The Applications and Future of Artificial Intelligence in Farming & Agriculture

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Introduction

In the history of human beings, agriculture and farming have been through three stages: original, traditional and modern stages. To meet the urgent need of food because of population explosion, developing intelligent agriculture by making use of artificial intelligence is necessary now.

Artificial intelligence integrates network technology, wireless communication technology, internet of thing technology and other technologies, which can realize tele diagnosis, warning disaster in advance and tele controlling in agriculture. These functions can improve the efficiency and increase the yields by making the producing process efficient and standardized.

This article will discuss the technology history, technology components and disadvantages and future works of intelligent agriculture used in farming and agriculture.

Technology history

The forming period (1970-1990):

In the 1970s, the expert system was first introduced by Edward Feigenbaum [1], which is a computer system that has making-decision ability.

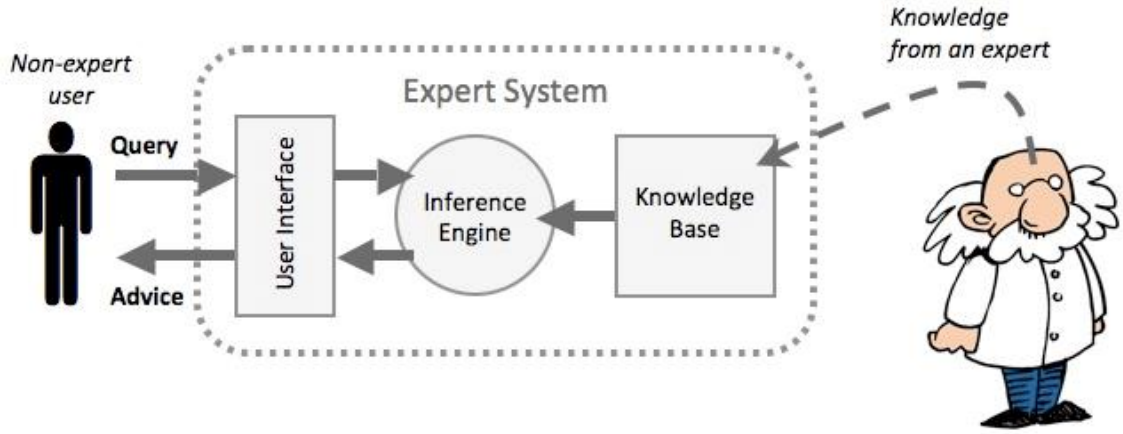

Figure 1 Components of Expert System [2]

The most important two components are the knowledge base and inference engine as it is shown in the figure 1. The knowledge base holds the facts and the rule, while the inference engine makes the use of rules in the facts to deduce the new facts. It was put

into use in 1980s and integrated geographic information system, intelligent computing, machine learning, knowledge discovery and other aspects of high-tech, bringing together the knowledge of agriculture, model and expert experience. Using appropriate knowledge representation techniques and reasoning strategies to provide advisory services to agricultural production management, scientific farming, to a certain extent, it acts a role as agricultural experts.

There're some excellent agriculture expert systems, one of which is COMAX/GOSSYM built in 1989, it provided effective aid to crop consultants, cotton growers, and researchers in the management of irrigation water, nitrogen, plant growth regulators, and crop termination chemicals. [3]

Besides, in this stage, robots used in agriculture and computer vision technology began to be put into use.

For example, in 1989 Byron Miller introduced a color vision system for peach grading, which includes a color vision camera, a grabber and a microcomputer. An image analysis algorithm was built inside to grade the peach automatically. [4]

Rapid development period (1990-2000):

Both expert system and computer vision technology were developed rapidly.

For example, in 1993, Liao introduced a vision machine to classify the corn kernel breakage using neural network classifier. "Shape parameters were selected by analyzing the kernel profile and were sent into a machine learning algorithm to train for a shape membership function of broken versus whole kernel." The classification success rate is above 90%. [5]

Large application period (2000-)

The expert system and computer vision technology are more and more mature. Besides, the cost of labor increases rapidly, so the agriculture robots are in great need and the robot technology get developed quickly.

For example, there's a robot company called Agrobot in Spain. It provides a harvester called SW 6010 which has two workstations qualified to monitor and pack the picked fruit. Agrobot invites a revolutionary navigation system called ATCross. A guidance and automatic operation system (AGM) is also integrated, which provides completely independent control of the main functions of the harvester. These components promote the high efficiency while picking fruit. [6]

Technology components [7]

Automated irrigation systems

Traditional irrigation management is an arduous work, which is coupled with a reliance on weather conditions. Automated irrigation system was developed to optimize water use for agricultural crops. The system has a distributed wireless network of sensors positioned in the root area of the plants to detect the soil-moisture and temperature. To maintain desired soil conditions constantly, this system is designed to capitalize on real-time machine learning. A gateway unit triggers actuator, handles information and transmits all the data to a platform such as web application. To control water quantity, an algorithm was programmed into a gateway with data and values of soil moisture and temperature. A duplex communication link based on a mobile web interface was allowed for data inspection and irrigation scheduling to be programmed conveniently. It was powered by photovoltaic panels. [8]

Crop health monitoring

Traditional crop health monitoring methods are considerably time-consuming. The process can be highly difficult for agriculture expert, analyst or farmer. In contrast, technology firms developing automated detection and analysis technologies will increase the precision and volume of data collected, such as 3D laser scanning and hyperspectral imaging. Drones are being used in agricultural formats to detect disease, identify overall crop health and improve predict times for harvest. Farmers can produce diagnostics specific to individual plots or single plants with the ability for microscopic data collection.

Facial recognition

Facial recognition is now extending into the field of domestic cattle. Existing systems mainly require the utilization of physical tracking devices whilst ‘intelligent’ cattle monitoring is more ordinary, facial recognition technology will eliminate the stress of adapting these devices, allowing light monitoring of an entire heard with lowest interaction. This is set to enable individual monitoring of group behavior, early detection of lameness and accurate recording of feeding habits.

Figure 2 The driverless concepts are said to be suited to repetitive field task. [9]

Driverless tractors

Technology companies through varieties of industries have been developing adaptations of driverless vehicle technology, and agriculture is no exception. Technology firms are combining more complicated software as a platform with technologies such as radars and lidars, sensors, multi-camera systems and GPS systems. Farmers will soon be able to hand this outdated machine over to smarter robots that could help speed up and lower the cost of developing autonomous farm machinery. Farmers will be able to reduce pressures on an already stressed labor force and allow for more acreage to be worked for longer time with autonomous harvests

Drones

Thanks to robust investments, drones time has arrived. Drones is one of the diffusely accessible gadgets in farming's high technology makeover nowadays. Drone technology is increasingly becoming invaluable for us. Farmers can increase their crop yields through long-distance crop spraying, high-efficiency crop monitoring and in-depth field analysis by implementing the drone technology. Pragmatic applications for drone technology are continually growing, it's likely that drone-powered methods will be popular in the following years.

Applications & advantages

When people think of the relationship between AI and agriculture, they always think the combination of AI and agriculture is just to develop robots to work in the fields as farmers. Actually, the combination of AI and agriculture is not only as simple as developing farmer robots but also has a large range of application. The application of the combination of AI and agriculture comprise agricultural disease identification and protection, animal behavior analysis, agriculture expert system, nondestructive examination (NDE) of agriculture products, Agricultural robot etc. These applications are helping us to increase output and improve efficiency while reducing the use of pesticides and fertilizers.

Agricultural disease identification and protection

In the past, when farmers discovered a plant that might be infected in the field, they needed to identify the crops disease through their own experience. However, the number of agricultural diseases was large and the plants in the field were numerous. Farmers sometimes cannot accurately identify the disease, this may cause the crops disease wreak havoc, causing huge losses. But today farmers can use intelligent image recognition technology to help identify crop diseases. With the help of machine learning and deep learning, the accuracy of intelligent image recognition is getting higher and higher. PlantVillage (USA) and Plantix (Germany) are two intelligent plant identification App, which can help farmers identify most diseases and insect pests of crops intelligently. Farmers upload photos of crops with diseases and pests, and App will recognize what diseases the crops have.

These methods provide great convenience to farmers but still need some artificial work. However, another AI company, Blue River, has a more intelligent product Lettuce Bot which can be completely intelligent work without human. When Lettuce Bot driving through farmland, it can shoot picture at a rate of 5,000 per minute and judge each plant is lettuce or weeds through the algorithm and machine vision. After judging that the plant is a weed, Lettuce Bot will spray pesticides on it. Lettuce Bot accuracy can be up to 1/4 inch, which means it can accurately locate each weed on the run and spray them with herbicides. Ben Chostner of Blue River Technology says by using the Lettuce Bot, farmers can reduce their use of chemicals by 90 percent. And this machine has been put into use, the fields in which Lettuce Bot is used supply 10 percent of the lettuce in the US annually. [10]

Animal behavior analysis

Artificial intelligence can also be used in livestock farming, animal behavior analysis is one of the most useful application in livestock farming, it is widely used in animal husbandry and research, such as in Cattle industry. Artificial intelligence obtains pictures of cattle faces and body conditions through farm cameras, and then analyzes the emotional and health conditions of cattle through deep learning. Then help farmers determine which cattle is hungry, which cattle is sick, what diseases it id suffered from, and even when the cattle are in estrus. In addition to the camera's "cattle face" recognition of cattle, cattle can also be fitted with wearable smart devices that will allow farmers to better manage their farms. The Netherland company Connecterra is an animal smart wearable technology company. They use a smart sensor which is mounted on a cow's neck, combined with a stationary detector in the farm, collects the data of the cattle. These data will be uploaded to the cloud server. The algorithms developed by this company using machine learning to make these vast amounts of raw data into intuitive graphs and information and send to customers. This application greatly saves the working time of the farmer and improve work efficiency, especially for large farm, because they can easily identify the state of each cattle.

Agricultural expert system

Agricultural expert system is a computer technology which applies the knowledge of expert to agriculture using artificial intelligent. Agricultural expert system can be used in every link of agriculture, and the most widely used agricultural expert system includes crop production decision system, crop disease diagnosis and protection expert system, aquaculture management expert system, and animal health breeding management expert system. Here is the reason why people use the expert system. Pest control and crop protection constitute a very significant class of agricultural expert systems; these works request a large number of knowledge in biology. Because the knowledge gathered over these years is voluminous and diverse, only the expert system can efficiently structure and organize the knowledge and make a good deal with this knowledge. Different farm has different environment, expert system can help farmers to manage their farms more professionally and find out the suitable production decision for every farmer with his own conditions. The agricultural expert system is not a completely new concept. Since the 80s of last century, expert systems have begun to be applied in the field of world agriculture. The soybean disease and insect diagnosis expert system (PLANT/ds) developed by Illinois University of America in 1978 is the earliest agricultural expert

system in the world, this system makes diagnoses on the basis of the answers to specific questions about the diseased crop and its environment.[11] Nowadays, a large number of countries has researched and developed the agricultural expert system, and the expert systems in China, the United States, India and other countries have been widely applied

Agriculture robots

Agriculture robot is the most famous application in the combination of AI and agriculture area. The application of agricultural robots is becoming more and more extensive, it can complete the arduous task in agriculture intelligently and automatically. At present, the agricultural robots can already complete seeding, planting, cultivation, harvest, harvest, weeding, sorting and packing and so on, mainly used in tractors, unmanned drone, materials management, planting and forest management, soil management, animal husbandry management. Using agricultural robots can improve labor productivity, solve the shortage of labor force, improve the agricultural production environment, prevent the harm of pesticides and fertilizers, and improve the efficiency.

Disadvantages

Sometimes, it can be a huge challenge to implement AI into farming and agriculture field. First of all, it is relevantly difficult to gather meaningful data from farm because most of the data from the crops can only be used once in a year when the growing time is coming, thus it will take few years to gather statistical data from a particular farm. Because the algorithm of AI requires large amounts of data to train properly, it will become difficult to form the algorithm.

Besides, mobile phone signal cannot be that stable or even exist in farm, therefore it is hard to transfer data to where it can be analyzed. Meanwhile, lack of standards and transparency in data usage and ownership, and difficulties in collecting and sharing data have caused AI algorithm developers in agriculture to still not be able to find the right data.

The most important point is that the requirements of AI on the agricultural environment are too harsh because there are a large number of variable factors in their growing environment. Data process can vary from time to time.

Future works

As far as human concerned, the future of AI to be implemented in farming and agriculture is visible. The most basic implementation for AI to be put into use is to completely substitute for human being universally. Like a farmer, AI technology needs to take the responsibility of harvesting and managing crops, fishing, grazing and everything that requires manual labor.

Crop management

To put AI automation technology into seeding and spraying in farming, which will be quite an achievement once it is implemented widely in the world. Blue River Technology is now working on it. It has developed two main smart machines to manage crops. One is See & Spray for cotton weeding, like Lettuce Bot that is mentioned in application part. Another is Drones for remote sensing, which is mentioned in the component part, use novel drone technology for phenotyping of crop and environmental factors. This can cooperate with See & Spray to achieve real-time monitoring and feedback outputting to the environment. [12] Furthermore, the company has developed a set of plants database in order to store and proceed data information gathered by smart machines. With its application of AI technology, Blue River Technology won the title of "the world's 100 largest artificial intelligence developers" out of 1600 competitors in 2017. These implementations can be applied in the near future as long as the technology is mature enough and the cost is low enough to be spread worldwide.

Grazing helper

As for graziery, it is highly requested to release human labor from grazing, especially in large farms. This gives inspiration to researchers to develop a grazing robot to take over the job from famers. The University of Sydney recently developed an automated robotic prototype called SwagBot. The prototype machine will have 4 legs and wheels with a main body contained many sensors, which is shown in figure 3.

Figure 3 SwagBot prototype machine. [13]

This can be a great assistant to help grazing in a large area. SwagBot is suitable for any complex terrain and is designed to help livestock go to somewhere with grass, avoid danger from them. The University of Sydney plans to test this robot for two years and it just got started for only few weeks. The robot has shown great abilities, such as bypassing obstacles and working without manual attention. Meanwhile, it can successfully get attentions from cattle. [14] They think it can be widely implemented as long as the test finishes successfully. Some functions are still yet to be developed such as using sensors to detect physical conditions of animals, or Monitor the status of the grass to determine which part is most suitable for grazing. It will be a huge achievement once it is implemented.

Some of the corporations like Orbital Insights, Descartes Labs, Gro Intelligence and Tellus Labs are dedicating in gathering information from satellite image, weather information and historical yield data etc. to predict production using particular algorithm, which can be more accuracy than U.S. Department of Agriculture. By using such kind of method, AI will provide more reliable environment to be implemented in farming and agriculture.

Conclusion

Although hailed as the future of farming, the extent to which Artificial Intelligence will change the daily operations of the traditional family farm is yet to be seen. Using AI and robots for farming crops may be the most beneficial technological venture.

Obviously, agriculture is an integral part of how we eat as human beings. Implementing AI into production could lead to higher quality food, and it has the potential to be a powerful tool in the fight against world hunger. More effort, skills, and funding is needed to test these technologies in farmers' fields for technology to truly make an impact in the field.

Anyway, with new agricultural technology firms researching and developing cumulatively accessible technology, the digital farm in the future may be close. There is huge potential for AI and machine learning to revolutionize agriculture by integrating these technologies into critical markets on a global scale. Only then can it make a difference to the grower, where it really counts.

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