendamm between July 2000 and March 2004. In total, 403,537 milkings were accumulated from 478 Holstein Friesian cows with a total sum of 645 lactations, the average herd size was 124 cows per day. The AMS measured the highest value of the EC of the milk every 200 ml for each udder-quarter and at the end of the milking the average value of the whole milking was recorded by the AMS. The milk production rate was defined as milk yield

per milking, divided by the respective milking interval. The trait average milk flow rate of the whole milking was supplied by the AMS. Udder health was classified on the basis of the cows' SCC, which was measured weekly from pooled quarter milk samples taken from each cow, as well as information on udder treatments. Two variants of mastitis definition were used: (1) Treat+100: treatment performed or a SCC > 100,000 cells/ml, (2) Treat+400: treatment performed or a SCC > 400,000 cells/ml.

The milking days were classified as "days of health" or "days of mastitis". If two succeeding SCC measurements either both exceeded the threshold or both did not, all days between these measurements were also defined as "days of mastitis" or "days of health", respectively. In the other case, the day on which the SCC was recorded and two days after and two days before were defined according to this SCC value and the days in the middle were set to "uncertain days".

In the Multilayer perceptron which was used there is a set of input nodes (input layers), whose only role is to feed input patterns into the rest of the network. Following the input layer, and before the output layer, there are one or more intermediate layers of units. These units are called hidden units because they have no direct connection to the outside environment neither input nor output. More details about the construction of NN are found in [Hs99].

Once the network weights and biases has been initialised the network has to be trained. In our study the training process followed a modified Levenberg-Marquardt algorithm (Bayesian regularisation, [FH97]). Finally, by comparing convergence, consistency and classification accuracy, a multilayer perceptron with one hidden layer was adopted. The input layer of the used NN had 5 nodes: the relative deviation between measured and estimated values (estimated values are performed by means of the moving average of the ten last values) of the three traits electrical conductivity of the milk, milk production rate and milk flow, as well as the maximum value of the electrical conductivity of the milk (over all quarters) and days in milk. The output layer consisted of one node, corresponding to suffering from mastitis and the hidden layer consisted of 10 nodes.

The system provided an alert signal when the resulting output value of the NN exceeded a given threshold value which depended on mastitis definition. The model performance was assessed by comparing these alerts with the actual occurrences of mastitis. The concerning day of observation was classified as true positive if the threshold was exceeded on a day of mastitis, whereas a non-detected day of mastitis was classified as false negative. Each milking day in a healthy period was considered a true negative case if no alerts were generated and a false positive case (FP) if an alert was given. The accuracy of these procedures was evaluated by the parameters sensitivity, block sensitivity, specificity and error rate. Multifold cross validation was used to evaluate the ability of the trained NN to accurately classify mastitis events.

3 Results and Discussion

The block-sensitivity in the training data was set to be at least 80%. The specificities with the training sets were 61.4% and 78.3% for variants 1 (Treat+100) and 2 (Treat+400), respectively. On the other hand, error rates were 46.5% and 79.1%, respectively. The fact that there were many more "days of health" than "days of

mastitis” caused a greater likelihood for FP to arise, which had an impact on the error rate.

The performance of the model was assessed by averaging the classification parameters under validation for the test data. The specificity decreased moderately to 51.1% and 74.9% for variants 1 and 2 respectively. In turn, the error rate increased to 51.3% and 80.5%, respectively. The results obtained for the test data agreed with those calculated for the training data, so that the model generalised well.

Averaged true positive and false negative cows/day were also determined, which means the number of cows per day classified as diseased rightly and wrongly respectively, and thus directly the farmers’ effort with regard to mastitis monitoring. The number of TP cows/day for the training data were 24.8 and 4.8 and the FP cows/day were 21.5 and 18.2 for variants 1 (Treat+100) and 2 (Treat+400), respectively. The average herd size for the training data was 99 cows/day. Due to the differences in mastitis definition and data properties, comparison of the model performance with other studies is complicated. However, it is possible to make a comparison with a previous study in which the applicability of a fuzzy logic model for mastitis detection was evaluated [(Ca06)]. In that study, specificity and error rate obtained with fuzzy logic could be found to be better compared to the estimates in the current research: for a block-sensitivity of about 80%, a specificity of 75.8% and an error rate of 41.9% for variant 1 (Treat+100), and a specificity of 88.1% and an error rate of 75.7% for variant 3 (Treat+400) were found.

4 Conclusion

A limited number of mastitis indicators were analysed in the present study. Additional information related to mastitis would probably improve the performance of the model. For analysis of more complicated data, an NN might be preferable, because of the non-linear relations between input and output and the fact that no assumption about the distribution of the different variables should be made.

References

- [Ba98] Barkema, H.W. et al., 1998. Incidence of clinical mastitis in dairy herds grouped in three categories by bulk milk somatic cell counts. *J. Dairy. Sci.* 81, 411-419
- [Ca06] Caverio, D. et al., 2006. Mastitis detection in dairy cows by application of Fuzzy Logic. *Livest. Prod. Sci.*, accepted
- [Dv02] DVG, 2002. Leitlinien zur Bekämpfung der Mastitis des Rindes als Bestandsproblem. Sachverständigenausschuss „Subklinische Mastitis“
- [FH97] Foresee, F.D., Hagan, M.T., 1997. Gauss-Newton approximation to Bayesian regularization. *Proceedings of the 1997 International-Joint Conference on Neural Networks*, 1930-1935
- [Hs99] Haykin, S., 1999: *Neural networks. A comprehensive foundation*. Prentice Hall International, New Jersey, 842 pp.

