CONSIDERATIONS IN LEVERAGING BIG DATA IN AGRICULTURE WITH THE OTHER AI (ARTIFICIAL INTELLIGENCE)

James E. Koltes, Ph.D.
Iowa State University
Ames, Iowa

Koltes

Dr. James Koltes is an Associate Professor in the Department of Animal Science within the Animal Breeding and Genetics group at Iowa State University. Dr. Koltes received his B.S. in Dairy Science and Genetics from the University of Wisconsin-Madison and Ph.D.in Genetics from Iowa State University. His research has two main focuses areas, including: 1) the use of new tools such as sensors and biomarkers as novel phenotypes in the genetic improvement of feed efficiency, methane production and health in dairy cattle; and 2) identifying the function of DNA that lays outside of genes (e.g., DNA regulatory regions) to assess the use of markers in these regions in selection.

Introduction

Artificial intelligence (**AI**) is revolutionizing a broad array of disciplines, including agriculture. AI is impacting our lives by helping researchers make remarkable discoveries in fields such as human medicine, data science, and impacting our internet and social media experiences. With all the hype around this technology, many are left with more questions than answers. What is AI? What is AI being used to achieve today? Should AI be used as a decision-making tool? How will AI impact agriculture, animal and veterinary science fields? These questions are not surprising given how rapidly AI technologies have been developed and adopted to conduct so many different tasks.

A review describing of the broad impact of AI on society is available online (AI index report 2024). Given the rapid advancements in AI, some are concerned that AI will take away human jobs, that the technology is moving too fast and that the use of AI may have ethical ramifications. We don't know all the potential challenges that may arise with AI, but governments have moved rapidly to develop policies for responsible use of AI to try to prevent problems. It is known that AI can make mistakes, known as hallucinations, but that these mistakes can be identified and managed if AI is used as a tool with human oversight. The objective of this article is to introduce AI technologies and applications, explore what AI is being used for today in agriculture, and discuss how AI may impact animal agriculture, with examples in the fields of reproduction and genetics. Despite the concerns

and challenges that exist with AI, there are overwhelmingly positive opportunities to use AI responsibly to advance society and agriculture.

What is AI?

Defining AI is a challenge even among scientists. The concept of AI originated in the 1940s but required recent advancement in technology and methods to bring it to fruition (Wikipedia 2025; Heaven 2023; AI definitions 2020). Broadly speaking, AI is software that allows computers to learn and adapt to unique situations allowing it to solve problems in ways similar to how humans think and reason. The term AI can also be referred to as a discipline of study by computer scientists dedicated to understanding the concepts, methods and practical approaches to develop different types of AI software or intelligent machines. This article will focus on the software-based definition of AI.

AI methods excel at automating repetitive processes when simple decision making is possible (e.g., deciding to change the temperature if it is too hot or cold given a clear set of rules to follow). The long-range goal is to develop AI that can make complex decisions that a human would make. There are many different types of AI algorithms, such as machine learning methods, or large language models (**LLM**). Each of these approaches is tailored to different types of problems. When most people hear about AI, it's likely they are hearing about Chat GPT (Open AI 2024), Gemini (Google 2024) or similar online tools that can answer questions written in the same way that we would ask a question to another person. These methods are LLMs, which typically parse out key words and language to identify the most likely answers using natural language processing methods.

Where are some helpful resources to start learning about AI?

Because AI methods are changing so rapidly, it is likely that new methods will soon be available beyond the scope of this review. Some helpful reading resources on AI include the following, which are likely to be updated overtime beyond what was known at the time this document was written (Google Cloud 2025; NASA 2025; Stryker and Kavlakoglu 2024). Universities have developed AI centers to study this new technology (e.g., Translational AI center, or TrAC at Iowa State), but outreach and extension for the public as trusted sources of information are limited today. It can be challenging to know where to get started in learning about AI. Figure 1 provides some general reading on AI for a range of readers that can be quickly evaluated to learn more about AI in relation to a variety of topics related to agriculture and society today.

What are common applications of AI today and how is AI impacting agriculture?

AI is being used all around us, for example within social media applications, and in computer vision applications to check license plates in parking lots, within self-driving cars and to gather information from checks for online banking applications. As an example of what online AI tools can do, Figure 2 was generated by Google Gemini when asked what a picture of AI managing dairy cows with sensors might look like.

Not surprisingly, the use of AI is rapidly expanding in agriculture. Self-driving tractors and robotic milking systems use AI today (Princy 2023; Vrochidou et al., 2022). Applications are currently being used in research settings to do virtual crop scouting to check for weeds and insects using satellite images and drone pictures (Chiranjeevi et al., 2023; Nagasubramanian et al., 2021). Models have even been developed to monitor crop stress levels, predict yields and crop nutrient needs to improve cropping management (Saleem et al., 2024; Shrestha et al., 2024). These applications of AI have the potential to be placed into use soon as they have been tested in a variety of settings with trust-worthy results.

Figure 1. *A summary of helpful resources to start learning about the impact of artificial intelligence (AI) in agriculture and society today organized by topic area. Primary focus in the agricultural section was given to cropping systems, dairy cattle, general considerations in applying AI to livestock species because these areas are generally more advanced in adapting AI technologies. However, new AI technologies are also rapidly being developed for other livestock animal species.*

In food animal species, fewer applications are in place, but a wide variety of technologies are in development. Smart barn technologies that moderate the temperature to avoid heat stress and reduce electrical

power demands using AI are actively in use (Boswell-Gore 2024; Princy 2023). New AI technologies are being developed to check when dairy cows come into estrous, when they are sick and to help monitor and improve efficiency through management practices (Siberski-Cooper and Koltes 2021). With the increasing number of precision technologies being used on livestock farms and ever-increasing amounts of data being generated, a perfect storm is underway to further expand the use of AI on farms (Koltes et al., 2019).

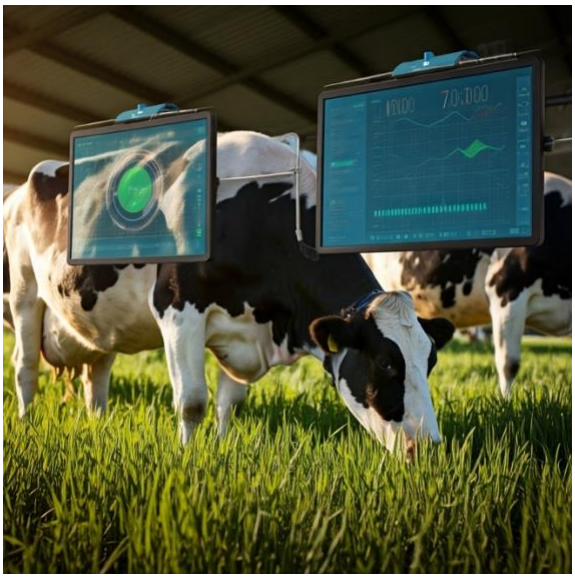

Figure 2. *An example of a figure generated by Gemini, an artificial intelligence (AI) algorithm freely available to the public from Google. This was the figure generated when the software was asked to provide an image of dairy cattle monitored by sensors and AI systems to check the health and production efficiency of cows.*

Where might AI have a big impact in the animal and dairy sciences in the future?

The use of AI on farms is closely tied to the large amounts of data being generated by agricultural technologies today. The term precision livestock farming (**PLF**) has been used to describe the use of sensing technologies and big data on farms to identify helpful information for management of all individual animals on farm (Koltes et al., 2019). More recently, the term precision animal breeding has also been suggested to enhance the speed at which genetic progress is made using new technologies. AI will likely have a role in both areas. AI has already been implemented in robotic milking systems, to detect early onset of lameness and in environmental controls in barns. In the near term, two examples where AI will likely have a large impact on animal agriculture include: 1) in generating new information (i.e., trait phenotypes) from animals using image-based data through expanded computer vision technologies, and 2) integrating large amounts of information to distill into actionable task lists and knowledge to enhance the efficiency of animal management. These AI systems will help to create new tools to measure things that are hard or expensive to measure on farm today (i.e., feed intake, early signs of illness, methane production, microscopic factors impacting fertility) (Rojas de Oliveira et al; 2024; Kerns et al., 2022; Siberski-Cooper and Koltes 2021). This information will allow for the rapid development of new AI measured traits for breeding, and tools for improving the management of animals. It is likely that AI will soon become integrated into a variety of existing farm management software.

Because of the potential of AI to identify hidden information and glean knowledge from large data sets, many other AI applications are likely in development or on the way for applications in agriculture. Among the most exciting applications of AI, are new digital twin methods that seek to create virtual farms to evaluate where farming systems may be working well or where they could be improved through prioritized management. The potential for AI to help farms prioritize the overwhelming about of information available today and identify potential problems before they occur is particularly exciting. Time will tell how well these methods work. However, initial results from other technologies using AI methods, such as wearable sensors, indicate that it is possible to predict or detect illnesses in early stages before human diagnosis in animals. These results create cautious optimize about the potential for AI to help farmers.

Cautions and Considerations in using AI applications.

Many in society today believe AI was developed to make decisions for humans, which was not the case. As with any new promising technology, AI is within a hype cycle where the technology is currently under performing the expected performance of the public. Experts have raised concerns that some AI methods may be better at mimicking information in its response than truly synthesizing new and appropriate responses when given a specific problem it has not encountered previously (Bender et al., 2021). This mimicking response can result in answers that are obviously false to humans, known as AI hallucinations. Scientists are actively working to prevent these failings in AI and to improve its ability to respond with no answer or a response of "I don't know." Only in rare cases will AI likely be used as a decision tool such as simplified situations such as adjusting climate controls, reading information from a picture, or doing repetitive tasks. Buyers of AI technology should be skeptical if the promised results from AI sound too good to be true without good evidence of how AI will work on

farming operations. In some cases, accuracy is important (e.g., hitting the bullseye in a dart game) and in other cases, precision (e.g., consistency of results regardless of accuracy) or recall (e.g., finding all the animals that need vet care, even if extra animals are checked) may be more important. In a scenario where comprehensive animal care is important, the most accurate method may not be sufficient if your goal is to never miss animals that need care, which requires high recall. These are the types of questions and considerations that should be made in determining if an AI tool will work on farm, along with how the tools will be updated and supported as technology advancements occur overtime.

An important consideration in evaluating AI is that the method can be great, but without the right data to train the method to make the right decisions in a specific location or application, the method won't work. Having good data to teach the AI methods is vitally critical to the success of these methods. It's likely that methods that will learn on your farm's data when compared to larger reference information from other farms will perform best, although new approaches such as zero-shot learning are demonstrating that some models can rapidly be applied to new data, without learning (i.e., training) from these new data, with high levels of success. No matter how well an AI method works, the best use of AI will mostly likely be as a trusted advisor to agricultural producers, providing recommendations that farmers will need to use their expertise to decide how to act upon. AI is an incredible tool, but it will not replace the experts who make final decisions on complex problems or situations on farm.

The future of AI is bright.

The applications of AI are expanding rapidly and are exciting to consider. In recent reports, AI methods are continuing to come closer and closer to making decisions similar to that of a human (Heaven 2023, 2024). It is likely that soon dairy farms will receive accurate daily reports on animal health and efficiency of individual animals using AI systems from milk data (Siberski-Cooper and Koltes 2021). These systems will assist farmers and be at their best as trusted assistants in providing actionable information, not decision makers, with rare exception. Who knows where creativity and innovation will take AI applications in the future, but it's reasonable to be both excited and cautious in applying AI technologies in food animals today.

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