Lero THE IRISH SOFTWARE RESEARCH CENTRE

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MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

Exploring machine learning algorithms on activity and feeding behaviour for early estrus detection in dairy cows

DAIRYMASTER Experience the difference...

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Background

The economics of milk production and herd replacement are directly affected by the level of reproductive performance.

The recent advances in sensor technology have allowed accurate predictions of estrus events using animal behavior information.

Individual cow sensors (MooMonitor+, Dairymaster, Co. Kerry, Ireland) can monitor cow neck movements 24/7 for heat related activity, rumination, resting, feeding, head position and restlessness. This system improves farm profitability by decreasing labour requirements for farm personnel, improving reproductive performance and minimising losses due to missed heats, undiagnosed illnesses and general animal cow health.

MooMonitor+ (Dairymaster, Co. Kerry, Ireland)

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Data and Analysis

The objective of this study was to evaluate the potential of machine learning techniques to identify the onset of estrus in dairy cows using hourly behaviour data collated from 1,750 dairy cows housed in a free-stall barn at 5 commercial dairy farms during the 2 years period. The behaviour was measured using the behaviour-monitoring collar (MooMonitor+, Dairymaster, Causeway, Co. Kerry, Ireland) of each animal 24 h/day. The MooMonitor+ recording system stores information every minute and then summarizes this data on an hourly basis.

Original variables (hourly data):
Cow ID: int
Date: datetime64[ns]
DIM – int
Heat (0,1)

Calving date – multiple per cow
Lactation – how many calves the cows have had int 1...n

+**Rumination** - int (mins spent rumination in an hour)
+**Resting** int (mins spent resting in an hour)
+**Feeding** int (mins spent feeding in an hour)
+**High activity** - int (mins spent rumination in an hour)
+**Med activity** - int (mins spent rumination in an hour)
+**Low activity** int (mins spent rumination in an hour)

Calculated variables:
DSLH = days since last heat, (eg. num days between heats)
mean DSLH = mean OF ALL period between heats per cow

X = df[['DSLH', 'meanDSLH', 'High_27 norm', 'Medlow_27 norm', 'High_6 norm', 'Medlow_6 norm', 'High_9 norm', 'Medlow_9 norm', 'High_12 norm', 'Medlow_12 norm', 'High_15 norm', 'Medlow_15 norm', 'High_18 norm', 'Medlow_18 norm', 'Rum_21 norm', 'High_21 norm', 'Medlow_21 norm', 'Rest_24 norm', 'High_24 norm', 'Medlow_24 norm', 'High_72 norm','Medlow_72 norm', 'High_120 norm','Medlow_120 norm', 'High_168 norm', 'Medlow_168 norm', 'High_240 norm', 'Medlow_240 norm', 'High_360 norm', 'Medlow_360 norm', 'High_432 norm', 'Medlow_432 norm']]

Different classification machine learning techniques (Extreme Gradient Boosting (GBDT), Random Forest (RF), Decision Tree (CART), K-Nearest Neighbors (KNN), Gausian Naïve Bayes (NB), Linear Discriminant Analysis (LDA), Logistic Regrssion (LR)) were evaluated to identify the onset of estrus in dairy cows.

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Results

- The study showed that the accuracy, precision, sensitivity, specificity and F1 score of the Random Forest algorithm were up to 94.98%, 99.19%, 94.62%, 96.60%, 96.85%, respectively, which indicates a great potential for early estrus detection.

Confusion matrix

		Predicted Class: Positive	Predicted Class: Negative	
Actual Class	Positive	183662	1432	Sensitivity $\frac{TP}{(TP+FN)}$
	Negative	10363	42112	Specificity $\frac{TN}{(TN+FP)}$
		Precision $\frac{TP}{(TP+FP)}$	Negative Predictive Value $\frac{TN}{(TN+FN)}$	Accuracy $\frac{TP+TN}{(TP+TN+FP+FN)}$

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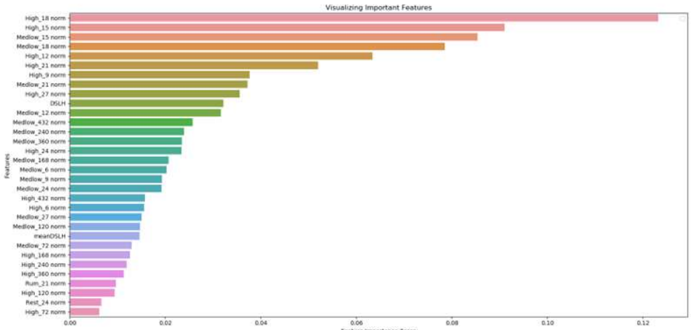
Conclusion

- To enhance reproductive performance in dairy cows, it is essential to detect estrus onset associated with ovulation time in a timely and accurate way to ensure high pregnancy rates and profitability.
- Behavioral data about dairy cows' rumination, resting, feeding, and activity were utilized in our model. These data were collected by Dairymaster's MooMonitor+, which is the first system validated in both indoor and outdoor systems. The model's accuracy was improved by including calculated variables like days since last heat and mean of days since last heat. Different rolling means were calculated after normalizing behavioral data to the herd level. Finally, the most important features for the model were selected and parameters were changed in the algorithm appropriately.



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