

SPATIALLY ENABLED LIVESTOCK MANAGEMENT SYMPOSIUM 2014



18th November 2014, Hamilton, New Zealand



New Zealand's specialist land-based university



PROCEEDINGS OF THE 2014 AUSTRALIAN AND
NEW ZEALAND SPATIALLY ENABLED
LIVESTOCK MANAGEMENT SYMPOSIUM

Edited by
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Contents

Contents	1
Programme	2
Keynote Speakers.....	4
Precision Dairy Management: The Good, The Bad, and The Ugly	5
Livestock management - does space really matter?	6
Paper Presentations.....	7
Mobile milking: Potential application and spatial land use implications	8
Understanding sheep behaviour from a tri-axial accelerometer	9
Use of supplementary feeding stations in a grazed wheat crop to increase the dispersion of sheep and their utilisation of the crop	10
Examining the potential for Virtual Fencing in Brangus cattle	11
The challenge of measuring energy expenditure in free-ranging production livestock.....	12
A “six inch front harvester” yield map: developing measures of spatial variability in productivity that are meaningful to graziers.....	13
Development of a speed-based behaviour model for grazing cattle.....	14
Use of remote sensing for urine patch detection	15
OPTIMUM-N: Machine vision for detection of clover and herbs in pasture.....	16
Spatiotemporal estimation of senescent grassland landscapes using Landsat.....	17
Land and Environment Plans on New Zealand Sheep and Beef Farms.....	18
An innovation systems approach to developing precision technologies.....	19
Good data practices and shared vocabularies to support better farm decisions.....	20
Building Collaborative Cyber-infrastructure for Spatially Enabled Livestock	21
A teaching resource to engage the next generation of agricultural scientists using autonomous livestock monitoring technologies	22
Poster Presentations.....	23
An animal monitoring system (PAWS) that could be used to trap dogs, dingos and foxes.....	24
Why are we evaluating the viability of two automatic milking systems (robotic milking) farm systems in Central Canterbury?	25
Learning from NI Go, Sow, Grow Autonomous Robotic Competition.....	26
Index	27

Programme

8.00 am Registration, tea & coffee

8.30 am Welcome address

Robyn Dynes, Precision Agriculture Association of New Zealand

8.45 am Keynote presentations

Precision Dairy Management: The Good, The Bad, and The Ugly

Jeffrey Bewley, University of Kentucky, Lexington, USA

Livestock management - does space really matter?

David Swain, Central Queensland University, Rockhampton, Australia

10.15 am Morning tea

10.45 am Presentations

Mobile milking: Potential application and spatial land use implications

Mark Neal, Dairy NZ, New Zealand

Understanding sheep behaviour from a tri-axial accelerometer

Jamie Barwick, PARG, University of New England, Australia

Use of supplementary feeding stations in a grazed wheat crop to increase the dispersion of sheep and their utilisation of the crop

Dean Thomas, CSIRO, Australia

Examining the potential for Virtual Fencing in Brangus cattle

Zac Economou, PARG, University of New England, Australia

The challenge of measuring energy expenditure in free-ranging production livestock

Robin Dobos, NSW DPI Beef Industry Centre of Excellence and PARG, University of New England, Australia

A “six inch front harvester” yield map: developing measures of spatial variability in productivity that are meaningful to graziers

Mark Trotter, PARG, University of New England, Australia

Development of a speed-based behaviour model for grazing cattle

Jessica Roberts, PARG, University of New England, Australia

12.05 pm Lunch

12.05 pm Lunch

12.50 pm Poster Session 1

1.05 pm Presentations

Use of remote sensing for urine patch detection

Ina Draganova, NZCPA, Massey University, New Zealand

OPTIMUM-N: Machine vision for detection of clover and herbs in pasture

Jessica Roberts, Lincoln Agritech Ltd, New Zealand

Spatiotemporal estimation of senescent grassland landscapes using Landsat

Rebecca Phillips, Landcare Research, New Zealand

Land and Environment Plans on New Zealand Sheep and Beef Farms

Erica van Reenen, Beef + Lamb, New Zealand

An innovation systems approach to developing precision technologies

Callum Eastwood, Dairy NZ, New Zealand

2.05 pm Afternoon tea

2.20 pm Poster Session 2

2.35 pm Presentations

Good data practices and shared vocabularies to support better farm decisions

Andrew Cooke, Rezare Systems Ltd, New Zealand

Building Collaborative Cyber-infrastructure for Spatially Enabled Livestock

Hamish Campbell, School of Environmental and Rural Science, University of New England, Australia

A teaching resource to engage the next generation of agricultural scientists using autonomous livestock monitoring technologies

Mark Trotter, PARG, University of New England, Australia

3.15 pm Panel Discussion

3.55 pm Close

4.00 pm End of symposium

Keynote Speakers

Precision Dairy Management: The Good, The Bad, and The Ugly

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Technologies are changing the shape of the dairy industry across the globe. In fact, many of the technologies applied to the dairy industry are variations of base technologies used in larger industries such as the automobile or personal electronic industries. Undoubtedly, these technologies will continue to change the way that dairy animals are managed. This technological shift provides reasons for optimism for improvements in both cow and farmer well-being moving forward. Many industry changes are setting the stage for the rapid introduction of new technologies in the dairy industry. Dairy operations today are characterized by narrower profit margins than in the past, largely because of reduced governmental involvement in regulating agricultural commodity prices. The resulting competition growth has intensified the drive for efficiency resulting in increased emphasis on business and financial management. Furthermore, the decision making landscape for a dairy manager has changed dramatically with increased emphasis on consumer protection, continuous quality assurance, natural foods, pathogen-free food, zoonotic disease transmission, reduction of the use of medical treatments, and increased concern for the care of animals. Lastly, powers of human observation limit dairy producers' ability to identify sick or lame cows or cows in heat. Precision dairy management may help remedy some of these problems. Precision Dairy Management is the use of automated, mechanized technologies toward refinement of dairy management processes, procedures, or information collection. Precision dairy management technologies provide tremendous opportunities for improvements in individual animal management on dairy farms. Although the technological "gadgets" may drive innovation, social and economic factors dictate technology adoption success.

Though Precision Dairy Farming is in its infancy, new Precision Dairy Farming technologies are introduced to the market each year. As new technologies are developed in other industries, engineers and animal scientists find applications within the dairy industry. More importantly, as these technologies are widely adopted in larger industries, such as the automobile or personal computing industries, the costs of the base technologies decrease making them more economically feasible for dairy farms. Because the bulk of research focused on Precision Dairy Farming technologies is conducted in research environments, care must be taken in trying to transfer these results directly to commercial settings. Field experiments or simulations may need to be conducted to alleviate this issue. Because of the gap between the impact of Precision Dairy Farming technologies in research versus commercial settings, additional effort needs to be directed toward implementation of management practices needed to fully utilize information provided by these technologies. To gain a better understanding of technology adoption shortcomings, additional research needs to be undertaken to examine the adoption process for not only successful adoption of technology but also technology adoption failures. Before investing in a new technology, a formal investment analysis should be conducted to make sure that the technology is right for your farm's needs. Precision dairy farming technologies provide tremendous opportunities for improvements in individual animal management on dairy farms. In the future, Precision Dairy Farming technologies will change the way dairy herds are managed.

Livestock management - does space really matter?

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A recently completed project in northern Australia, funded by Meat and Livestock Australia (MLA), used a series of case studies to explore the potential benefits of precision livestock management technologies. Location tracking technologies were considered. All of the case study managers agreed that they wanted to know where their cattle were. However, when asked to define the benefits, all of the managers found this question difficult to answer. The benefit that the managers could most easily define related to the cost saving from more efficient mustering. But all of the managers found it more difficult to identify or estimate a production benefit.

The availability of global positioning systems (GPS) to monitor livestock location and movement has provided researchers with expanding opportunities to explore previously unknown drivers of livestock behaviour. Monitoring the location and movement of livestock has generated some interesting research results but there is little evidence that these novel data have been translated into practical spatially enabled livestock management.

Research studies have used livestock location information to explore a range of questions including; landscape preferences (Bailey et al., 2001), social behavior (Swain and Bishop-Hurley, 2007), movement behaviour and links to physiological drivers (Rutter et al., 1997) and the effect of livestock on the landscape (Betteridge et al., 2010). Given the research effort to use livestock spatial data, it is surprising that there isn't greater industry use of spatially enabled livestock management. The MLA precision livestock management case study project demonstrated that farmers are looking for opportunities to use spatially enabled livestock management tools. The economic assessment of the value proposition demonstrated that the cost of the technology was a limiting factor. Some of the practical constraints e.g. long-term power needs are also limiting uptake of spatially enabled livestock management technologies.

Perhaps the single most important area that spatial livestock data could have commercial value is through better information on livestock behaviour. Behavioural information can be used to directly quantify production drivers e.g. grazing efficiency and indirectly through proxies that quantify physiological drivers such as reproductive performance. The role of social organisation and the relative location of individual animals is emerging as an important driver of production outcomes. Research is beginning to show that there are hidden consequences if social groupings are disrupted.

The presentation uses the MLA funded precision livestock management data to explore the potential role of spatial livestock information as a tool to aid livestock management. The challenge of determining production benefits is explored. In the context of both the cost and the practical constraints of collecting spatial livestock data I consider whether space really matters for livestock managers. I also explore the potential research avenues that could be used as stepping-stones towards greater uptake of spatially enabled livestock management. I will use examples of how spatial data are being used to determine behavioural preferences for both direct and indirect production drivers. Finally I will provide examples of how understanding the relative location and social organisation of livestock might be an important element of future spatially enabled livestock management.

Bailey, D., Welling, G., Miller, E., 2001. Cattle use of foothills rangeland near dehydrated molasses supplement. *Journal of Range Management* 54, 338–347.

Betteridge, K., Costall, D., Balladur, S., Upsdell, M., Umemura, K., 2010. Urine distribution and grazing behaviour of female sheep and cattle grazing a steep New Zealand hill pasture. *Animal Production Science* 50, 624–629.

Rutter, S., Champion, R., Penning, P., 1997. An automatic system to record foraging behaviour in free-ranging ruminants. *Applied Animal Behaviour Science* 54, 185–195.

Swain, D., Bishop-Hurley, G., 2007. Using contact logging devices to explore animal affiliations: Quantifying cow-calf interactions. *Applied Animal Behaviour Science* 102, 1–11.

Presentations

Mobile milking: Potential application and spatial land use implications

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Mobility and milking from grass have a long and linked history, with nomads milking cows, goats, sheep and camels over 10,000 years ago, moving to food and feed supplies. Concurrent factors that are likely to have led to a reduced mobility of the milking process include agricultural advances and land cultivation, improved feedbase, development of property rights, specialised milk production genetics, new technology, feed conservation, relative costs (eg labour to capital) and increasing income (modern economics and skill specialisation).

Despite these general trends, there still exists a niche for mobile milking parlours. There are mobile (or relocatable) multiple-stall milking parlours, similar to herringbones or walkthroughs, operating in a number of countries, including New Zealand, Chile, Argentina, UK, Ireland, and Italy. Furthermore, there has been a range of efforts to incorporate Automatic Milking System (AMS) “box” units into mobile systems, in countries including Denmark, Belgium, France, the Netherlands, Norway and Germany. AMS mobility ranges from being moved a few times per year, Lessire et al. (2014) to daily movement (Kea et al., 2011).

What needs does a mobile milking solution address that a traditional fixed parlour cannot? Mobile milking allows the use of smaller or fragmented land parcels. It also allows land to be milked off where land owners are unwilling or unable to build a fixed facility, potentially facilitating new entrants in lease or share-farming arrangements. Mobile AMS also addresses situations where milking labour is difficult or expensive to employ and manage.

Mobile AMS offers the potential to exploit lower cost land that is not economically milked with a fixed parlour. For example, in New Zealand, the minimum economic size for a farm unit to support a full time skilled labour unit is around 200 cows (80 hectares). If the trend for decreasing real cost of AMS technology continues, and scale economies are potentially reached with one AMS box at a herd size as low as 120 cows at 1.3 milkings per day (50 hectares), mobile technology may allow a significant number of land fragments to enter (or return to) milk production from grazed grass. Economic feasibility would be improved by advances that reduce labour input, allowing a mobile AMS unit of 120 milking cows to operate with 0.3 to 0.5 of a labour unit.

The presented review considers the opportunity for mobile AMS to be applied in New Zealand. While the feasibility of mobile AMS has been demonstrated (Oudshoorn et al., 2013), its optimal management requires further investigation. Furthermore, in sensitive catchments, the opportunities to use mobility in avoiding nutrient overload in critical source areas and laneways needs to be evaluated. Then the economics of the optimised system, taking into account any environmental constraints, needs to be analysed initially for the most likely niche – land fragments with minimal infrastructure, relatively expensive labour and sensitive catchments. Ultimately, the scope of opportunities and the potential spatial distribution can be estimated.

Kea, MV (2011) Cow behaviour in a mobile AMS farm system. Masters Thesis, Wageningen University.

Lessire F, Hornick JL, Dufrasne I (2014) Effects of concentrate levels on milk production and traffic of cows milked by a mobile automatic milking system on pasture, Proceedings of the 25th General Meeting of the European Grassland Federation, 19, 154-156.

Oudshoorn FW, Philipsen B, Dufrasne, I (2013) Using mobile milking robots for special quality dairy products based on site specific Grazing. Proceedings of the 25th General Meeting of the European Grassland Federation, 19, 276-278.

Understanding sheep behaviour from a tri-axial accelerometer

Jamie Barwick, Mark Trotter, Robin Dobos, David Lamb, Mitchell Welch, Derek Schneider and Zac Economou

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An animal's behaviour can be a clear indicator of their physiological and physical state. Therefore as resting, eating, walking and ruminating are the predominant daily activities of ruminant animals, monitoring these behaviours could provide valuable information for management decisions and individual animal health status. Traditional animal monitoring methods have relied on human labour to visually observe animals. Accelerometer technology offers the possibility to remotely monitor animal behaviour continuously. Accelerometers are being used in the dairy industry to detect lameness and oestrus but to date there has been limited research using accelerometers to classify sheep behaviour. The aim of this study was to determine the effectiveness of an eartag, collar and front leg deployed accelerometer sensor to differentiate between, grazing, standing and walking behaviours in a single merino ewe. The raw x, y and z acceleration values were used to calculate the following movement metrics: Average X, Y and Z, Energy, Entropy, Movement Intensity (MI), Standard Deviation of Movement Intensity (SDMI), Signal Magnitude Area (SMA) and Average Intensity (AI). All possible combinations of 2 and 3 metrics were analysed using Linear Discriminant Analysis (LDA). The accuracy of each deployment location and the most accurate metric combination is displayed in Table 1. Figure 1 shows a five-second trace of the raw X axis accelerometer signal from the eartag deployment. Results indicate that accelerometer technology is capable of identifying sheep behaviour; however developing suitable accelerometer sensors still remains a limiting factor to the commercialisation and uptake of such technologies.

Table 1. Summary of the correctly identified behaviours for each deployment location

Accelerometer Deployment	Behaviours Correctly Identified		
	Grazing	Standing	Walking
Front Leg	78%	100%	100%
Collar	79%	96%	100%
Eartag	100%	92%	89%

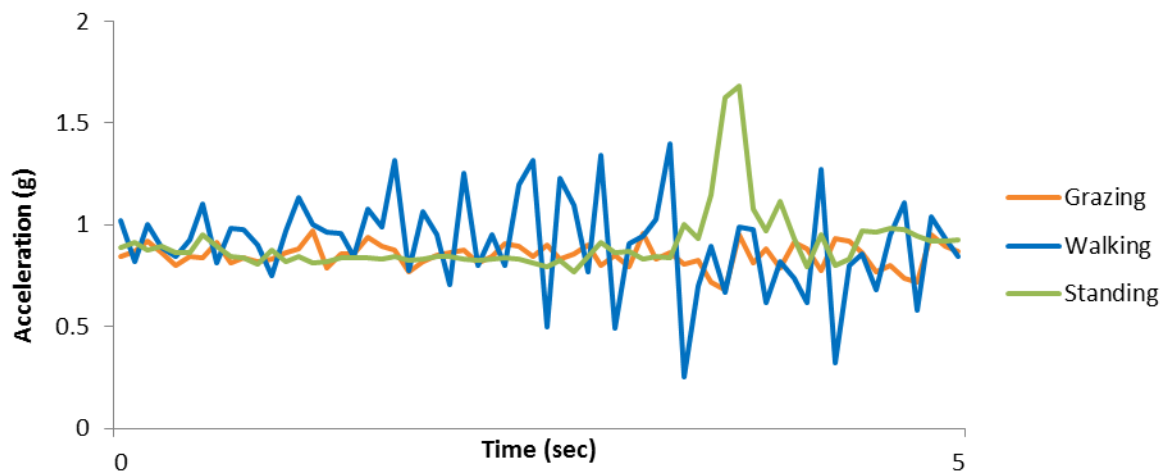


Figure 1. A five second trace of the X axis accelerometer signals for each activity taken from the eartag deployed sensor.

Use of supplementary feeding stations in a grazed wheat crop to increase the dispersion of sheep and their utilisation of the crop

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Interest in grazing sheep on cereal crops, that go on to produce grain, has increased in the lower-rainfall parts (< 350 mm) of the cereal-livestock zone, where the shorter-season crop varieties are grazed for several weeks prior to the plants reaching the stem elongation stage. Grazing of crops can provide farmers with an important source of feed in late autumn and early winter, where demand for feed typically exceeds supply from pastures, while having a minimal impact on subsequent crop yield. In lower-rainfall regions, grazing short-season wheat crops has some unique challenges. Whole-farm stocking rates are lower and paddocks are larger, which tends to result in lower grazing intensity and patchy utilisation of crops (Mata et al. 2014). Preference for particular areas of crop is presumably associated with various paddock features (such as shelter and topography) and also differences in the chemical characteristics of the crop within the paddock. Uneven grazing may exacerbate any yield penalties from grazing of crops and will make farmers reluctant to graze the crops for longer periods to gain the full benefit of crop grazing. Our aim was to improve the uniformity of grazing by attracting sheep from over- to under-utilised areas of a wheat crop with the use of a mineral supplement.

Two ~50 ha paddocks of spring wheat cv. Magenta were grazed by Merino sheep (4 sheep ha⁻¹) for 2 weeks without supplement. Subsequently in each paddock, plots of high (H=3), medium (M=3) and low (L=6) grazing intensity (60 m x 60 m) were selected based on GPS tracking of 7 sheep per paddock and kernel density analysis. A mineral supplement was placed in half of the low grazing intensity plots (LS), and the remaining low intensity plots were used as a control treatment. The paddocks were then grazed for a further two weeks to determine if the supplement altered grazing distribution. Crop biomass cuts and visual grazing score measurements were taken throughout the experiment to investigate any effects on the crop associated with the distribution of the sheep.

Supplement was consumed throughout the post-supplement grazing period, with an average consumption of 17.5 g head⁻¹ day⁻¹. Installing the supplement feeding stations did not affect the daily distance travelled by the sheep (pre- v post-supplement; 9.2±0.4 v 8.8±0.2 km day⁻¹). There was a significant time (pre- v post-supplement) x treatment (grazing intensity) interaction for the proportion of GPS points per plot (P<0.001). Compared with the pre-supplement period, activity in H plots was halved, while there was 2.1 and 4.1 times more activity in L and LS plots, respectively, after the stations were installed. No significant changes in crop biomass and grazing score were observed across the treatments with the introduction of the supplement stations, although there were some statistical trends in the expected directions in these data (P>0.05). The results indicate that sheep activity became more evenly distributed overall after the introduction of supplement stations, and activity in low intensity grazing areas with supplement (LS) increased by twice the amount of the control areas without supplement (L). However, there was some natural transfer of activity from high to low intensity areas, perhaps due to depletion of feed at the H sites. The lack of supporting evidence from the pasture biomass and grazing score measurements meant we cannot be sure sheep actually grazed more in the areas adjacent to the supplement and it is possible that the sheep spent more time in the LS area to consume the supplement, rather than grazing the crop.

Mata, G., Thomas, D., Toovey, A., Ota, N. and Hancock, R.N. (2014) Spatial correlation of livestock movements, grazing impact assessments and biomass loss from grazing a vegetative wheat crop. *Proceedings of the 30th Biennial Conference of the Australian Society of Animal Production*. 8-12 September 2014, National Convention Centre, Canberra ACT, Australia. p 287.

Examining the potential for Virtual Fencing in Brangus cattle

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Managing livestock grazing behaviour has a number of benefits for both the producer and the environment. There is enormous potential for the adoption of virtual fencing (VF) technology for the control of livestock distribution and landscape utilisation (Anderson, 2007; Umstatter, 2011). An important factor of livestock behaviour is their tendency to over and under-utilise parts of a paddock. This behaviour causes a number of environmental problems, including changes in sward characteristics, nutrient redistribution and environmental degradation.

To test the viability of VF technology for managing cattle behaviour 6 Brangus bullocks were fitted with VF units. The bullocks were allowed to graze their paddock freely before being moved to one end and the VF activated. The objective was to study animal responses to stimuli and evaluate the potential for cattle to be fitted with VF devices as well as highlight any potential problems for long term deployment.

Cattle showed a strong associated learning ability as the experiment progressed. Approaches to the VF became more hesitant when

receiving the audible warning once animals had associated it with the proceeding electrical stimuli. After a number of approaches to the VF, the audible warning was sufficient to stop half the animals from approaching the VF. No short-term behavioural effects were noticed, with cattle returning to graze within 5-20sec following electrical stimulation. Individual variation in the responses to the VF were apparent with two particular animals (ID 2 & 5 in Table 1) interacting with the VF considerably more than others. Full utilisation of the paddock occurred immediately after the VF device was deactivated.

These results suggest that there is potential for the application of VF technology to cattle for modifying paddock utilisation. It also demonstrated that for this group of cattle responses to the VF and subsequent changes to behaviour were minor and that normal grazing/paddock utilisation was not adversely affected.

Table 1 Individual animal approaches and responses to VF

ID	Approaches			Average time to return to normal behaviour
	Audible warning	Electrical stimulus	Breach	
1	0	1	0	10
2	1	5	1	5
3	0	1	0	15
4	0	1	0	5
5	1	5	0	10
6	1	2	0	3

Anderson. (2007). Virtual fencing—past, present and future. *The Rangeland Journal*, 29(1), 65-78.

Umstatter, C. (2011). The evolution of virtual fences: A review. *Computers and Electronics in Agriculture*, 75(1), 10-22. doi: <http://dx.doi.org/10.1016/j.compag.2010.10.005>

The challenge of measuring energy expenditure in free-ranging production livestock

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Energy expenditure (EE) is an inevitable occurrence since it is an unavoidable consequence of existence. Data on energetics provide valuable information on energy expenditure and consumption. Comparative energetics can test hypotheses concerning variation in energy expenditure due to behavioural, physiological, morphological or ecological differences. The history of describing the energetic efficiency of livestock has been focused on groups or genotypes and the factors that determine their diet energy requirements. More recently Johnson et al. (2003) has recommended a change in focus towards methods to assess individual animal differences in energetic efficiency, particularly on variations in energy requirements for maintenance. To accomplish this goal, a practical means of identifying individuals of merit must be developed to replace the very costly and cumbersome respiration or slaughter balance methods. Five mechanisms contributing to variation in efficiency under genetic control have been suggested that could be studied (Oddy and Herd 2001). These are: 1) feed intake, 2) digestion of feed, 3) metabolism, 4) activity, and 5) thermoregulation. Johnson et al. (2003) suggested adding the following to the list: 6) rate of gain, 7) body weight (BW), and 8) prolificacy. Also, metabolism should be separated into at least two components: 3a) maintenance and 3b) growth metabolism. None of these traits can be ignored, if only to ensure minimum or no negative consequences. There are a number of indirect techniques and the two that are relevant to autonomous livestock management are heart rate (HR) and accelerometers. The need to “calibrate” each animal and then to show they are not “stressed” by the measurement process presents serious limitations. Calibrated O₂/HR monitoring combined with accelerometers may provide a way to investigate activity energy loss variations in production circumstances. Accelerometers have been used on various wildlife species to understand how they hunt and feed, as well as calculate the overall dynamic body acceleration (ODBA) of some of these species (Shepard et al., 2008). This theoretically valid proxy of EE is the acceleration of the animal’s body mass due to movement of its body parts. Similar to the HR technique and others, ODBA requires calibration using indirect calorimetry. Therefore, to improve our understanding of EE and efficiency in grazing livestock and hence improve selection for more efficient livestock, we propose the use of ODBA as a proxy for EE in production livestock. This idea requires testing and validation in production livestock.

Gleiss AC, Wilson RP, Shepard, ELC (2011) Making overall dynamic body acceleration work: on the theory of acceleration as a proxy for energy expenditure. *Methods in Ecology and Evolution* 2, 23-33

Johnson DE, Ferrell CL, Jenkins TG (2003) The history of energetic research: where have we been and where are we going? *J. Animal Science* 81, E27-E38

Oddy VH, Herd RM (2001) Potential mechanisms for variation in efficiency of feed utilization in ruminants. Pages 30–34 in *Feed Efficiency in Beef Cattle*, Proc. of the Feed Efficiency Workshop. CRC for Cattle and Beef Quality. Univ. of New Armidale, Armidale, Australia.

Shepard ELC, Wilson RP, Halsey LG, Quintana F, Laich AG, Gleiss AC, Liebsch N, Myers AE, Norman B (2008) Derivation of body motion via appropriate smoothing of acceleration data. *Aquatic Biology* 4, 235-241

A “six inch front harvester” yield map: developing measures of spatial variability in productivity that are meaningful to graziers

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The cropping industry has had access to measures of spatial variability in production (yield maps) for over two decades now. Yield maps facilitate a range of management decisions: producers can identify and ameliorate underperforming areas; better match crop type to land class; classify areas for removal from production based on economics; develop zonal management strategies that facilitate variable rate application of numerous inputs such as seed and fertiliser; and undertake

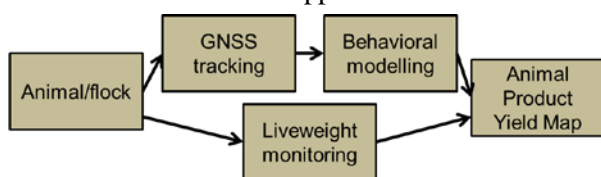


Figure 1 Schematic of data sources and flow for producing an animal product yield map information, however they lack the link to the actual commodity being produced on the property (i.e. they measure pasture not meat, milk or wool production). This abstract reports proposes a protocol for producing animal product yield maps (APYM) by integrating GNSS tracking and animal behavioural modelling (specifically grazing activity) with live-weight gain monitoring (Figure 1). An APYM reveals the spatial variability and productivity expressed in terms relevant to producers (e.g. kg of red meat grown per day). In this case study we developed an APYM for a 3.7 ha field grazed by sheep on the UNE SMARTfarm. Twenty mixed aged Merino ewes were randomly selected from a larger commercial flock and fitted with UNTracker GNSS collars and tracked for a period of 43 days. Live weight change was recorded by static weighing at the start and finish of the trial period. The GNSS data were processed to identify grazing behaviour-related

complex on-farm experimentation. However, to date, no such system has been developed for grazing livestock systems. Attempts have been made to use plant biomass monitoring technologies to provide an indication of landscape variability, and these do provide valuable

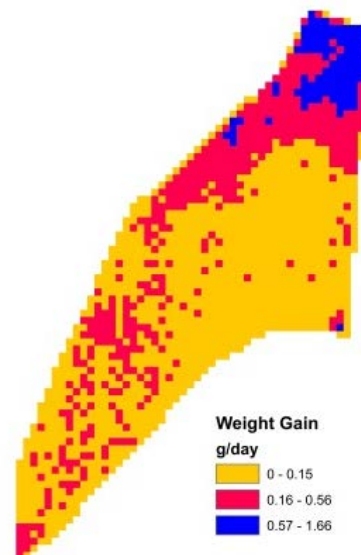


Table 2 Statistics for each production zone

Zone	% of area of paddock	% of weight gain
Low	82	44
Medium	13	33
High	5	23

position records which were then mapped as a livestock residence

Figure 2 Animal Product Yield Map derived for a case study field grazed by sheep. The map has been zoned into high (blue) medium (red) and low (orange).

index (LRI). The live-weight gain was then pro-rated across this grid map. The clustered weight

gains (Figure 2) indicate the spatial variability in potential animal growth rate per day for the field. The area and % contribution of each to the weight gain (Table 1) reveals that, in the case of this field the high and medium production zones represented 18% of the field area but contributed 56% of the animal production. While we recognise this approach carries with it a number of assumptions, namely that both feed quality and intake rate is constant during the grazing periods, it nonetheless represents a first pass at creating product-related indicators of in field performance.

Acknowledgements

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Development of a speed-based behaviour model for grazing cattle

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Speed-based behaviour models can allow for the determination of an animal's behavioural state remotely. For example, prominent cattle researchers have developed speed-based behaviour models from GPS tracking of livestock (Anderson *et al.* 2012 and Putfarken *et al.* 2008) in order to ascertain when, where and the plant species cattle grazed. However, there is considerable discrepancy between reported grazing speeds, i.e. grazing speed = 0.06-0.55 and 0.059-0.5m/s (Anderson *et al.* 2012) and grazing speed = 0.22-0.33 m/s (Putfarken *et al.* 2008). Variations are likely due to location logging interval, cattle class and breed, and environment. Thus, it is apparent that behaviour associated speeds need to be verified situationally.

Visual observations of the activity of three focal cattle were recorded at 15 minute intervals during daylight hours every three days over four weeks. The cattle were rotationally grazed in three herds of six, across six paddocks, each of area 0.35ha. The distance and time between two consecutive GPS logs was used to determine the interval speed (average speed of an animal between two recorded locations). The calculated speeds were linked to time aligned activity from the visual observations.

A new statistical model based on generalised extreme value (GEV) distribution and bootstrapping was used to determine speed activity thresholds due to the non-normality and lack of statistical independence of the records. The speed threshold determines whether the cattle's activity is classed as either *moving* or *stationary*. It is determined by calculating the probability (from the GEV distribution) of the animal moving (as opposed to stationary) as being 0.5. The calculated speed threshold in this research was 0.25m/s. Thus, stationary behaviour was assumed when cattle speeds were less than 0.25m/s and moving when cattle speeds were equal to, or larger than, 0.25m/s. There was an overlap of speeds between- and within- animals (between days). This was not unexpected because individual animals are likely to move at different speeds in response to daily influences and GPS error also effects calculated speed.

The development of this speed-based behaviour model allowed researchers to monitor behavioural responses of cattle to declining feed availability, and the purpose was to determine if remote monitoring of livestock behaviour could indicate limiting feed availability. This successfully led to the identification of several behaviours which responded to declining pasture biomass, including daily time spent moving and the daily proportion of a paddock utilised by the cattle, as monitored through GPS livestock tracking.

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Acknowledgements

This project is supported by The AW Howard Memorial Trust; MLA and the CRC for Spatial Information.

Use of remote sensing for urine patch detection

Draganova I., Yule I., Irwin M., Von Bueren S.

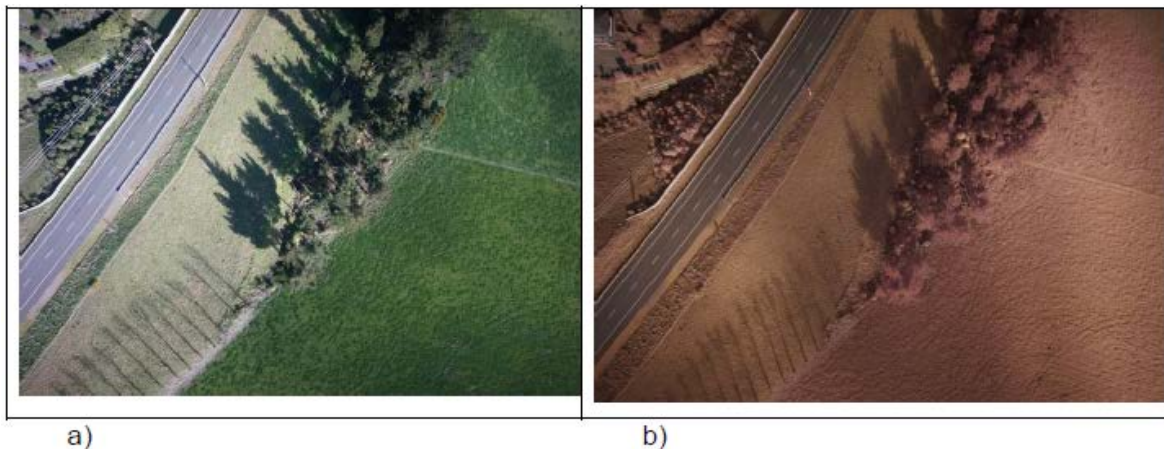
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New Zealand farmers are facing pressure to reduce nutrient losses from their farming enterprises to the environment. Research suggests that on farms the major source of nutrient loss is animal excreta, which for nitrogen (N) relates to cattle urine in particular. Most models used to predict N cycling and loss assume homogeneous distribution of bovine urine patches across paddocks. This study aims to use multi-rotor and fixed wing remotely piloted aircraft systems (RPAS) to locate and identify urine patches from dairy cows, and also monitor their distribution and longevity on the pasture. This can give farmers a more realistic opportunity to inform their nutrient, grazing and pasture management decisions to maximise farm productivity.

Photography has been carried out using modified cameras, Cannon Power Shot SD 780 IS digital camera, both true colour and infrared, and Sony NX5, again both true colour and infrared. The former system was mounted on a hexacopter, flying at between 50 and 70 meters above ground level and covering an area of between 50m x 35m and 70m x 45m per flight. The Sony NX5 camera was mounted on the Trimble UX5 (fixed wing), flying at 115m above ground level covering approximately 60ha in 35min of continuous flying (Figure 1). Ground control points were incorporated into the UX5 survey to allow the mosaic to be georeferenced.

Figure 1. True colour image taken from Trimble UX5 using a Sony NX5 camera (a), infrared image taken from Trimble UX5 using modified Sony NX5 camera (b).



While RPAS can speed up and simplify the data gathering process, image mosaicking and vegetation mapping is extremely processor intensive. It can be prone to interruption from environmental factors such as changes in cloud cover and lighting conditions, and changes to vegetation cover with season. These can make the accurate measurement and calculation of urine patches difficult to achieve.

OPTIMUM-N: Machine vision for detection of clover and herbs in pasture

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The presence of legumes in pastures is known to improve milk production of dairy cattle, due to the high nutritive value compared to grass (Harris *et al.* 1997). Additionally, conventional production systems need to know the legume amount to estimate the contribution of legumes to the nitrogen balance and organic livestock production systems rely exclusively on legumes to fix nitrogen into the soil. Unfortunately, grazed dairy pastures in NZ are commonly underpopulated by legumes (Cosgrove *et al.* 2006). The ability to easily monitor legume content in mixed pasture swards with a high accuracy would assist producers in making agronomic decisions for managing sward composition and nutrients.

A four-channel multispectral camera capable of imaging both RGB (red, green and blue) and NIR (Near Infra-Red) through the same optical path has been used in the development of a system for the detection of grass and broadleaf plants. A broadleaf detection system has been successfully achieved, as displayed in Figure 1 below. This process results in a proportion of clover per area, based on the camera footprint. A calibration study was undertaken in which the biomass captured by the image was harvested and dissected into clover and grass. Proportions of clover and grass estimated by the machine vision were compared with measured harvested biomass. This initial investigation had positive results, despite only four mixed sward sites being included.

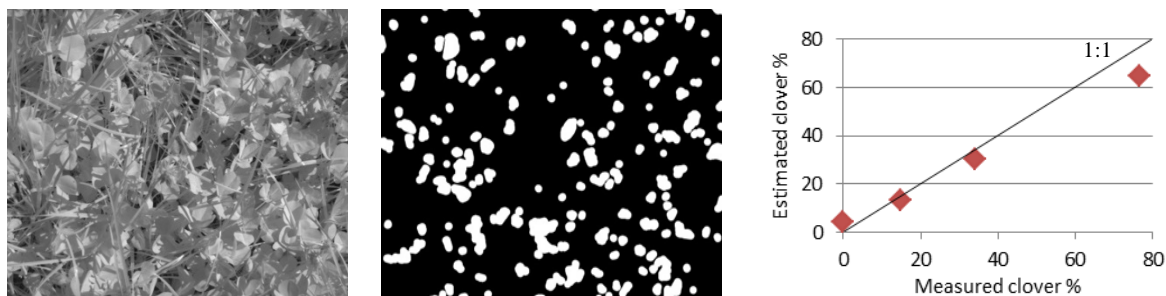


Figure 1. A) NIR image B) clover mask and C) results of comparing estimated and measured clover percentage; of a mixed white clover and rye grass sward.

This technology can be linked to GPS and could be mounted on a vehicle which is regularly driven across paddocks to provide regular paddock estimates of clover or other herbs in pasture. Additionally, the algorithms developed for use with the multispectral camera have been adapted and further developed for a mobile phone app. This will provide farmers with an easy to use solution to instantly estimate sward mix.

Further research challenges for the development of the broadleaf detector include: overcoming sensing a 3D pasture sward with 2D images, calibrating imagery to pasture dry matter amount and determining the proportions of clover relevant to nitrogen fixation rates.

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Acknowledgements

This project is primarily funded by the New Zealand Ministry of Business, Innovation and Employment (grant no: LVLX1203), and involves consultation with farmers, industry and public representatives in New Zealand including C-DAX, Dairy NZ and Environment Canterbury.

Spatiotemporal estimation of senescent grassland landscapes using Landsat

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Large grassland reserves are often used to support both livestock and wildlife in central North America, and total standing crop (TSC) data are often used to assess potential effects of grazing on wildlife habitat cover at the end of the grazing season post plant senescence. Data maps are needed to assess TSC for expansive rangelands, which can be derived from imagery collected by the Landsat. Application of image data to estimate senescent grassland biomass can be problematic post plant senescence, as the 'greenness' signal is diluted by non-photosynthetically active vegetation. Further, it is difficult to know if a spectral model developed for year is reliable the next year. We asked the question: How can we optimise Landsat and field data to accurately map total standing crop (TSC) post-plant-senescence for changing grassland landscapes?

High correlations have been reported between TSC and spectra when plant canopies are mostly green. Vegetation indices using the red and near infrared regions are often effective for mapping plant vigour at peak season across years. These indices, however, are not well correlated when grasses are senescent, particularly when plant canopies are comprised of both photosynthetically active and non-photosynthetically active vegetation. Previous work has indicated that the ratio of short-wave infrared bands predict TSC for senescent grassland canopies using hyperspectral data (Phillips et al. 2013). However, it is not known if the ratio of short-wave infrared bands is effective for estimating senescent grassland TSC using multispectral, Landsat data.

Spectral vegetation indices derived from Landsat data are influenced by variable landscape factors such as plant community distribution, bare soil, canopy greenness, topography, and canopy water content (Phillips et al. 2012). We developed an approach to account for these factors in a Landsat data-driven models in 2010 and 2012 for a 36,000 ha area located in the Northern Great Plains, USA. We used a landscape study design and re-sampling model selection technique to identify indices most predictive of canopy TSC according to topographic position (summit, midslope or toeslope). Predictive models for TSC over the same field plots were modified to achieve lowest root-mean square error for each image (Phillips et al. 2013).

In 2010 and 2012, topographic position and the ratio of the Landsat short-wave infrared bands were predictive of TSC. Canopy percent water content was also selected for 2010 but not 2012. The soil-adjusted vegetation total index was selected in 2012 but not 2010. Results indicates TSC post-plant-senescence can be estimated for expansive landscapes, with data needed for precision grazing that vary year to year. Differences in predictive variables between 2010 and 2012 were likely driven by differences in canopy percent water content.

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Land and Environment Plans on New Zealand Sheep and Beef Farms

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Sheep and beef farming in New Zealand is fundamentally about using the soil resource to grow grass and turn it into high quality protein in the form of red meat and wool. The production of grass requires soil, water and nutrients and it is the careful management of these resources that determines the success or otherwise of a farmer. Land and environment plans (LEP) provide a useful tool for farmers to assess their resources and develop a management plan to achieve the best economic and environmental outcomes. The process of land and environment planning has been used in New Zealand since the late 1940s, adapted from a process used in the United States to deal with reoccurring drought conditions (McCaskill 1973). The underlying principle is to identify the most productive and profitable system of land use according to farm-unique characteristics and capabilities of land, soil and other base resources.

In 2008, Meat & Wool New Zealand launched the first Land and Environment Plan Toolkit which has subsequently been updated as a Beef + Lamb New Zealand Resource. In early 2014, the resource was developed into a tool that could be presented to farmers in a workshop format enabling 10-15 attendees the opportunity to develop an LEP that met the needs of their farm system. The toolkit is constructed with three levels. Level 1 introduces farmers to the concepts of land and environment planning and supports them through a stocktake of resources and the development of a response plan – the LEP. This is done using farm maps and aerial photos in conjunction with a risk assessment process. Level 2 is more detailed and helps the farmer divide the farm into land management units (LMU), includes a strengths and weaknesses analysis and a nutrient budget which all inform the subsequent LEP. Again the plans are developed by the farmer using maps to inform the process. Level 3 draws on standards and methods used by professional farm planners to produce a more detailed LEP. This will primarily require specialist, one-on-one support with some information potentially developed in a workshop setting (Paterson *et al.* 2014).

In early 2014 Morrison Farming, who own Mangara Station, a 1000 hectare Rangitikei sheep and beef breeding farm, completed the Level 1 LEP. Morrison Farming, a family owned company, also included their staff members in the planning process to empower them, and helped everyone to understand the LEP. The LEP has enabled them to undertake development on the property in a way that will provide long-term sustainability of the business.

Future development of the Beef + Lamb New Zealand LEP will involve continuous improvement of the current resource, building and delivering level 2 workshops and developing a delivery plan for level 3. In areas where Regional Councils are requiring farmers to have environment plans, specific compliant versions of the LEP will be developed. These compliancy LEPs will be supported through a workshop process with the same level of support as the existing toolkit. The Beef + Lamb New Zealand Land and Environment Planning Toolkit enables sheep and beef farmers to have a visual and written plan to understand their natural resources and how best to manage them in a sustainable manner for a confident and profitable sheep and beef sector.

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An innovation systems approach to developing precision technologies

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The development of precision technologies often has the researcher as an initial end-user. However, when considering new technologies with for farmers as end-users or the adaptation of research tools for eventual on-farm use, we need to consider the technology within a broader innovation systems context. Innovation systems thinking examines how the interaction of people, knowledge, and institutions can lead to successful innovation.

Research into on-farm use of precision dairy technologies (Eastwood et al. 2012; Eastwood and Kenny, 2009) highlighted the need to carefully assess new high-challenge technologies in a farming context. This involves considering benefits for farmers and realistically assessing the process required to achieve that value. Existing theoretical frameworks of adoption and innovation, such as the ADOPT approach (Kuehne et al. 2012), the innovation uncertainty framework (Meijer et al. 2007), and key functions of innovation systems (Hekkert et al. 2007), all highlight the influence of various aspects of the innovation system on successful innovation.

A technology development framework has been designed to help researchers, developers, and funding agencies step through the wider implications of a new precision farming technology. The framework has three aspects. 'Market considerations' addresses the size and features of the probable market, what pre-existing need it addresses for farmers, potential perceptions among wider farming community, who are the main actors needed to ensure success, and the potential for wider implications (positive or negative) for the industry. 'Technological considerations' examines whether the technology is feasible including development lead times, the interaction/integration with existing technologies and thoughts on ongoing development based on user feedback. 'Capability and skill considerations' assesses the adaptation required by farmers to use the technology, the new skills required for the farm team, capability required in the relevant network of practice (e.g. technicians, consultants, vets, contractors), who is best placed to develop the capability, and how can actors be organised and connected to share knowledge around best practice?

The framework is only in a pilot stage, but provides a useful process for those involved with technology development to consider the external context within which the technology would operate. Lessons learnt from the process could lead to better technology design, or more proactive development of capability and necessary skills within those who will eventually have to support the technology. While based on innovation theory, the framework has been written to minimise jargon and to provide straight-forward suggestions of aspects to consider when thinking of a new technology concept.

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Good data practices and shared vocabularies to support better farm decisions

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Increasing use of precision sensing and management technologies in agriculture, and the adoption of consumer technologies such as smartphones and apps, is driving substantial increases in the quantity and use of data to support on-farm decision making and actions. Most biophysical processes, from soil nutrient management to cow performance, have both paper-based and software systems recording status, productivity, and intentions. There are a significant number of tools covering livestock, nutrition, and financial management, including over 127 that have been developed for rural professionals (Allen & Wolfert. 2011).

A substantial amount of data remains isolated in individual vertical systems, meaning that for other tools information must be collected again, or approximated and re-entered by farmers. Farmers will benefit from a highly innovative technology sector delivering applications that are simple to use and access, which can source the information they need without impedance, and deliver value. From the farmers' perspective, any data collected about their land or herd should be kept with due custodianship and be available for a variety of uses as and when required, all with minimal overhead (Cooke *et al.* 2013).

In June 2014 six industry organisations provided a mandate for the establishment of the Farm Data Code of Practice: Beef & Lamb New Zealand, DairyNZ Limited, Dairy Companies Association of NZ, Federated Farmers, Te Tumu Paeroa and the NZ Veterinary Association. The new Code of Practice outlines steps organisations must take to safeguard farmers' data. Adoption and implementation of the Farm Data Code of Practice is expected to improve how farm information is shared and used.

A Code of Practice addresses behaviours or practices within organisations and transparency between organisations and farmers in how data is managed. It must be complemented by a standardised vocabulary to describe data, allowing information to be interchanged between diverse systems. Some 60 New Zealand organisations have been involved in the ongoing development of data dictionaries and data interchange standards to support interchanging a variety of farm data, including individual animal and mob recording, applications of sprays and fertilisers, stock reconciliations, farm financials, and feed, effluent, and grazing information.

Future adoption of standardised representations of data would allow information collected using sensors and precision farming technologies to be utilised and aggregated to support a range of farm decisions and industry benchmarks.

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Building Collaborative Cyber-infrastructure for Spatially Enabled Livestock

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Researchers have been tracking the spatial movements of wildlife with electronic devices for decades. Recently, the wildlife community have developed collaborative cyber-infrastructure for wildlife tracking, and shown it to enhance scientific innovation across the sector. The ability for researchers to seamlessly access the latest analysis tools, store their data in a standardised format, and discover and access other research projects has changed a short-term, fragmented, and inefficient research effort into one that is long-term, globally connected, and delivering benefits for all concerned. We are currently developing cyber-infrastructure for the spatial tracking of livestock, and consider this symposium a great platform to demonstrate our vision and obtain feedback from those directly connected with the field.

A teaching resource to engage the next generation of agricultural scientists using autonomous livestock monitoring technologies

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Concern regarding the reduced number of graduates from agricultural degrees across Australia is increasing. One of the key challenges that has been identified is the need to attract intelligent young people into this industry. At least one of the issues that prevents young people considering a career in agriculture is their perception that the industry is archaic and devoid of any interesting and exciting challenges. This abstract reports on one learning exercise that has been developed to overcome this issue and demonstrate to secondary students the challenges associated with the development of autonomous livestock monitoring technologies.

The teaching exercise starts with an explanation of why livestock producers are interested in having autonomous monitoring systems on their animals and identifies some of the particular issues that can be addressed by this technology. After the introduction, the students work through a 3 part practical exercise.

Part 1- Students become familiar with accelerometer data using a real-time streaming 3 axis accelerometer viewable via a smartphone application.

Part 2 – Using simple store-on-board data loggers students simulate 5 different behaviours using a nearby flock of sheep as a reference. This becomes their calibration data set. A group of students is then asked to simulate a flock of grazing sheep displaying normal behaviour before they are attacked by a pack of wild dogs (simulated by another group of students) the “wild dogs”

initially circle the flock causing the flock to rotate before they move in to attack an individual. This becomes the “behavioural simulation” investigated in laboratory analysis.

Part 3 – The students are then moved into a computer lab where they work through the calibration data set. Once complete, the students then use the calibration set to interrogate the predation simulation and determine if they think they could detect the event based on sensor data.

The students clearly enjoy the physical activity involved in the initial smart-phone app exercise, the calibration exercise and the final behavioural event simulation. The final predation event sees students engaged in describing how the “wild dogs” should attack and how the “sheep” should respond providing an excellent opportunity for learning about animal group behaviour. The strong link between the students physical involvement in creating the data sets and the subsequent computer lab exercise results in good engagement in the data analysis. Ultimately students are exposed to a completely new field of agriculture which engages them on numerous levels and hopefully changes their paradigm regarding the type of activities and challenges that are involved in livestock research and agriculture in general.

This exercise was evaluated alongside a number of other student activities held as part of a secondary student university engagement camp (30 students) and scored an average of 9.0/10.0 against an average of 7.9/10.0 for other agriculture related activities in student feedback.

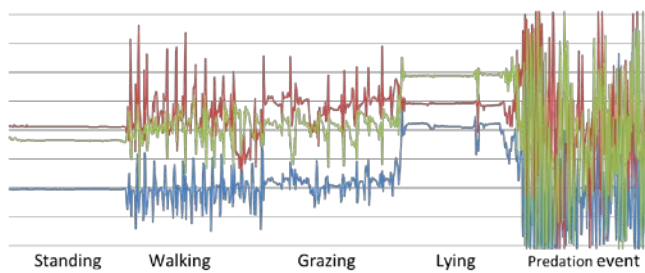


Figure 2 Student simulation of different sheep behaviours using a 3 axis accelerometer. This trace looks remarkably similar to actual data taken from live animals indicating the students can make the connection between the sensor and actual animal behaviour.

Poster Presentations

An animal monitoring system (PAWS) that could be used to trap dogs, dingos and foxes

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Invasive vertebrate animals including the wild dog (*Canis lupis familiaris*), dingo (*Canis lupis dingo*) and European Fox (*Vulpes Vulpes*), cause tremendous losses to Australian sheep and cattle production. Economic losses to livestock production are through both predation (Fleming *et al.* 2006) and spread of disease (King *et al.* 2011). An evaluation of the annual impact of these species undertaken in 2004 presented estimated annual economic loss of \$103,800,000 (McLeod, 2004). Additional losses also occur through implementation of control measures. These measure include avoiding grazing certain pastures due to risk of attack and the cost of attempting to control populations, for example, through fencing, baiting or shooting (McLeod, 2004).

A new method for detection of mammals has been developed called 'PAWS' (Blackie *et al.* 2014) that can identify small mammal species from their prints as they walk across a sensor pad. The system can identify 7 New Zealand pest mammals with almost 100% accuracy, with the largest pest animal being the introduced brushtail possum (*Trichosurus vulpecula*).

The system is currently being adapted to other mammal species, and prints from Australian pest species such as foxes and dogs can easily be captured on the PAWS sensing pad. This provides a mechanism to actively monitor and potentially control traps for control of these pest animals. Further, addition of print identification of non-target species can be developed so that PAWS ignores their passage across the sensing pad.

The Australian Invasive Animal Cooperative Research Centre (IACRC) identified several objectives to reduce the impacts of wild dogs and foxes on livestock production. This sensor has the potential to contribute to two of the key objectives to:

- investigate and develop user-friendly and useful monitoring methods for field operators in management programs
- investigate the movements of these animals for home range, dispersal and corridors (Fleming *et al.* 2006).

The detection of key species using PAWS will assist the ultimate goal of reducing losses in farmed animals throughout Australia and beyond.

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Why are we evaluating the viability of two automatic milking systems (robotic milking) farm systems in Central Canterbury?

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The New Zealand dairy industries 'twice per day' batch milking system, is creating a labour shortage in New Zealand, as it is "not attractive compared to other industries" (Tipples, Hill, & Wilson, 2008, p. 159). The industry faces this challenge, while simultaneously being required to lift its environmental performance, and maintain or increase its productivity and profitability (Macdonald, Scrimgeour, & Rowarth, 2013). However, a mechanical innovation is available which can "automate all the functions of the milking process and cow management currently undertaken in conventional milking by a mix of manual and machine systems" (Jago, Jensen, & Berdell, 2008, p. 1). This mechanical innovation is Automatic Milking Systems (AMS), and "no other new technology since the introduction of the milking machine, has aroused so much interest and expectations among dairy farmers" (Koning & Rodenburg, 2004, p.1). Currently, the commercial economic and environmental factors are unknown for both pasture-based and indoor-based AMS farm systems within the New Zealand dairy industry. The goal of this study is to provide information, which will help future adopters of AMS technology in New Zealand, to choose whether indoor-based or pasture-based AMS is best suited to them. As the evaluation of their viability (the economic and environmental aspects), is essential for future adopter's decision making. Therefore, the hypothesis for this study is that: - barn-based AMS farm systems are more viable than pasture-based AMS farm systems.

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Learning from NI Go, Sow, Grow Autonomous Robotic Competition

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Over the past many decades, robotic technology has been successfully used in numerous humanly impossible or extremely challenging tasks like exploration of distant planets, driving passenger cars, or performing precision surgical procedures to name a few. While this is truly amazing and result of outstanding technological advancements, a number of avenues for robotic applications are still under-investigated. One such field is agriculture where the usage of unmanned intelligent machines is still considered rather futuristic⁰. This is apparently due to the fact that agriculture is done outdoors in unstructured harsh environments and most of the successful mobile robots of today are either designed for structured environments or lack sufficient hardware/software capabilities to function in the fields.

In general, agricultural robots can be designed with similar flesh and bone as their industrial or mobile counterparts but they need be designed differently. One design approach that mimics nature and has also been successful in mobile robotics is bottom-up building of application specific autonomous agents. This approach when implemented in agricultural robotics through the best of current technology can revolutionize the way machines help humans on the farms. In this regard, National Instruments Aus-NZ has taken an initiative to organize/sponsor autonomous robot building competition (NI ARC)⁰ annually.

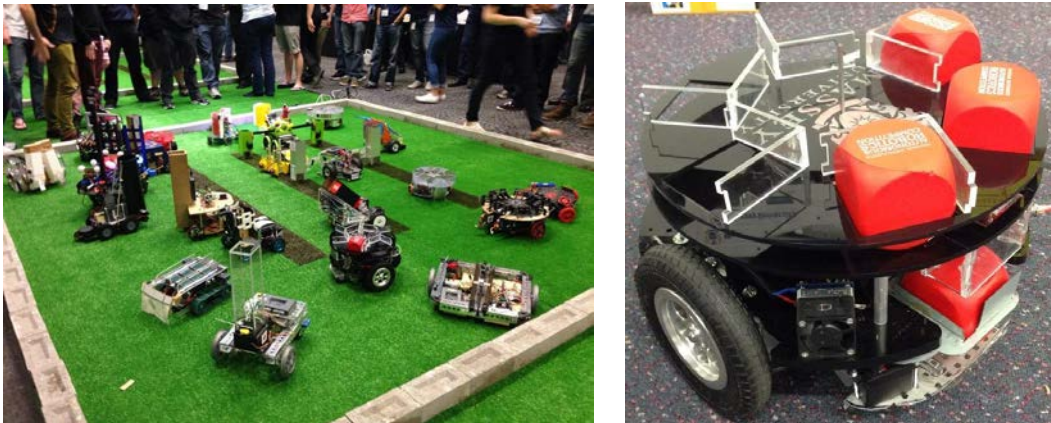


Figure 1. NI ARC 2014 finalist robots (left). Massey University robot (right)

This year NI ARC focused on agriculture with a theme of “Go, Sow, Grow”. Our team named “iFarmers” participated in the competition by designing a robot shown in Figure 1. We built the robot from scratch using bottom-up methodology for autonomous navigation through an obstacle laden arena and planting of seeds (red blocks) on the specified field locations in the shortest possible time to beat other competitors. Our robot featured state-of-the-art hardware and software technologies which are used in many popular robots around the globe e.g. laser distancing and ranging, localization, goal seeking, obstacle avoidance, communication to the base, etc. This robot building exercise has been a great learning opportunity for us and we expect that our prototype can be easily extended to field applications through hardware and software upgrades.

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Robot farmers are the future of agriculture, says government.

<http://www.theguardian.com/environment/2014/jan/09/robots-farm-future>

2014 NI Autonomous Robotics Competition (NI ARC). <http://nz.ni.com/ni-arc>

Index

ABSTRACTS

Campbell, Hamish, 21
Cooke, Andrew, 20
Dobos, Robin, 12
Draganova, I, 15
Eastwood, Callum, 19
Economou, Zac, 11
Mark Neal, 8
Phillips, Rebecca L, 17
Roberts, Jessica J, 14
Thomas, Dean, 10
Trotter, Mark, 9, 13, 22
van Reenen, Erica, 18
Werner, Armin, 16

KEYNOTE SPEAKERS

Bewley, Jeffrey, 5
Swain, Dave, 6

POSTERS

Arif, Khalid, 26
Clarke, Hamish, 25
Irie, Kenji, 24



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