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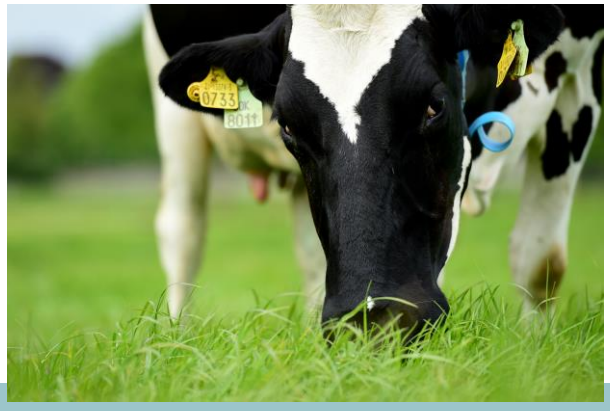
Integration of PRECISIONDAIRY within agricultural systems



Key external stakeholders:
Scientific, Advisors, Policy makers, Farmers, Tech companies,

Practical implications for stakeholders:

- Technologies were evaluated within grass based settings
- Commercially available accelerometers have the potential to be extremely accurate at monitoring individual cow grazing behavior

Main results:

The main research outputs of this project included the independent validation of 3 technologies (Rumi Watch, Moo Monitor, Ingenera BodyMatt F) and support in the development of 3 capabilities, important in adding value to pasture-based dairy production. These novel capabilities included the localisation of cows and grazing behaviour detection of cows using the SmartBow system, and lameness detection using the Rumi Watch accelerometer/pedometer. New and novel sensors were developed in order to monitor animal behaviour within a paddock setting and new techniques were developed to generate smart decisions within the instruments themselves. Linkage was created between remote sensor technology with an existing web-based decision support resource (PastureBase Ireland) to add value to decision making at the farm level. In addition, progress was made on creating a decision support tool to support farmers during the challenging process of selecting and investing in existing technologies, a review paper was written and published on Precision technologies. A paper was published on the development of a methodology around grass levels in the diet of a dairy cow. Finally, progress was made towards developing the novel capability of automated lameness technology that could be integrated into existing technology.

Opportunity / Benefit:

This project was one of the first movements to precision technologies within the overall Teagasc Moorepark team. It has lead to Teagasc Moorepark in conjunction with collaborators from INSIGHT, TSSG, Tynall and ICBF in conjunction with industry groups in securing VistaMilk (The latest SFI funded centre). The potential for precision technologies to develop agriculture solutions is huge once the overall focus is solution based and not focused on the development of technology for the sake of technology itself.

Collaborating Institutions:

TSSG, Dairymaster, Smartbow, Rumiwatch, Ingenera

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1. Project background:

The potential benefits of PLF include increased efficiency, reduced costs, improved product quality, reduced environmental impact, and improved animal health and welfare (Bewley, 2012), thereby facilitating a holistic approach to sustainable farming (i.e. economic, environmental, stakeholder perception, and food security). Unfortunately, however, the development of PLF has, for the most part, been driven by the availability of technologies developed for other purposes, rather than a specific identified need in dairy farming. Because of this lack of a market driven approach, uptake of PLF has not been aggressive, despite the availability of multiple technologies, because the value proposition has been unclear. In addition, many of the PLF technologies available operate in isolation and are incapable of communication with each other, since the platform infrastructures that can integrate outputs from a number of sensors do not exist; in fact, the application of large scale networking and data management and processing solutions has been neglected. This limits the value from investment in multiple technologies. In addition to these limitations in the approach to-date, pasture-based systems present a unique set of problems and opportunities. Dairy farmers that rely on pasture as their primary source of feed require accurate real-time measurement of pasture biomass to optimise cow nutrition and grazing management, as well as individual cow indicators of animal production and health to ensure animal welfare is optimal (Donnelly et al., 2005; Eastwood et al., 2010). This is much more complex than international dairy systems, where cows are primarily fed a mixed ration in confined housing; in these systems, the accurate mixing of feed ingredients and the proximity of cows to the 'technology hub' makes currently available PLF technologies more useful.

2. Questions addressed by the project:

- To develop or enhance sensors to increase the precision of pasture-based dairy farming
- To develop a novel communication solution for PRECISIONDAIRY wireless sensor-devices. The solution will cater for both real-time and delay-tolerant communication between sensors, while ensuring its reliability and durability and
- Development of data management, communication, interpretation and predictive analysis for animal and pasture based agricultural data
- To develop a test bed for testing technological solutions incorporating evaluation and validation of sensors used on farm
- To demonstrate the potential of linking remote sensor technology with an existing web-based decision support resource (PastureBase Ireland) to add value to decision making.

3. The experimental studies:

Fog Enabled Sensor

A new generation animal wearable technology, namely the Universal Sensor was developed was developed with an open design which can be extended with any I2C-compliant sensory units. Hardware design and fog Analytics functionality were included in the technology developed

Communication module

Communication modules that facilitate delay tolerant and real data transmission were developed to allow Edge and Fog communicating

Data transfer

The collected data is processed, transformed, and stored effectively in order to derive insights that help farmers to make decisions to optimize the farming process. In this research, the focus was on developing

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novel data analytics techniques using state-of-the-art machine learning methods and then use them to analyze data in the smart dairy farming domain.

Test Bed

The key focus of this work package centred around precision technology development and adoption. A farm technology hub was developed where novel technologies could be deployed and tested at Dairygold Research Farm in Kilworth, part of the Animal and Grassland Research Centre in Moorepark. The broad theme of the work conducted in this work package centred on the evaluation and validation of existing commercially available sensors so that farmers could make more informed decisions on whether to invest, or which PT to invest in, and thus support technology adoption.

Decision Support

This work package centred around the development of decision support tools for use around grassland with a key focus on PBI which is a web based grassland management system for use on Irish farms. The development within PBI which included the inclusion of an Off-line APP as well as the integrated linkage with the GrassHopper grassland measurement tool.

4. Main results:

WP 1 & 2 delivered a prototype device strongly resembles its industrial counter-parts (e.g. MooMoniter+ by Dairy Master, RumiWatch by ITIN + HOCH GmbH). Similar to the existing solutions the prototype's operation closely follows the Delay Tolerant Communication (DTC) paradigm that (1) on the one hand allows to improve energy-consumption and successfully mitigate issues with on-farm connectivity (2) and on the other hand is sufficient for some of the farm-based scenarios. Subsequently, novel functionality developed for the prototype during the project can be adopted by the existing solutions rather easily. Appropriate communication protocols will linked with the technologies.

WP 3 delivered a data processing framework for the smart farming (SF) domain. A theoretical model for computation offloading in micro-solar powered energy harvesting sensor devices was developed and a model for optimising data partitioning to minimize the total energy consumption based on the energy harvesting status of sensor nodes for different scenarios was developed within the work package.

The main research outputs of Work Package 4 can be represented by an independent validation of 3 technologies (Rumi Watch, Moo Monitor, Ingenera BodyMatt F) and support in the development of 3 capabilities, important in adding value to pasture-based dairy production. These novel capabilities included the localisation of cows and grazing behaviour detection of cows using the SmartBow system, and lameness detection using the Rumi Watch accelerometer/pedometer. As lameness is also one of the biggest welfare challenges on commercial dairy farms.

Work Package 5 delivered on its specific objective to demonstrate the potential of linking remote sensor technology with an existing web-based decision support resource (PastureBase Ireland) to add value to decision making at the farm level. In addition, progress was made on creating a decision support tool to support farmers during the challenging process of selecting and investing in existing technologies, a review paper was written and published on Precision technologies, a second paper is currently in review in the Irish Journal of Agriculture and Food Research with a review paper on accelerometers currently accepted in the Journal of Dairy Science. A paper was published on the development of a methodology around grass levels in the diet of a dairy cow. Finally, progress was made towards developing the novel capability of automated lameness technology that could be integrated into existing technology.

5. Opportunity/Benefit:

The outputs from this research have fed in VistaMilk, into PastureBase Ireland and into studies evaluating different technologies for use at farm level. This research has contributed to PastureBaseIreland and to the development of decision support tools for farmers. Precision Technologies have been evaluated and validated for use within pasture based settings.

6. Dissemination:

An overview of the project was given at the Moorepark Open Day in 2015, 2017 and 2019. Visitors to Moorepark, both national and international, received presentations on the project and many interesting discussions took place. Poster and oral presentations were made at the EGF, ECPLF, BSAS AND World Buiatrics Conferences. In total between peer reviewed papers published or still under review there will be over 30 scientific or conference papers from this project. A large number of conference publications were published during the project. Advisors and farmers were informed and received demonstrations on technologies from the project

Main publications:

O Brien D., Moran B and Shalloo L. (2018). A national methodology to quantify the diet of a dairy cow.

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Shalloo L,O' Donovan M, Leso L, Werner J, Ruelle E, Geoghegan A, Delaby L and O'Leary N 2018. Review : Grass-based dairy systems, data and precision technologies. Animal. 12 S2 262-271 https://doi.org/10.1017/S175173111800246X
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Dixon Vimalajeewa, Chamil Kulatunga, Donagh P. Berry, 2018, Learning in the com- pressed data omain: Application to milk quality prediction, Journal of Information Sciences. vol. 459, pp 149-167. DOI: 10.1016/j.ins.2018.05.002
Chamil Kulatunga, Kriti Bhargava, Dixon Vimalajeewa, Stephan Ivanov, Cooperative In- network Computation in Energy Harvesting Device Clouds, Sustainable Computing: Informatics and Systems, Elsevier, vol. 16, December 2017, pp. 106-116, DOI: 10.1016/j.suscom.2017.10.006
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Hanrahan, L., A. Geoghegan, M. O'Donovan, V. Griffith, E. Ruelle, M. Wallace, and L. Shalloo. 2017. PastureBase Ireland: A grassland decision support system and national database. Computers Electronic Agriculture 136:193–201. doi:10.1016/j.compag.2017.01.029.

Popular publications:

Leso L, O'Leary N, Werner J, Kennedy E, Geoghegan A and Shalloo L 2018. Associations between cow behaviour at pasture, weather conditions and day length. In European Grassland Federation General Meeting. Cork.
Shalloo L, O'Leary N, McDonagh A, Geoghegan A, Werner J and Leso L 2018b. Big data and smart technologies in grassland research and grassland management. In European Grassland Federation General Meeting, pp. 789–806. Cork.
Werner J, Leso L, Umstatter C, Schick M and O'Brien B 2017. Evaluation of precision technologies for measuring cows' behaviour. Grassland Science in Europe 22, 82–84.
O'Leary N, Mcsweeney D, Werner J and Shalloo L 2018b. Accuracy and agreement between human observed Body Condition Scores (BCS) and an automated BCS system. In World Buiatrics Congress. Sapporo, Japan

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