# Across flock predictions of the behaviours of grazing sheep using ear and jaw mounted accelerometers

*I.M. Harris*[A,D], *M. Ferguson*[A], *C. Macleay*[B], *and A. N. Thompson*[C]

[A]neXtgen Agri, St Martins, Christchurch 8022 New Zealand
[B]Department of Primary Industries and Regional Development, South Perth WA 6151 Australia
[C]College of Science, Health, Engineering and Education, Murdoch University, Murdoch WA, 6150, Australia
[D]Email: ian@nextgenagri.com

Recent advances in the development of wearable accelerometer sensors together with analytical techniques through machine learning approaches have provided new opportunities for the sheep industry. These new tools bring a completely new level to monitoring the behaviour patterns of individual animals to inform decision-making and enhance productivity, animal welfare and labour efficiency in the sheep industry. Machine learning solutions have been used on accelerometer data to accurately classify behaviours such as running, walking, grazing, lying and or standing (Barwick *et al*. 2018; Walton *et al.* 2018). The algorithms developed in these studies have been validated using a small number of sheep within the same flock. The hypothesis tested in this paper was that algorithms could be developed to accurately predict the behaviours of sheep across flocks.

This study involved attaching accelerometers to the ear and jaw of 10 sheep in five different flocks. The resulting tri-axial acceleration data and concurrent video recordings (about 10 hours per sheep) were collected to generate a dataset of ten second epochs of acceleration data and corresponding behaviour observations. Each ten second epoch was coded with one or more of the following behaviours: walking, sitting, standing, grazing and ruminating. All the initial machine learning was performed by combining the observed behaviours into three classifications: grazing, ruminating and other. Reducing the categories allowed the machine learning algorithms to train on balanced datasets of ~82,000 observations. Most of the previous studies converted the acceleration data into metrics which were used as the feature columns rather than directly using the acceleration waveforms (le Roux *et al.* 2017; Barwick *et al*. 2018; Walton *et al.* 2018). All the metrics used in these studies were included, along with the Fourier coefficients (frequency, real and imaginary) for the frequencies with the five largest amplitudes.

The six-best metrics as prioritised by a Random Forest Classifier were: (i) Acceleration slope difference between 25% and 75%; (ii) Acceleration difference between 25% and 75%; (iii) Movement variation; (iv) Acceleration spectral entropy; (v) Acceleration standard deviation; and (vi) Acceleration slope standard deviation. The six favoured metrics and the associated observed behaviours were used to train Deep Neural Network (DNN) behaviour classifiers. Data was collected from five flocks with different feeding conditions in order to increase the generality of the trained classifiers. Validation was performed with leave-one-out testing where the DNN was trained on four flocks and tested on the remaining flock. All flocks were cycled through the role of being the validation flock resulting in a cross-flock average classification accuracy of over 80% for ear-mounted sensors and 84% for jaw-mounted sensors. The classifier was most accurate at predicting when an animal was grazing (Figure 1).

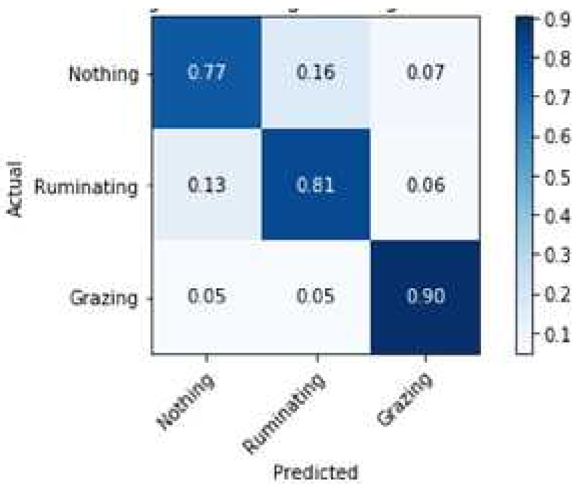


**Figure 1. Behaviour classifier confusion matrix for jaw mounted accelerometers**

In conclusion, both sensor locations provided useful prediction accuracy allowing the potential of continuous monitoring of sheep behaviours in other un-observed flocks. These and other behaviors are now being used to predict changes in feed intake to assist with paddock movement and feeding decisions and the time of lambing.

**References**

Barwick J, Lamb D, Dobos R, Schneider D, Welch M, and Trotter M (2018) *Animals* 8(1), 12.
le Roux SP, Marias J, Wolhuter R and Niesler T. (2017). *Animal Biotelemetry* 5:25.
Walton E, Casey C, Mitsch J, Jorge A, Vázquez-Diosdado A, Yan J, Dottorini T, Ellis K, Winterlich A and Kaler J (2018). *Royal Society Open Science* 5, 171442.

*Special thanks to Meat and Livestock Australia, Australian Wool Innovation, Department of Education and Training WA and Murdoch University for helping to fund this work.*