

Artificial intelligence (AI) is the ability of computers to mimic the functions of the human mind. Machine learning is a subset of AI (Fig. 1). It is a series of functions that allow a computer to increase its abilities following each new task. It can identify patterns from data that can be applied to new problems. Deep learning is a subset of machine learning that uses neural nets, based loosely on how the human brain works. These allow the software to train itself to perform a certain task (Brown, 2021). The examples provided in this fact sheet generally focus on deep learning AI models because of their ability to be trained to classify images in the field.

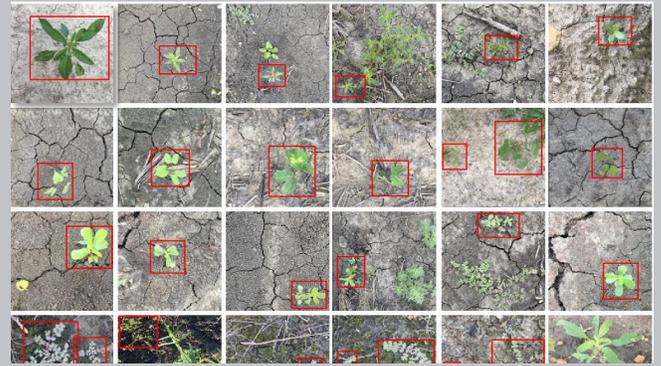


Fig. 2. Examples of weeds identified by red squares called bounding boxes (image from Dang et al., 2023).

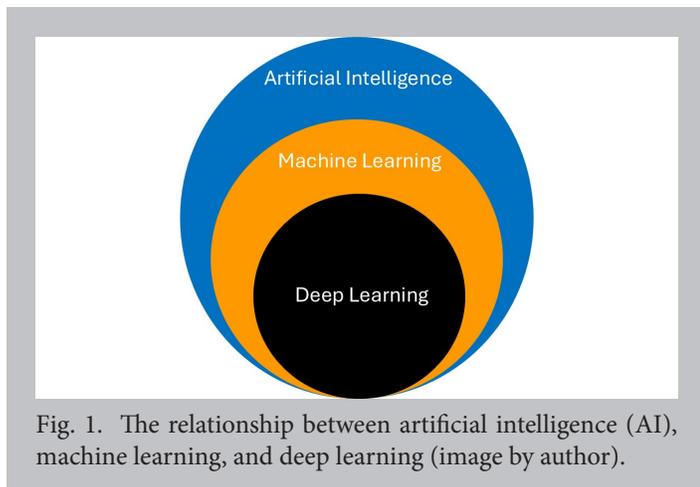


Fig. 1. The relationship between artificial intelligence (AI), machine learning, and deep learning (image by author).

AI in weed detection

Deep learning systems can be trained to identify specific weeds in the field. This is done by providing a model with hundreds of example images to train with. Researchers draw shapes called bounding boxes around each weed so that the AI model knows what to classify as a weed (Fig. 2). In most cases, some of the images are used to train the model and the remaining images are used to test the model. In one study, researchers used 5,648 images with 9,370 bounding boxes to train a model to identify 12 different classes of weeds (Dang et

al., 2023). In the end, the researchers were able to train a model that had high precision and recall.

AI in water stress

Similar to the previous example, images of non-stressed and moisture-stressed plants can be used to train an AI model to detect this stress in the field (Fig. 3). A group of researchers used 3200 images with varying levels of moisture stress in wheat and corn to train a model that could be used with a handheld system in the field (Chandel et al., 2024). Images were collected over the

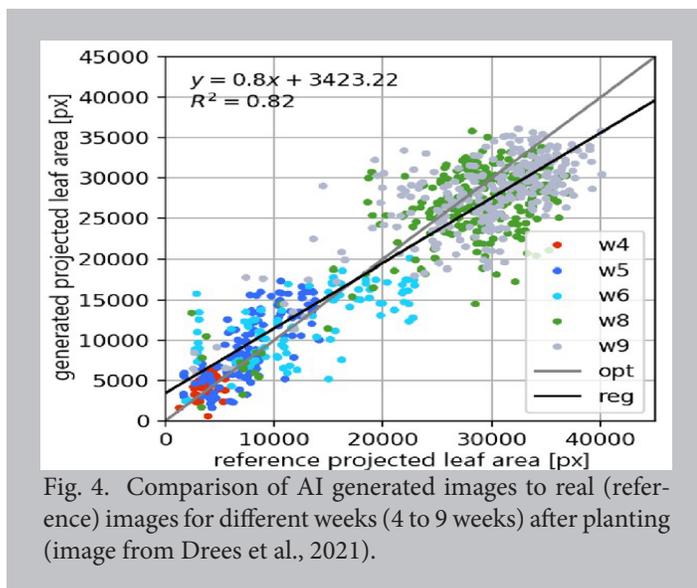


Fig. 3. Examples of images used to train an AI model to detect field moisture stress (image from Chandel et al., 2024).

growing season using five different cameras to incorporate variability in the training and testing of the model to ensure it would work under different conditions. They were able to achieve a 93% accuracy for wheat and a 98% accuracy for corn.

AI in crop yield estimation

Digital images of a particular crop at different stages of production can be used to develop models to predict how large a plant will be at different periods based on its current size and shape. One research group (Drees et al., 2021) developed a model based on cauliflower production that could create an image that showed how large it would be 3 weeks after the original image. The generated images related well with the real images and the AI model had the potential to predict total leaf area (Fig. 4).



AI in plant breeding

Over the years there have been many crop research projects that collected data related to the environment (i.e., climate, soil) where the research is being done, the varieties or genetics that are being planted, the management practices used, and the resulting yields achieved. Developing an AI model based on all of this “Big Data” can allow scientists to better predict which genetics will lead to the best outcomes for a particular area with a certain type of climate and soil and that engages in specific management practices. This will make field trials more efficient and help save time and money (Xu et al., 2022).

Current technology using AI

For the information below, omission of similar products is not intentional and inclusion of the products described here is not an endorsement.

[John Deere See & Spray technology](#) contains 36 cameras in the spray boom which collect images and use an onboard AI model to determine if a weed is present. If a weed is identified, a nearby nozzle turns on to spray the weed based on its location and the speed of the tractor.

[CattleEye livestock monitor](#) uses AI technology to review real-time video of cattle to help reduce and prevent lameness in cattle. It monitors their movement and identifies cows for hoof trimming and treatment.

[Harvest Croo](#) designed a strawberry harvester that uses AI and machine learning to scan each berry and determine if it is ripe for picking. Then, the fully autonomous harvester picks the ripe berries using robotic arms.

[CropX](#) assesses the field and makes predictions to optimize crop performance. It takes data from multiple sensors, satellite imagery, and agronomic models to predict things like water use, crop stress, and crop growth and then makes recommendations.

Regardless of the AI technology employed, it is always important for the user to verify that the equipment is working properly and any AI-based recommendations fit with what is observed on the ground.

For more information

Brown, S. 2021. Machine learning, explained. Ideas Made to Matter. MIT Sloan School of Management. <https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained>

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Dang, F., D. Chen, Y. Lu, and Z. Li. 2023. YOLOWeeds: A novel benchmark of YOLO object detectors for multi-class weed detection in cotton production systems. Computers and Electronics in Agriculture 205, 1-13.

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Xu, Y., X. Zhang, H. Li, H. Zheng, J. Zhang, M.S. Olsen, R.K. Varshney, B.M. Prasanna, and Q. Qian. 2022. Smart breeding driven by big data, artificial intelligence, and integrated genomic-environmental prediction. Molecular Plant 15, 1664-1695.