BRIEFING

European Parliament

Transforming animal farming through artificial intelligence

SUMMARY

By 2033, global meat protein consumption is projected to increase by 3 %, which is expected to result in higher greenhouse gas emissions. Artificial intelligence (AI) and the internet of things have the potential to revolutionise the livestock sector by enabling farmers to increase productivity while reducing environmental impact.

AI-powered systems support real-time monitoring of animal health, behaviour and welfare, allowing for the early detection of disease and stress and enabling personalised care. Precision livestock farming uses sensors, cameras and machine learning algorithms to collect and analyse data, thereby facilitating data-driven decision-making and optimised production methods. This approach can increase productivity while reducing emissions and improving animal welfare.

The integration of AI in farm management has resulted in innovative solutions that contribute to a more sustainable and efficient farming and food system. In terms of animal health, AI can predict disease outbreaks, identify potential host reservoirs and detect emerging disease threats, enabling prompt intervention and treatment. Animal welfare can also benefit from AI on farms, thanks to the early recognition of discomfort, stress or pain.

However, it is essential to acknowledge the potential risks associated with AI, such as cyberattacks, accidental failures and unintentional environmental consequences. Additionally, AI decisions may prioritise efficiency, productivity and cost savings over ethical considerations, potentially leading to negative repercussions for animal welfare.

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Introduction

The OECD-FAO Agricultural Outlook 2024-2033 (Chapter 6) projects that, by the year 2033, the average daily intake of meat protein per person worldwide will increase by 3 %. This trend is expected to lead to a corresponding rise in greenhouse gas (GHG) emissions. While meat production will need to grow by 12 % to meet this demand, a shift towards poultry and the adoption of more efficient production methods may mitigate the overall increase in GHG emissions.

Technological and management improvements in the meat industry have enabled producers to obtain more meat per animal while generating fewer emissions. However, the industry faces certain challenges such as growing concerns about animal welfare and the risk of animal disease outbreaks. Heightened biosecurity measures and increased cooperation could help overcome health challenges – particularly with regard to the use of antibiotics – although such measures entail economic costs.

The application of artificial intelligence (AI) to improve farm management and enhance livestock production has become increasingly widespread in recent years. By efficiently processing data and integrating various tools, farmers can predict disease outbreaks, optimise feeding routines and automate the monitoring of animal well-being and welfare. New technologies empower farmers to administer and improve the health, wellness and reproductive capacities of their livestock through informed decision-making, accurate forecasting and anomaly identification.

The success of animal production systems relies heavily on human intervention and decision-making. These systems can provide a source of income, labour and food, especially in family farming settings where livestock is raised. However, public expectations regarding the ethical treatment and welfare of animals remain high.

Internet of things and precision livestock farming

The internet of things (IoT) technology enables real-time data exchange between various smart devices, facilitating the collection and transmission of data to cloud systems or end devices through gateways and communication protocols like Wi-Fi and Bluetooth. This technology has numerous applications, including precision livestock farming (PLF), which involves the real-time monitoring of animals using sensors that track livestock-related data. PLF uses advanced technologies, such as sound analysers, sweat and salivary sensing and image-detection techniques, to monitor animal health, welfare, production and environmental impact. The IoT system – with its devices and applications – plays a crucial role in PLF. Sensors, such as accelerometers, gyroscopes, and biosensors are used to collect data on animal behaviour, including pace, speed, position, temperature and heart rate. Innovative video monitoring and facial expression recognition technologies can be used to track and analyse animal behaviour, movement and activity. The collected data is then stored and analysed using machine learning models, simulations and decision support systems. This enables farmers to make informed decisions about animal care and management, ultimately reducing the complexity and challenges associated with traditional livestock farming methods.

Artificial intelligence in livestock farming

The integration of artificial intelligence into farm management has resulted in a more tailored approach to livestock care. Facial recognition technology enables the monitoring of individual cows' behaviour and provides the farmer with practical knowledge about each animal in the herd. Combined with PLF, AI can help farmers establish a farming system that prioritises sustainability, efficiency and animal well-being through a holistic approach.

For example, the introduction of real-time monitoring in feeding behaviour, which tracks and analyses individual animals, can allow for swift intervention, if necessary. Accurate monitoring of feed consumption is essential for maintaining optimal health and nutrition. Early detection of feed refusal or empty feeders, for example, is vital in preventing disease outbreaks or ensuring animals receive the necessary nutrients. Thanks to AI, farmers can develop customised feeding plans that forecast the most effective nutritional strategies for each animal. AI-powered feeders can offer personalised feeding schedules based on an animal's specific characteristics, such as weight, age, and health status. Furthermore, sensors in feeders can detect and prevent both overfeeding and underfeeding, while AI models optimise the feed conversion ratio (FCR), reducing waste and promoting efficient feed use.

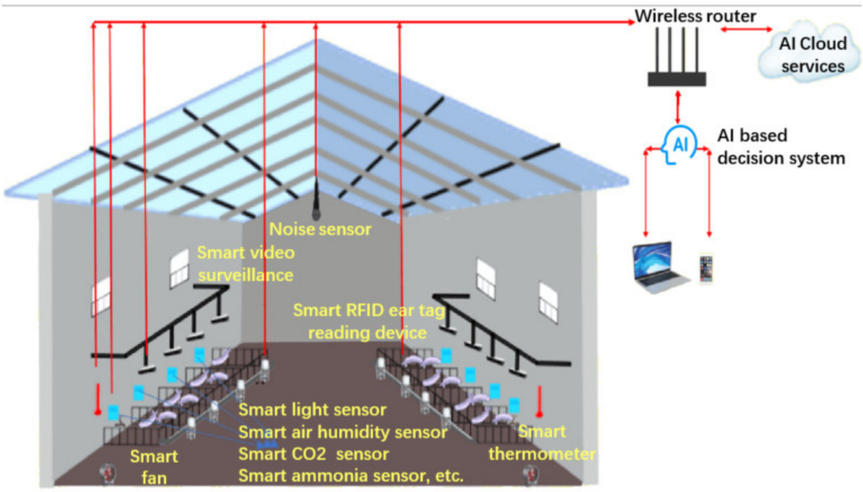
Telemetry technologies, such as GPS, are gaining attention. GPS tracking has been used for automatic monitoring of foraging patterns, to estimate both animal intake and emissions from grazing animals through inverse modelling. Precision feeding is expected to have a direct impact on emissions reduction. Additionally, emerging technologies such as smart ventilation systems and optimised barn climate control are expected to contribute to emissions reduction in the near future.

AI-driven technologies have transformed animal breeding, providing a data-driven approach that refines techniques, minimises mistakes and maximises reproductive success. The artificial insemination process has been revolutionised by the integration of AI algorithms. Recognition technologies have become a vital tool in monitoring animal reproductive cycles, allowing for the analysis of visual indicators, such as signs of heat, through images and videos. Farmers and veterinarians can forecast fertility cycles, which allows them to choose the best timing and approach for artificial insemination. Moreover, they can select the most effective breeding techniques, optimise insemination protocols and reduce errors, with the final aim of achieving higher conception rates, improved reproductive efficiency in livestock breeding programmes and better reproductive outcomes. Radar-sensors have been successfully used to recognise pre-partum behaviours.

In dairy farms, AI systems can monitor milk quality as well as the Hazard Analysis and Critical Control Points (HACCP). Milking robots are able to learn and adapt to the individual characteristics of each cow. By utilising data on factors such as milk production, udder shape and teat placement, these robots can tailor the milking process to each cow's specific needs, resulting in an optimised milking routine that boosts overall milk production.

Mobile-based solutions can enable farmers in remote rural areas to maintain seamless contact with veterinarians who have access to real-time health reports. These innovative applications primarily revolve around data management, providing a platform for farmers to monitor and track their flock's health, and facilitating timely interventions. Finally, advanced computer vision algorithms have been designed to detect anomalies in the farm environment, including the presence of unauthorised vehicles, intruders, or suspicious activity, enabling farmers to maintain a secure and monitored agricultural setting.

Figure 1 – Implementation of precision pig-farming technology



Source: The Research Progress of Vision-Based Artificial Intelligence in Smart Pig Farming, 2022.

Virtual fencing (VF) technology offers an innovative solution for managing grazing livestock and containing animals in pastures without traditional physical fencing. By utilising GPS technology and specialised neck collars that deliver a benign sound signal, VF systems enable farmers and ranchers to define and adjust boundaries as needed, reducing the need for labour-intensive fencing and additional infrastructure.

Artificial intelligence in animal health

Traditional methods of controlling animal diseases, such as mass culling and antibiotic use, are increasingly deemed as unacceptable by society. As a result, alternative approaches must be explored and evaluated, with AI potentially playing a key role. The management of animal populations involves ongoing decision-making that affects health outcomes, including trade and disease control measures. When assessing animal health control strategies, it is essential to consider the economic implications, such as the impact on farmers' incomes, as these can sometimes conflict with societal expectations or be misinterpreted.

The vast amount of data collected from herds or local groups of animals may lead to predictive epidemiology, enabling the identification of environmental bacterial strains with high infectious potential, prediction of potential host reservoirs or vectors, and detection of emerging disease threats. Machine learning algorithms have been employed to analyse pathogen sharing among hosts, allowing for the classification of potential reservoirs of zoonotic diseases, increasing our understanding of the relationships between animal and human health and the environment. Technology can be applied to the control of vector-borne diseases through the accurate identification of mosquito species caught in traps. AI can collect and store data to better understand mosquito behaviour in relation to factors such as capture date and time, species identification and environmental conditions like humidity and temperature. This makes it possible to spatially map disease outbreaks and connections between virus strains.

One example of the use of advanced AI algorithms for animal health is the detection of mastitis in dairy cattle. This is done through the analysis of indicators such as udder temperature, swelling and colour, as well as milk somatic cell count and historical herd data. Another example is the early detection of lameness in horses, which is often difficult to detect and represents a severe cause of distress for the animal.

Artificial intelligence in animal welfare

In recent years, there has been an increasing awareness of animal welfare, sparking discussions about the ethical and moral responsibilities that come with our interactions with and treatment of animals.

The current method of identifying abnormal behaviour in animals relies on manual observation by trained professionals, such as veterinarians, technicians or farmers, who visually assess the animals. However, this approach is limited by its time-consuming and subjective nature, which can lead to delayed detection of animal discomfort. As a result, there is a high risk of missing early signs of distress, allowing potential issues to progress and worsen before being addressed. Changes in behaviour can include a shift towards lethargy, a decrease in interest in food, increased vocalisation, withdrawal from social interactions, development of unusual eating habits, heightened activity levels, and an increase in breathing rate, all of which can indicate underlying issues or distress.

Environmental factors, such as temperature, humidity and air quality, are crucial to ensuring appropriate welfare conditions. Sensors and data analytics – as used in AI-driven monitoring systems – continuously assess and optimise these conditions. They can automatically adjust environmental parameters, such as ventilation, heating and cooling, to maintain a comfortable and healthy environment for the animals. This includes monitoring five air pollutants: carbon dioxide, sulphur dioxide, nitrogen dioxide, PM (particulate matter) 2.5, and PM10.

AI-powered systems can analyse data from various sources to conduct animal welfare audits. They can identify areas for improvement and ensure compliance with welfare standards. By using historical inspection data with a low prevalence of violations, the machine can develop an index that is able to predict law violations with few false negative results (referred to as 'high sensitivity').

The CuRly Pig TAIL project

The project Creating Resilience in Pigs Through Artificial Intelligence (CuRly Pig TAIL), combines computer vision, deep learning techniques and behavioural knowledge to detect declines in pigs' resilience. A pig's behaviour and physical appearance, such as its posture, feeding habits, skin and eye colour, coat condition and tail position, can reveal valuable information about its resilience. Through automated, non-invasive monitoring systems, both individual and group animal signals can be detected and recognised as early warning signs of declining endurance, which can lead to diseases and undesirable behaviours. Group dynamics and tail biting are considered key indicators. Once AI is taught to recognise normal herd behaviour, it is then capable of noticing unusual motion patterns and sending an alert to the farmer, thereby enabling early intervention and proactive management of welfare issues.

Conclusions

AI can be put to an incredible variety of uses at the farm level. However, for AI and digital agriculture to be accessible to all farmers, especially those in rural areas, there must be affordable and widespread access to data infrastructure and IT networks. Farmers and SMEs also need support to invest in the necessary technologies and receive training in utilising AI effectively. A study conducted in February 2025 highlights risks encountered in this domain, including cyberattacks, accidental failures and unintentional environmental consequences. While a machine may assume that past events may re-occur, the study emphasises that data should be interpreted in biologically meaningful and welfare terms. Overall, the increasing use of AI in livestock farming is a significant step towards creating a more efficient, productive and sustainable food production system.

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