Artificial Intelligence in Veterinary Ultrasonography: Can B-mode Image Analysis from the Mammary Gland Predict Productive Stage of Dairy Cows? - Abstract

Konstantinos Themistokleous[1], Nikolaos Sakellariou[2], Evangelos Kiossis[1]

[1]Clinic of Farm Animals, Faculty of Veterinary Medicine, Aristotle University of Thessaloniki, 54627, Thessaloniki, Greece; e-mail: konsthem@vet.auth.gr
[2]Information Technologies Institute, Centre for Research and Technology Hellas, 57001, Thermi, Greece

Summary

Objective. The present study investigated the ability of a supervised machine learning model to predict whether a dairy cow is in lactation or in dry period (non-lactating), utilizing image analysis parameters from B-mode ultrasonography of the mammary gland.
Materials and methods. Eight clinically healthy Holstein dairy cows were selected from the same herd. Seventeen examinations were performed to each one of them during successive stages of their production; 7 days prior to dry-off, at dry-off, at 3rd, 7th, 21st, 35th day of dry period, 7 and 3 days prior to calving, at calving and at 3, 7, 14, 30, 45, 60, 75, 90 days in milk. All four quarters of the mammary gland were examined via B-mode ultrasonography, using a curved-linear transducer (3-7 MHz), frequency of insonation set at 4.3 MHz and scanning depth of 15 cm. At each examination, 2 separate images from each quarter were taken. The total number of images was 1016; 368 images from quarters in dry period and 648 images from quarters in lactation. Each image was classified according to productive stage either as "0" referring to dry period or "1" referring to lactation. Image analysis was performed using the Echovet v.2.0. software and 15 of its' parameters were utilized; mean value, standard deviation, skewness, excess, gradient mean value, gradient variance, percentage non-zero gradients, contrast, correlation, entropy, homogeneity, run percentage, long-run emphasis, gray value distribution and run-length distribution. A simple binary classification model based on the Decision Trees algorithm was used for the development of the supervised machine learning model. The selection of input variables was performed via Pearson correlation analysis between productive stage and the aforementioned 15 parameters. The total dataset was split into two sub-sets: 80% for the training set and 20% for the testing set. Hyper parameter tuning by 5-fold cross-validation was applied on the training set to determine the best hyper-parameters but, also, to increase the generalization ability of the model. Due to high accuracy of the model in every result of the cross-validation procedure, the default parameters were selected for testing the final model on the unseen data of the testing set.
Results. Five variables with the highest correlation were selected; mean value (ϱ=0.006), standard deviation (ϱ=-0.053), gradient variance (ϱ=-0.013), percentage

Proceedings of the 9th International Conference on Information and Communication Technologies in Agriculture, Food & Environment (HAICTA 2020), Thessaloniki, Greece, September 24-27, 2020.

non-zero gradients (ϱ=0.147) and homogeneity (ϱ=0.091). Therefore, the model's input was represented by a vector of 6 values; productive stage was the prediction variable while mean value, standard deviation, gradient variance, percentage non-zero gradients and homogeneity were the independent variables. The final model applied on the testing set achieved 100% accuracy; 81/81 images of class 0 and 123/123 images of class 1 were correctly identified. The results for the metrics precision, recall, accuracy and f1-score were all 1.00.
Conclusion. The supervised machine learning model utilizing B-mode image analysis from the mammary gland presented exceptional accuracy in predicting whether a dairy cow is in lactation or in dry period.

Key words: machine learning; veterinary ultrasonography; mammary gland; dairy cows.

JEL Codes: Q01; Q16