Artificial Intelligence and Decision Support Systems

Definition: Artificial intelligence (AI) refers to the development of intelligent agents that can reason, learn, and solve problems. Decision support systems (DSS) are computer-based systems that help decision-makers analyze data and make informed decisions.

Applications in Agriculture:

- **Crop Yield Prediction:** Using AI algorithms to predict crop yields based on historical data, weather forecasts, and other factors. This can help farmers make better decisions about planting, harvesting, and marketing.
- **Pest and Disease Management:** Employing AI to detect and identify pests and diseases early, enabling timely intervention to prevent crop damage.

- **Precision Agriculture:** Using AI-powered technologies (e.g., drones, sensors) to collect data on crop health, soil conditions, and other factors to optimize resource management. This can help farmers use resources more efficiently and reduce their environmental impact.
- **Decision Support Systems:** Developing DSS to help farmers make informed decisions about planting, harvesting, marketing, and other agricultural activities. DSS can provide farmers with access to relevant data, analytics tools, and expert advice.

Key AI Techniques:

- **Machine Learning:** Algorithms that allow computers to learn from data and improve their performance over time. For example, machine learning can be used to develop models that predict crop yields based on historical data.
- **Natural Language Processing:** Enabling computers to understand and respond to human language. This can be used to develop chatbots that can answer farmers' questions about agricultural practices.
- **Computer Vision:** Algorithms that allow computers to interpret and understand visual information. This can be used to develop systems that can automatically identify weeds or detect plant diseases from images.

Example: A farmer can use a DSS to analyze weather data, soil information, and crop prices to determine the optimal planting date for a particular crop. The DSS can also provide recommendations for fertilizer application, irrigation scheduling, and pest control.

Artificial Intelligence:

Benefits of AI in agriculture

Until recently, using the words AI and agriculture in the same sentence may have seemed like a strange combination. After all, agriculture has been the backbone of human civilization for millennia, providing sustenance as well as contributing to economic development, while even the most primitive AI only emerged several decades ago. Nevertheless, innovative ideas are being introduced in every industry, and agriculture is no exception. In recent years, the world has witnessed rapid advancements in agricultural technology, revolutionizing farming practices. These innovations are becoming increasingly essential as global challenges such as climate change, population growth together with resource scarcity threaten the sustainability of our food system. Introducing AI solves many challenges and helps to diminish many disadvantages of traditional farming.

Data-based decisions

The modern world is all about data. Organizations in the agricultural sector use data to obtain meticulous insights into every detail of the farming process, from understanding each acre of a field to monitoring the entire produce supply chain to gaining deep inputs on yields generation process. AI-powered predictive analytics is already paving the way into agribusinesses. Farmers can gather, then process more data in less time with AI. Additionally, AI can analyze market demand, forecast prices as well as determine optimal times for sowing and harvesting.

Artificial intelligence in agriculture can help explore the soil health to collect insights, monitor weather conditions, and recommend the application of fertilizer and pesticides. Farm management software boosts production together with profitability, enabling farmers to make better decisions at every stage of the crop cultivation process.

Cost savings

Improving farm yields is a constant goal for farmers. Combined with AI, precision agriculture can help farmers grow more crops with fewer resources. AI in farming combines the best soil management practices, variable rate technology, and the most effective data management practices to maximize yields while minimizing minimize spending.. Resulting in reduced use of herbicides, better harvest quality, higher profits alongside significant cost savings.

Automation impact

Agricultural work is hard, so labor shortages are nothing new. Thankfully, automation provides a solution without the need to hire more people. While mechanization transformed agricultural activities that demanded super-human sweat and draft animal labor into jobs that took just a few hours, a new wave of digital automation is once more revolutionizing the sector.

Automated farm machinery like driverless tractors, smart irrigation, fertilization systems, IoT-powered agricultural drones, smart spraying, vertical farming software, and AI-based greenhouse robots for harvesting are just some examples. Compared with any human farm worker, AI-driven tools are far more efficient and accurate.

Applications of artificial intelligence in agriculture

Traditional farming involves various manual processes. Implementing AI models can have many advantages in this respect. By complementing already adopted technologies, an intelligent agriculture system can facilitate many tasks. AI can collect and process big data, while determining and initiating the best course of action. Here are some common use cases for AI in agriculture:

Optimizing automated irrigation systems

AI algorithms enable autonomous crop management. When combined with IoT (Internet of Things) sensors that monitor soil moisture levels and weather conditions, algorithms can decide in real-time how much water to provide to crops. An autonomous crop irrigation system is designed to conserve water while promoting sustainable agriculture and farming practices. AI in smart greenhouses optimizes plant growth by automatically adjusting temperature, humidity, and light levels based on real-time data.

Detecting leaks or damage to

that indicate potential leaks. Machine learning (ML) models can be trained to recognize specific signatures of leaks, such as changes in water flow or pressure. Real-time monitoring and analysis enable early detection, preventing water waste together with potential crop damage.

AI also incorporates weather data alongside crop water requirements to identify areas with excessive water usage. By automating leak detection and providing alerts, AI technology enhances water efficiency helping farmers conserve resources.

Crop and soil monitoring

The wrong combination of nutrients in soil can seriously affect the health and growth of crops. Identifying these nutrients and determining their effects on crop yield with AI allows farmers to easily make the necessary adjustments.

While human observation is limited in its accuracy, computer vision models can monitor soil conditions to gather accurate data necessary for combatting crop diseases. This plant science data is then used to determine crop health, predict yields while flagging any particular issues. Plants start AI systems through sensors that detect their growth conditions, triggering automated adjustments to the environment.

In practice, AI in agriculture and farming has been able to accurately track the stages of wheat growth and the ripeness of tomatoes with a degree of speed and accuracy no human can match.

Detecting disease and pests

As well as detecting soil quality and crop growth, computer vision can detect the presence of pests or diseases. This works by using AI in agriculture projects to scan images to find mold, rot, insects, or other threats to crop health. In conjunction with alert systems, this helps farmers to act quickly in order to exterminate pests or isolate crops to prevent the spread of disease.

AI technology in agriculture has been used to detect apple black rot with an accuracy of over 90%. It can also identify insects like flies, bees, moths, etc., with the same degree of accuracy. However, researchers first needed to collect images of these insects to have the necessary size of the training data set to train the algorithm with.

Monitoring livestock health

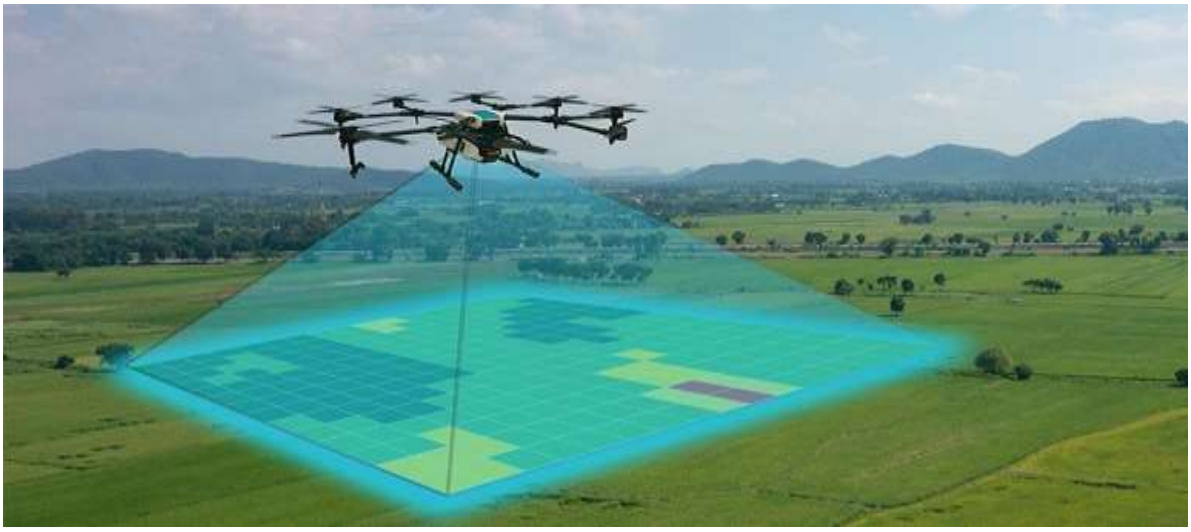
It may seem easier to detect health problems in livestock than in crops, in fact, it’s particularly challenging. Thankfully, AI for farming can help with this. For example, a company called CattleEye has developed a solution that uses drones, cameras together with computer vision to monitor cattle health remotely. It detects atypical cattle behavior and identifies activities such as birthing.

CattleEye uses AI and ML solutions to determine the impact of diet alongside environmental conditions on livestock and provide valuable insights. This knowledge can help farmers improve the well-being of cattle to increase milk production.

Intelligent pesticide application

By now, farmers are well aware that the application of pesticides is ripe for optimization. Unfortunately, both manual and automated application processes have notable limitations. Applying pesticides manually offers increased precision in targeting specific areas, though it might be slow and difficult work. Automated pesticide spraying is quicker and less labor-intensive, but often lacks accuracy leading to environment contamination.

AI-powered drones provide the best advantages of each approach while avoiding their drawbacks. Drones use computer vision to determine the amount of pesticide to be sprayed on each area. While still in infancy, this technology is rapidly becoming more precise.



Yield mapping and predictive analytics

Yield mapping uses ML algorithms to analyze large datasets in real time. This helps farmers understand the patterns and characteristics of their crops, allowing for better planning. By combining techniques like 3D mapping, data from sensors and drones, farmers can predict soil yields for specific crops. Data is collected on multiple drone flights, enabling increasingly precise analysis with the use of algorithms.

These methods permit the accurate prediction of future yields for specific crops, helping farmers know where and when to sow seeds as well as how to allocate resources for the best return on investment.

Automatic weeding and harvesting

Similar to how computer vision can detect pests and diseases, it can also be used to detect weeds and invasive plant species. When combined with machine learning, computer vision analyzes the size, shape, and color of leaves to distinguish weeds from crops. Such solutions can be used to program robots that carry out robotic process automation (RPA) tasks, such as automatic weeding. In fact, such a robot has already been used effectively. As these technologies become more accessible, both weeding and harvesting crops could be carried out entirely by smart bots.

Sorting harvested produce

AI is not only useful for identifying potential issues with crops while they're growing. It also has a role to play after produce has been harvested. Most sorting processes are traditionally carried out manually however AI can sort produce more accurately.

Computer vision can detect pests as well as disease in harvested crops. What's more, it can grade produce based on its shape, size, and color. This enables farmers to quickly separate produce into categories — for example, to sell to different customers at different prices. In comparison, traditional manual sorting methods can be painstakingly labor-intensive.

Surveillance

Security is an important part of farm management. Farms are common targets for burglars, as it's hard for farmers to monitor their fields around the clock. Animals are another threat — whether it's foxes breaking into the chicken coop or a farmer's own livestock damaging crops or equipment. When combined with video surveillance systems, computer vision and ML can quickly identify security breaches. Some systems are even advanced enough to distinguish employees from unauthorized visitors.

AI and its Application

The concept of expert systems, artificial intelligence, ‘‘fuzzy logic,’’ and knowledge-based decision support systems (information systems) was accepted rapidly in business and industry. Production control systems in factories have included these concepts so that operating problems, such as bad welds, can be either prevented or fixed much more quickly than under simpler control systems.

Robotics

Robotics has been considered a part of the overall field of artificial intelligence by many authors. A robot is not just an automatic welding machine on a car body production line, but a machine that can be programmed to do a variety of tasks and that can interact with its environment. A robot may need to make a decision about whether an object that it must select is a nut or a bolt, a green tomato or a ripe, red tomato. Thus robots need to ‘‘see,’’ recognize objects, and make decisions, so they need intelligence ‘artifi cial’’ intelligence.

Natural Language

For easier and greater application of the computer in our working world, we need better and more natural ways for hu- mans to communicate with the computer. The computer needs to be shown more about how we communicate so that we can spend less time learning how the computer communicates. This is a difficult field, but progress is being made. The programs that can process natural language sentences must determine which words are the noun, the verb, and the object, In addition, voice recognition by the computer is a part of this, because we often do not want to or are unable to type our input, but should speak to the computer. The development of programs that understand human natural language is a vital part of the whole artificial intelligence investigation, because this requires intelligence. We are going no further into this area.

Fuzzy Logic

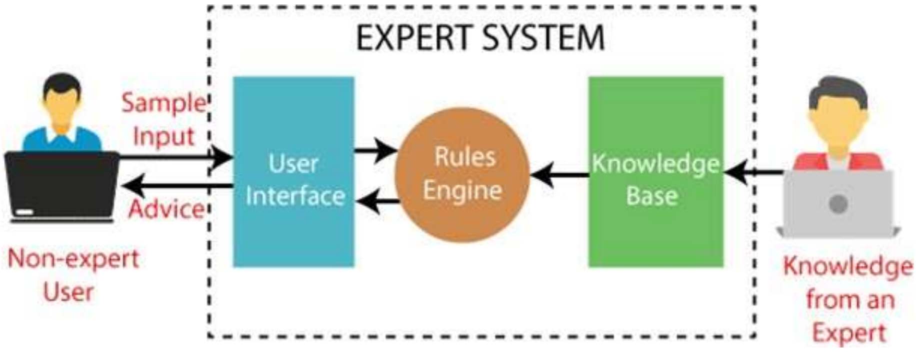
To simulate human intelligence, artificial intelligence must be able to handle more than just numbers, yet the heart of any computer is just a very fast processor of data in binary form, zeros and ones. Our programming languages, such as FORTRAN, C++, and Java, have allowed us to program computers with English words and mathematical symbols, yet most programs are very precise and objective in their results. They usually produce a table of numbers, and they can rank these results numerically, even with huge numbers of possibilities.

But humans often must make decisions in which the input data and the resulting output are not in neat mathematical or completely logical form. For example, a computer using a linear programming algorithm can select the one best combination of several ingredients that will result in the lowest-cost feed mixture that meets the specifications in terms of protein, fat, fiber, and total digestible nutrients from among an almost infinite number of possible combinations. However, until artificial intelligence, the computer could not solve less precise problems, such as determining the most profitable combination of crops to plant for the coming year, with prices and costs being uncertain. And managers often want a recommendation in terms somewhat like a weather forecast, such as, ‘‘If you do not spray, chances are about 1 in 5 that the disease will cause more damage than the spraying cost.’’

Expert Systems

An expert system simulates a human expert in a narrow subject matter domain. For example, to develop an expert system program to give soybean growers advice about insect problems like a consulting entomologist might give, the program needs to do the following:

1. when and what type of insecticide is recommended if treatment is needed.



Programs such as these probably will not replace the consultant, but they will be used by the consultant to give better advice and probably to produce good printed reports for the client. Many agricultural expert systems are diagnostic in nature, such as the example just given. In addition, expert systems may be (and a few have been) developed for making technical management decisions, such as purchase of new equipment, deciding on a crop rotation, making a marketing plan for grain, or culling livestock from a breeding herd.

Knowledge-Based Decision Support Systems

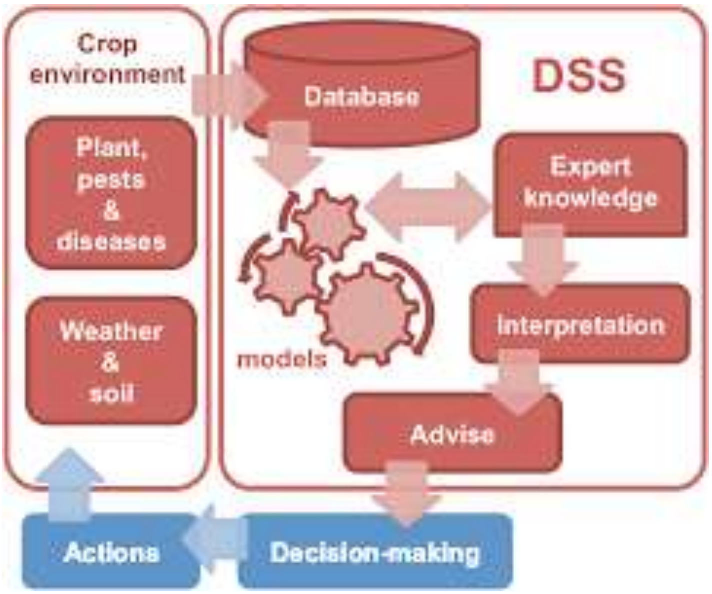
The term *knowledge-based decision support systems* (or *decision support systems*) includes expert systems but covers a broader range of program types .*Often it would be advantageous.* for an expert system to have available the latest data from the commodity futures market or cash markets or to be able to run a simulation program with current weather data to get crop yield estimates in order to give the user the best up-to- date expert advice. When an expert system uses a database, a spreadsheet, or some other external program, such as a simulation program, the whole integrated system is referred to as a decision support system. An expert system is also a knowledge- based decision system or *decision support system*, because it contains the knowledge of the expert and it helps, or supports, the user in making a decision.

The word *support* emphasizes the important idea that the computer is not controlling the decision. It is not the decision maker. It helps (supports) the human decision maker by keeping track of many factors, whereas the decision maker is also likely taking into account other factors, especially more subjective ones. A citrus production manager in Florida makes a very sound point about the use of computers in management: ‘‘Use the computer for what it can do best, calculating and remembering lots of data, and use the human for what the person can do best, integrating the output of the decision sup- port system and other factors, including the human’s experience, and come to a decision based on all these things.’’

More recently, a broader common term has come to include decision support systems: *information systems*; the field has become known as *information technology* (IT).

Models of Decision Support system

Eg: Decision support system for crop disease.



Decision Support System Applications

Potential applications are innumerable, but many of them will fi t under one of the following types.

- *Diagnostics*
- *Marketing*
- *Systems operations management*
- *Automatic control*
- *Strategic planning*

Static and Dynamic Decision Support Systems

Especially for agricultural systems, the idea of dynamic vs. static decision support systems is important for the development and operation of these systems. *Static* systems are those that are used, usually, at a single point in time; and each use is a new one, keeping no information from the last time it was used or ‘‘run.’’ A diagnostic system telling the user with a poor- looking crop what the problem is—disease, some nutrient lacking, drought, etc.—is a typical static system. An early ex- ample of such a system was used to identify soybean insect problems and recommend treatment.

However, many agricultural problems may be used throughout a growing season. Once the user enters data about the crop to assess the threat of an early-season disease, for example, the user may want to do it a week later to check on the same disease or on a question such as irrigation needs. These subsequent uses can take advantage of the earlier data entered to give decision support based on the history of the crop up to that point. These programs are called *dynamic* decision sup- port systems, and they must keep earlier data from one use to the next.