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Ethical concerns of Artificial Intelligence (AI) applications in livestock farming

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Overview

AI-applications in livestock farming are intended to improve performance, efficiency, health and welfare. However, such technological advances also present challenges and risks, including potential to threaten health and welfare. A lack of validation and oversight in marketed AI technologies is evident, creating distrust and potential for a more immediate negative impact on animals (e.g. injury from unsuitable sensors). Lessons can be learned from the human medical and wellbeing sectors where any new technology is subject to rigorous quality assurance processes and regulations before being commercially marketed. We propose that any technology should adhere to a Hippocratic oath of 'first do no harm' and be subject to similar quality assurance protocols and accountability.

Main Findings

The enthusiasm for AI-applications in agriculture can sometimes seem like a panacea and the future of livestock farming. Whilst there are certainly opportunities if the promise of AI is realised, there are also challenges including many practical/infrastructure hurdles to overcome. Ethics are increasingly discussed with valid concerns for animal welfare, as well as important socio-economic concerns.

Animal health and welfare risks include:

- Lack of user-driven design for wearable sensors can result in injury and/or changes in behaviour by both wearer and conspecifics
- Lack of validation, reliability of AI
- Stockperson over- or under-reliance on AI
- Potential for down-skilling of the work force
- Potential to damage the human-animal relationship

Wider ethical debates include:

- Loss of autonomy for the farmer
- Uneasiness around AI from other stakeholders, including consumers
- Concerns about intensive farming practices and potential for further objectification of animals

'Do androids dream of electric sheep?'
Baxter, SRUC©

To inform this brief and outline policy implications we performed a scoping exercise involving literature searches and experiential reports, providing some insight from the authors' research and practical experience in the pig and sheep sectors.

Introduction

Artificial Intelligence (AI) in agriculture includes various Precision Livestock Farming (PLF) technologies, together with AI software and integration methods (machine learning, deep learning and reinforcement learning), that are intended to improve performance, efficiency, health and welfare. Whilst many of these technological advances offer such opportunities, they also present challenges and risks, including potential to threaten animal health and welfare. Some of these have recently been reviewed[1,2,3] and are further discussed here, as well as the practical challenges of implementation and an insight into what farmers think about PLF in particular.

Trusting the tech

The concern of technology push was raised early on in the emergence of PLF and the question was asked as to whether adequate market research was being conducted[4]. Technological change across most industries is mainly driven by technology push rather than user demand. So whether farmers want it or not, advancements in technology may mean that the market for PLF has been created and it is here to stay.

A critical aspect of accepting AI in agriculture is trusting the technology, but the route from inception to market is not always transparent, particularly concerning **validation**. For example, in a recent review[5] of pig PLF technologies, authors determined that just 5% of commercially available sensor systems had been externally validated.

> A systematic literature review found that just 5% of commercially available pig sensor systems have been externally validated [5]

The 'big data' being generated from sensor-aided monitoring and other AI-applications is heralded as a major selling point[6] but **data privacy, data sharing, commercial sensitivities, data ownership, and permissions**[7] are all issues, as is **data quality**. Algorithms are only as good as the data upon which they are trained[8] and having access to properly validated (i.e. labelled) data for model training and testing is a key starting point. If AI-outputs and any decision-support tools informing farmers are based on **inaccurate data** this **could lead to poor decisions or no decisions**. This decreases confidence in AI and might explain why on-farm adoption of AI-technologies lags behind the rapid evolution of these technologies. Farmers have also highlighted several practical limitations which hinder any adoption.

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[1] Schillings et al. 2021. Animal welfare and other ethical implications of Precision Livestock Farming technology. CABI Agri & Biosc 2(1)

[2] Tuyttens, et al. 2022. Twelve threats of precision livestock farming (PLF) for animal welfare. Front. in Vet. Sci 9: 889623

[3] Bos et al. 2018. The quantified animal: precision livestock farming and the ethical implications of objectification. Food Ethics, 2.

[4] Wathes et al. 2008. Is precision livestock farming an engineer's daydream or nightmare, an animal's friend or foe, and a farmer's panacea or pitfall? Computers & Electronics in Agric. 64(1):2–10

[5] Gómez, et al. 2021. A systematic review on validated precision livestock farming technologies for pig production and its potential to assess animal welfare. Front. in Vet Sci 8: 660565

[6] Weersink et al. 2018. Opportunities and challenges for big data in agricultural and environmental analysis. Ann. Rev. of Resource Economics, 10:19-37.

[7] Collins & Smith 2022. Smart agri-systems for the pig industry. Animal, 16, 100518.

[8] Siegford et al. 2023. The quest to develop automated systems for monitoring animal behavior. App. Anim. Behav. Sci, 265: 106000

Practical challenges

There are a host of practical challenges that would need to be overcome for more widescale adoption. They include:

- Equipment not being fit for purpose for the wearer and/or the environment
- Connectivity and infrastructure issues
- Software obsolescence, lack of technology support

These are not only experienced by farmers but also animal scientists trying to validate AI technologies.

Top row: Pig with unsuitable 'wearable' (size, weight) affecting wearer and behaviour of pen-mates. Bottom row: Sheep undergoing trials by ethologists to improve collar type for wearer. Images Baxter & Reeves, SRUC©.

Often equipment is not designed to cope with the rigours of farm life (e.g. dirt, dust, cob-webs, vermin) and additional challenges are expected when trying to introduce technologies to extensively managed species (e.g. rain, wind, snow). Wearable sensors will be favoured over camera-based systems but there is often a **trade-off between battery life and the ability to transmit data in real time**. **Lost connections to transmitters** can occur and data can stop being collected for periods of time and/or be completely lost if **real-time data transmission relies on a reliable gateway-to-network server connection**[9]. Collars or tags can be lost or damaged. Many wearable sensors have been developed for dairy cattle and been repurposed for smaller ruminants,[10] or even tried on pigs, a species that can find weakness in any equipment. Though the equipment often comes off second best, there are **serious animal welfare concerns when sensors are too heavy or unwieldy for the wearer, cause injury or changes in behaviour**.

It is critical that AI-applications for livestock are **species-specific, developed with the wearer in mind, with proper testing across different age categories, in different management systems and during different situations for that species.**

In human medicine, a new drug or technology would be subject to rigorous quality assurance processes before being made readily available on the market. For example, wearable digital health technologies whether they be classed as 'fitness devices' (e.g. FitBits™) or 'medical devices' are subject to quality assurance standards. The software and hardware components must meet specific compliance rules determined by regulatory bodies[11,12] and if classed as 'medical devices' by US, UK, and EU regulators, they are generally required to be manufactured, certified, validated, controlled, and distributed in accordance

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[9] Waterhouse et al. 2019. Opportunities and challenges for real-time management (RTM) in extensive livestock systems. European Conf. on PLF. pp. 20-26.

[10] Barwick et al. 2018. Predicting lameness in sheep activity using tri-axial acceleration signals. Animals, 8(1):.12.

[11] IEEE Standard for System, Software, and Hardware Verification and Validation. IEEE Std 1012-2016.

[12] U.S. Department Of Health and Human Services, U.S. Food and Drug Administration, Center for Devices and Radiological Health & Center for Biologics Evaluation and Research. General Principles of Software Validation; Final Guidance for Industry and FDA Staff, 47 (2002)

with a quality management system that is approved by the respective governmental regulatory authorities[13]. Part of those quality assurance processes involve scrutiny of the ground-truth data – i.e. the validation process, as well as testing accuracy, consistency, and reliability. It is not unreasonable to ask why such scrutiny of similar technologies does not apply to non-human animals.

Having this oversight would not only offer some protection of animal welfare but also go someway to providing reassurance for the farmer, as well as other stakeholders who may be concerned with technology push.

Socio-economic challenges

There is a need to understand the lived experiences of farmers using technology to be able to assess the risks and recognise the benefits of AI-applications. Reeves and colleagues[14] identified themes from interviewing Norwegian sheep farmers about their experience with PLF – there were positives, but challenges were identified:

- Early adopting farmers invest a lot of capital in small start-ups that often do not survive
- They are left with expensive equipment that cannot be serviced or updated
- Farmers expect tech to save them time and money, instead it is often developed at the farmers' expense
- They purchase beta versions that need expensive upgrades or get scrapped

> Yeah, but you have to have a system, you have to have the PP, PC computer programmes and they change it. [Company B] change it several times so... and then I have to do something new. Yes, it's annoying because we have - in May it's very busy. So it [the software] has to be there. *Farmer 158 (Reeves et al, 2025[14])*

Some farmers specified that given the technology's costs, they expected durability and consistency. Other feedback we have experienced from farmers or stock-workers involved in proof-of-concept trials for camera-based technologies in the pig sector includes issues around job security. One stock-worker commented 'I'm paid to watch the animals, not this [camera]'. Others have commented that even if there was some AI-application on farm that was meant to deliver information to act on, there's not enough time to do that and all the regular tasks.

If technology can save time it is looked upon more favourably and some farmers like the sense of control it offers them. This is evident from the sheep sector[15] and something discussed by participants in our study where they said technology increased their control and benefitted their relationship with their sheep. This perceived improvement in the human-animal relationship was interesting, as many studies[1,2,3,4] have identified AI-applications as having a deleterious effect on the human-animal relationship.

Human-animal relationships

By delegating tasks to technology, the opportunities for contact between farmer and animals can be reduced. Animals may become more fearful of farmers, negatively impacting their welfare[16]. There is evidence from farmer interviews that some AI-users felt that the human-animal relationship had

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[13] Doyle, 2021. Wearables and quality assurance in a clinical trial setting. White Paper. https://www.worldwide.com/

[14] Reeves et al. 2025. Norwegian sheep farmers' perception and use of PLF technologies. Journal of Rural Studies - *accepted*

[15] Kaler & Ruston, 2019. Technology adoption on farms: Using Normalisation Process Theory to understand sheep farmers' attitudes and behaviours in relation to using precision technology in flock management. Prev. Vet Med. 170:104715.

[16] Rault et al. 2020. The Power of a Positive Human–Animal Relationship for Animal Welfare. Front. in Vet Sci, 7.

deteriorated[17]. Some farmers appear to be aware of this risk but might not think it applies to them. Part of the work with Norwegian sheep farmers[14] involved asking them about this risk and they responded that they purposefully prioritised their relationship with their animals to counteract this risk. Others felt the AI-applications brought them closer to their animals (they could track them with GPS for example) and empowered them to make more informed management decisions. Farmers often reported that their increased sense of control gained from AI benefitted the human-animal relationship. However, in many cases, their ways of building relationships with their sheep appeared one-sided. They involved observing the sheep during feeding or making more informed decisions about flock health. This view is telling of how little the animal's perspective was considered in that relationship. **This is an area that should be considered – how AI-applications may bring about benefits for all stakeholders, including meeting the animal's behavioural and physiological needs.** One approach to this challenge could be to increase the research on positive welfare measurements by AI-applications[18]. However, even if this more animal-centric approach was adopted, **it is not clear whether consumers are accepting of technology**, **as it appears in conflict** (for the sheep sector at least) **with the perceived 'naturalness' of the environment**[19].

Final thoughts and policy implications

By understanding some of the common challenges and risks occurring when developing AI-applications for livestock, we can develop frameworks for successful mitigation and realise the opportunities more effectively. This must take into account the ethical considerations. There is also a **fundamental issue that all this tech does not necessarily lead to a better understanding of an animal's world**[20]. Properly validated AI-applications may, however, help animal scientists working in this area to conduct the fundamental studies to provide this insight.

Policy Implications

- AI-applications for livestock, particularly wearable sensors, should be subject to similar quality assurance standards and regulation as human wearables.
- Multiple stakeholders should be involved in development of any new AI-applications for livestock, particularly farmers and others representing the animal's needs (animal welfare scientists, vets). Consumer-acceptance should be considered.
- AI-applications should not be seen as a replacement for more traditional techniques for raising animals, but rather as a tool to support farmers and other stakeholders.

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[17] Kling-Eveillard et al. 2020. Farmers' representations of the effects of precision livestock farming on human-animal relationships. Livestock Science, 238: 104057

[18] Buller et al. 2020. Animal welfare management in a digital world. Animals, 10(10):1–12.

[19] Dürnberger (2024). A Better Wilderness? Ethical Questions and Social Ambivalences of Precision Livestock Farming. In Greentopia: Utopian Thought in the Anthropocene (pp. 193-205).

[20] Hebblewhite & Haydon 2010. Distinguishing technology from biology: a critical review of the use of GPS telemetry data in ecology. Philosophical Trans of the Royal Society B: Bio Sci, 365(1550):2303-2312