Identification of the Best Accelerometer Features and Time-scales to Detect Disturbances in Calves

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Objective

Identify the best performing features for the detection of the disturbances in calves' health and welfare using time series data from tri-axis accelerometer sensors mounted on a neck-collar.

Hypothesis

Features depicting the energy level and structure of the activity derived from accelerometer time series data have the ability to identify disturbances related to calves' health and welfare.

Research Strategy

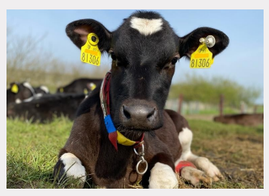
Calves' dehorning was used as the stressful event. Accelerometer features were extracted the day before and the day after dehorning with several time-scales. Machine Learning feature selection methods and Machine Learning models were used to find the best set of features and time-scales to classify between the day before and after dehorning.

BACKGROUND

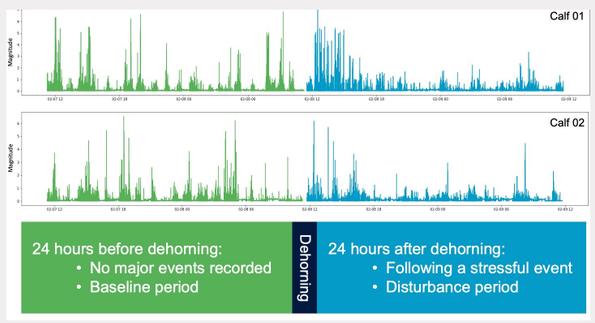
- Development of new decision tools in the context of Precision Livestock Farming but lack of tools to detect stressful events or diseases, especially in calves.
- Early detection of health and welfare would help to increase cattle welfare and decrease the cost of treatment of cattle.
- Automatic early detection of stressful events in calves would be a major contribution to the field.

MATERIALS AND METHODS

- Trial conducted at the Teagasc Moorepark Research Farm (Ireland) with ethical approval from Teagasc Animal Ethics Committee.
- 47 calves equipped with a tri-axis accelerometer sensor (25 Hz) were used.
- The data of the day prior and the day after the dehorning event (i.e. stressful event) considered for the experiment.

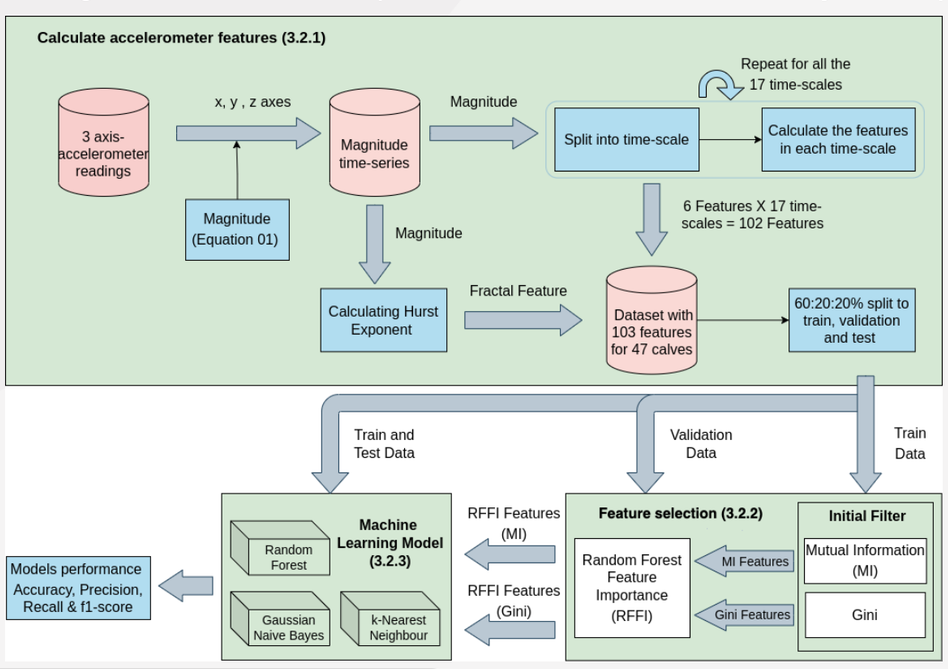


Calf equipped with a 3-axis accelerometer sensor (Axivity Ltd)



Behaviour of raw magnitude series on the day before and after dehorning

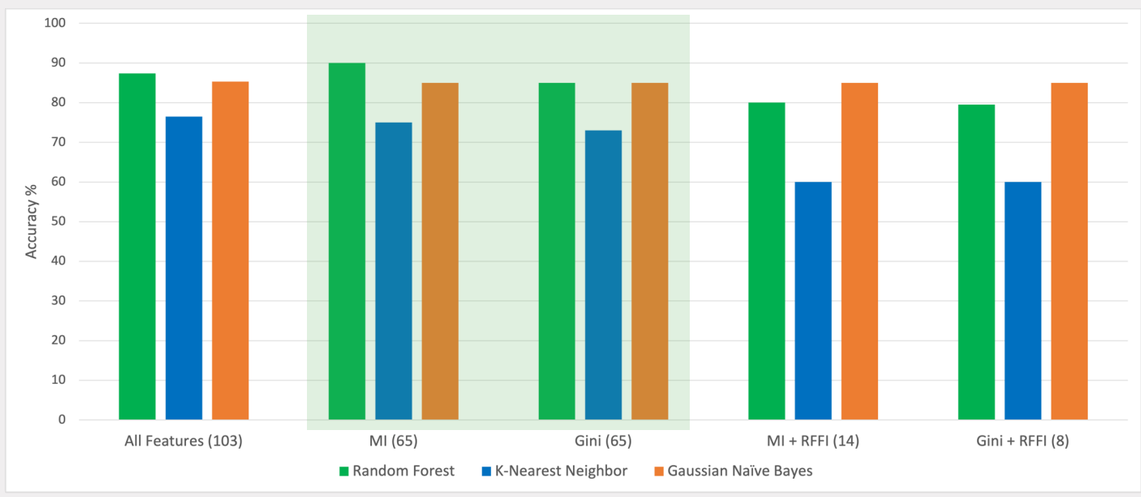
1. **103 features derived from accelerometer magnitude**:
   - 17 times scales: 1 second - 24 hours.
   - Six features at each time scale: maximum, mean, medium, standard deviation, entropy, motion variation.
   - Hurst exponent at 24-hour time scale.
2. **Feature Selection: 2 stages:**
   1. Mutual information (MI) and Gini index to remove 60% least informative features.
   2. Random Forest Feature Importance to reduce the most important feature set further.
3. **Modeling with three ML models (Random Forest, Gaussian Naïve Bayes, k-NN)**



Pipeline

RESULTS

- The highest accuracy of 90% with Random Forest with features selected using MI.
- Random Forest Feature Importance (RFFI) results in a reduction in accuracy – probably due to overfitting.
- Conclusion: Use MI or Gini procedures alone (without RFFI).



Model accuracies obtained for all the features, 65 non-zero MI features, 65 best Gini features, best 14 MI + RFFI features and best 8 Gini + RFFI features

Top features and associated time-scales obtained from MI and Gini ranking scores

Top Features	Time-Scale							
	1 sec	15 mins	30 mins	1 hour	2 hours	6 hours	12 hours	24 hours
Maximum								
Standard Deviation								
Hurst Exponent								
Spectral Entropy								

MI Selection — Gini Selection — MI and Gini Selection

CONCLUSION

- Both features for energy expenditure and structure are included in the most important features with a time scale that is different from one feature to another, suggesting that:
  1. Both components of the activity must be considered.
  2. Time-scale should be adapted to each feature.
- For future work, 65 non-zero MI features are the best candidates as the addition of the second filter stage with RFFI decreases the model performance. This may be due to the high correlation between features. Thus, other feature selection methods such as Correlation Based Feature Selection should be investigated to address this issue.
- Accelerometer features indicating activity level and structure are promising for developing a model for early detection of calf disturbances, which would be a major contribution to the field.

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